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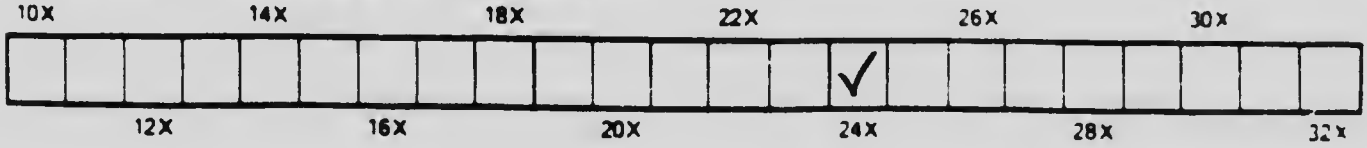

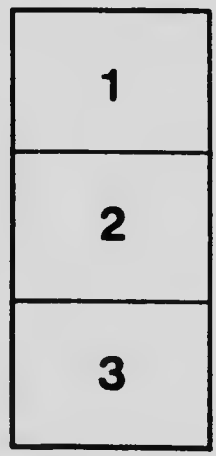

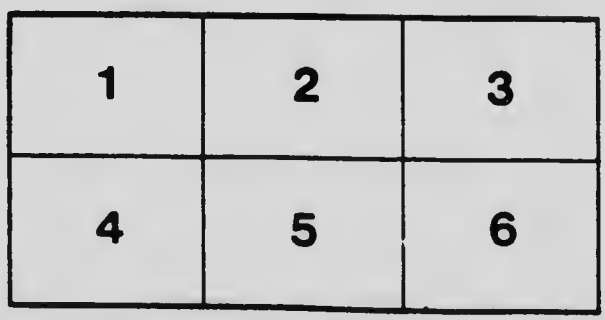

THE OPERATIONS OF SURGERY

THE OPERATIONS OF SURGERY

(JACOBSON)

SIXTH EDITION

BY

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With 797 Illustrations (40 in Colour)

VOLUME I

THE UPPER EXTREMITY; THE HEAD AND NECK;
THE THORAX; THE LOWER EXTREMITY;
THE VERTEBRAL COLUMN

TORONTO
THE MACMILLAN COMPANY OF CANADA LTD.
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PREFACE TO THE SIXTH EDITION

This book, of which five previous editions have appeared, was the outcome of a strong belief which Mr. Jacobson held for many years, that a work on operative surgery which aimed at being more comprehensive in scope and fuller in detail than those already published, would be of service to many who had recently been appointed to hospital staffs, and to those who were working for the higher examinations. For these this book is specially intended, and, as the authors have pointed out here and there, some of the recommendations made apply to those who have not a well-appointed hospital staff at their back

Time and space set a limit to the operations which can be described. Therefore preference is given to those we have found most useful

In the special departments of surgery such as those of the ear and throat, gynæcology and orthopædics, only the important well-established operations which a general surgeon can safely perform are considered here, and no attempt is made to compete with treatises on these special subjects.

In this edition we have endeavoured to save space and avoid repetition by devoting special chapters to "the examination, preparation and after-treatment of the patient."

The whole book has been carefully revised and a great deal has been entirely rewritten; this applies especially to the section on Abdominal Surgery, and the chapters on the Surgery of the Blood-Vessels, and of the Brain, Ear, Nose and Throat.

We are well aware that the book will, from time to time, require much alteration. This is unavoidable in a subject so progressive and changeful as modern surgery; it is especially unavoidable when a writer desires to do full justice to the work done by the crowd of labourers engaged in the same field at the present time. Many of the methods suggested in these pages will, later on, be rejected, but it is only by submitting novelties and suggestions to the one true test, that of time, that we shall know how many are really worthy to survive. If this book aids in bringing about the application of this test, it will not have failed, altogether, in its purpose.

The plan of the book, with which some judges found fault, remains unchanged. Mr. Jacobson adopted the division by regions deliberately, desiring that those for whom the book is intended should study the anatomy of each region at the same time as the account of the operations. In this edition it has been found convenient to insert the section on the Leg in the first volume, so that the increasing claims of abdominal surgery could be adequately met in the second volume.

To our great regret Mr. Jacobson has been unable to continue the laborious and brilliant work which built up this book and maintained

its great reputation for so many years. Mr. Philip Turner has made himself entirely responsible for the sections dealing with the Surgery of the Head and Neck, Chest and Upper Extremity. Mr. G. Bellingham Smith, Senior Obstetric Physician and Gynæcologist to Guy's Hospital, has again thoroughly revised and largely rewritten the chapters dealing with the operations on the Ovary and Uterus.

Many new and original illustrations have been added, and we desire to express our grateful acknowledgments to Sir Watson Cheyne, Sir A. Pearce Gould, Sir Victor Horsley, Sir Arbuthnot Lane, Sir W. Macewen, Sir Henry Morris, Sir Berkeley Moynihan, Sir St. Clair Thomson, Messrs. Barker, James Berry, Burghard, Dobson, Freyer, Hey Groves, Sampson Handley, Jonathan Hutchinson, McGavin, Miles, Paul, Rawling, Scott, Swain, Tilley, West, and to Doctors Binnie, Connell, Crile, Garré, Halstead, Kelly, Kocher, C. H. Mayo, W. J. Mayo, Willy Meyer, Quincké, Scudder, Tuttle, Young and others; also to *The Annals of Surgery*, and acknowledgments are also made to some who have passed away, such as Bucknall, Edebohls, Heath, Lockwood, Greig Smith, and Wheelhouse. It remains for us to acknowledge very gratefully the encouragement given by the reviewers of previous editions, and a host of correspondents from all parts of the world. We only wish that this edition may deserve some of the kind things written of its predecessors, and that it will be found to give proof of the two main objects which we have tried to keep before us—to do justice to the work of others and to save our readers some of the difficulties and anxieties which have beset our paths.

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PART I

OPERATIONS ON THE UPPER EXTREMITY

CHAPTER I

PRELIMINARY CONSIDERATIONS. EXAMINATION AND PREPARATION OF THE PATIENT

PATIENTS requiring surgical operative treatment may roughly be divided into two groups: I. Those in whom the operation is urgently required for some injury or disease which seriously imperils life. II. Those in whom the condition is less urgent, so that there is no immediate necessity for the operation.

In the first group, cases of acute intestinal obstruction for instance, the symptoms may be so grave that previous examination of the patient may be undesirable; any risk must be taken in the attempt to save life.

In the latter group undue haste is not only unnecessary but should be avoided; a careful examination and preparation of the patient should always be made before the operation. The preliminary examination will frequently enable the surgeon to decide upon the most desirable treatment, *i.e.* as to whether, in elderly patients, a palliative or a radical operation will give the best prospect of ultimate success; it will also aid the anæsthetist in the selection and the administration of the anæsthetic. The preliminary preparation, too, will usually play a very important part in determining the success of the operation.

In addition to an examination of the physical condition and the functional activity of the chief organs it is also necessary to take into consideration the age, sex, occupation, habits, and temperament of the patient, and to make inquiries as to the existence of any general constitutional or hereditary disorder.

Age. It was formerly thought that operations were not well borne in childhood and in old age. Though to a certain extent still true, modern methods and precautions have considerably diminished the risk of operations at the two extremes of life. Young children are said to stand hæmorrhage badly, but as Sir Frederick Treves has pointed out, if the relation of the amount of blood lost to the total amount in the body is considered, young children are probably not more seriously affected than adults. Post-operative shock is often excessive in infants and young children, and is a frequent cause of death after abdominal and other operations which necessitate the manipulation of the intestines or other important viscera. On the other hand, children often show a remarkable power of recuperation and may recover from an apparently desperate condition. Both these points are illustrated by the results obtained by the modern method of treating an intussusception by laparotomy (*q.v.*). Difficulties with children often arise from the restless character of the patients, which may make it almost impossible to keep the affected part at rest; displacement of dressings may also occur, which is likely to interfere with the healing of the wound. When the

incision is in the region of the groin the dressings may, in spite of the most careful nursing, get soiled, and then infection of the wound and serious suppuration may ensue. A point in favour of operations in children is that they are not adversely affected by prolonged rest in bed and show no tendency as the result of this to develop such complications as chest troubles or bed-sores.

In old age attention should be directed to the condition of the patient's organs and tissues rather than to the actual number of years. Some elderly people are quite good subjects for operation. Such, generally speaking, are spare, active and wiry; fat, flabby, plethoric old people are, on the other hand, usually bad subjects.

Like children, old people do not stand shock well; they also are seriously affected by loss of blood and do not show the recuperative powers of younger patients.

It must be remembered, too, that in old people confinement to bed may lead to congestion of the base of the lungs and hypostatic pneumonia a very fatal sequela in such patients.

Bed-sores may appear as the result of long-continued pressure on the ill-nourished skin over the bony prominences, and will not infrequently contribute to a fatal result.

No operation, however, for an acute condition, seriously threatening life, and capable of cure or relief by surgical interference, is contra-indicated solely on account of old age. If a skilled anæsthetist considers that a general anæsthetic is not desirable, either spinal anæsthesia or local anæsthesia may be employed.

The results of prostatectomy show what can be done by operative treatment in old men, who apart from their urinary trouble are often very feeble and whose organs are by no means healthy.

Sex. By some, women are regarded as better subjects for surgical operations than men. This, however, is the effect of temperament rather than sex, and the bearing of the former upon operative treatment will be discussed below.

When operating upon women it is always necessary to bear in mind the importance of any unsightly or disfiguring scar, especially upon any exposed part of the body. In a man a scar upon the face can often be completely concealed by the moustache or beard; in a woman such concealment is impossible.

It is thus necessary, when planning any such operation, to take care that the scar is in as inconspicuous a position as possible. This can frequently be accomplished by making the incision in the line of some natural fold or crease in the skin. Accurate apposition of the edges of the incision, early removal of stitches, and primary union of the wound are all of the greatest importance in securing a neat scar.

Unless urgently called for by some acute trouble, operations in the groin, perineum, or abdomen should not be carried out during menstruation. With regard to operations in other regions the wish of the patient should be considered. Many women prefer to have nothing done at this time, but should the patient make no objection no harm is likely to result. Operations are best avoided during pregnancy, especially during the later months. The danger here, of course, is that an abortion may follow. The chance of such an accident is however slight, and not infrequently it will be felt that the risk should be taken.

Operations for acute abdominal troubles, and the removal of ovarian

cysts, have frequently been undertaken in pregnant women without any mishap. What has been said about pregnancy also to a great extent applies to operations during lactation. This throws considerable strain on the system and renders it desirable to postpone any operation which is not urgently required.

Temperament. Before recommending any serious operation it is always well to have some knowledge of the patient's temperament and to observe his mental attitude towards the disease and the treatment. Such information may help one considerably in the choice of treatment, operative or otherwise; it will also frequently have a great influence upon the ultimate result. A placid and cheerful state of mind is an encouraging sign in a patient who has to face a serious operation. An apathetic fatalistic attitude, in which the patient does not care, or scarcely wishes to recover, is on the other hand of very bad omen. Considerable care must be exercised before recommending operations, unless they are very obviously indicated, in neurotic subjects.

A good example of this is seen in the symptoms which are associated with a movable kidney. These patients are very often neurotic, and in such, even though the kidney by the operation of nephropexy be firmly fixed in its normal position, the symptoms will probably continue. The same operation for similar symptoms in a patient of normal sensibility and placid temperament will probably result in their complete disappearance. Mental worry of any description is a serious disadvantage to any patient who requires operative treatment. Restlessness of mind will probably lead to bodily restlessness, and the two combined may have a very ill effect. Worry in men is generally due to business matters, and in women to their household affairs and their children. On this account, as well as for convenience of nursing and treatment generally, it is usually advisable not to operate in the patient's own home but to have them removed from familiar surroundings to a hospital or nursing institution. Under these circumstances visitors can be limited or if necessary totally forbidden, and the worries, which though often trivial are very real, can thus be kept from the patient; it is practically impossible to secure this freedom from mental irritation if the operation takes place in the patient's own home. In restless and neurotic patients, too, the new surroundings and unaccustomed faces are often of the very greatest benefit.

Habits. The success of an operation may be seriously affected by the patient's habits. Unfortunately these are often unrecognised before the operation, for the patient is naturally averse to give information, and if the suspicions of the surgeon are aroused the suggestion will probably be denied. That the vicious habit is indulged in is thus usually revealed by disturbances, either mental or physical, after the operation. The most frequent and important of these habits to be considered is alcoholism. An alcoholic is certainly a bad subject for at any rate major operations. This is true not only in the case of drunkards but also in that more numerous class of individuals who, though they would deny ever being intoxicated, are yet continually taking small doses and are unable to do without the drug. The dangers attending operations upon alcoholics are three in number: (*a*) there is the possibility of an attack of delirium tremens, or of some less serious mental disturbance; (*b*) the normal healing of the wound is likely to be interfered with; (*c*) there may be serious general complications.

Delirium tremens may appear for the first time in an alcoholic subject after an operation. It may occur in a chronic alcoholic patient as well as in an occasional or habitual drunkard. The actual cause is probably alteration in diet and mode of life, and enforced abstinence, rather than the actual operation. When operating on an alcoholic subject it is thus best not to deprive him completely of the drug, but to allow small regular doses of stimulant. Post-operative delirium tremens is always a serious and not infrequently a fatal complication.

The continued absorption of alcohol has undoubtedly a deleterious effect upon the tissues. The powers of repair are seriously affected, so that the healing of the wound, both superficially and in its deeper parts, may be impeded. The resistance of the tissues to bacterial infection is also diminished, and hence suppuration, cellulitis, and erysipelas occur much more readily and are overcome with greater difficulty than in a healthy patient.

Alcoholics are also liable, for much the same reasons, to a number of grave visceral troubles, such as pneumonia, dilatation of the heart, chronic nephritis, while gastric disturbances of more or less severity are also exceedingly common. These may appear after, or if already present are likely to be accentuated by, an operation. These troubles are often accompanied by delirium tremens. All these complications are especially likely to appear in hard drinkers after severe operations for serious acute injuries and diseases. It will thus be seen that a considerable mortality is to be expected after such operations on these patients. Alcoholics, too, will probably give much trouble to the anæsthetist. They may be expected to take large quantities of ether or chloroform, the stage of excitation is much prolonged, and it is difficult, and indeed in some cases almost impossible, to secure complete muscular relaxation.

What has been said of alcohol is to a great extent true of the subjects of other drug habits, such as morphia and cocaine. The sudden deprivation of the drug is likely to upset both the mental and physical functions of the body. On this account the patient should in all these cases be still allowed reduced quantities of the drug to which he is accustomed. Excessive smoking may lead to troubles in anæsthetising of a similar though less severe character to those seen in alcoholics. Such a patient may often with advantage be allowed to smoke occasionally a few days after the operation, provided of course that the disease or injury was not in the region of the mouth, respiratory passages, or other situation where the practice would be harmful.

We must now consider certain general constitutional conditions which have an important bearing upon operative treatment.

Obesity. This is of the greatest importance, for such patients are bad subjects for nearly all operations. This is due to a variety of causes. The excessive deposit of fat may be the result of continued excess in eating and drinking, which of itself is a serious matter. The excess of fat in the subcutaneous tissues may be associated with a fatty deposit in the mesentery and the omentum, while fatty liver and fatty infiltration or degeneration of the heart are also likely to be present. Such patients may be unable to breathe satisfactorily unless well propped up in bed, a position which their weight may render it difficult to maintain. The administration of the anæsthetic will, on account of the fatty viscera, be both difficult and dangerous. Their unwieldiness may make subsequent nursing and after-treatment very difficult. The skin itself is

often unhealthy, eczema may be actually present, or readily appear in natural folds or clefts such as the groin, the axilla, the umbilicus, or in women, beneath the breasts. Satisfactory cleansing of the skin is under these circumstances difficult or impossible, and the wound on this account is very liable to become infected. The thick layer of adipose tissue may impede the satisfactory exposure of deep parts, and also interferes with the exact closure of the wound; its blood-supply is poor and hence sloughing and cellulitis are likely to occur, especially if the margins of the skin incision have been much undermined. These facts help to explain the bad prognosis in cases of strangulated umbilical hernia, which nearly always occurs in excessively obese patients. The mortality after operations in these cases is very high, and is a great contrast to the results after operations for strangulated femoral and inguinal hernias, which are not usually associated with obesity.

The prognosis in malignant disease, *e.g.* of the breast, is worse in obese than in spare patients. The growth extends widely in the fat, and its limits cannot be recognised; the presence of the fat, too, obscures and renders difficult the recognition and complete removal of outlying nodules and of enlarged glands.

Hæmophilia is a contra-indication to any but an absolutely essential and necessary operation. It is a rare condition, and as nothing abnormal is usually noticed until the hæmorrhage occurs, the surgeon often does not suspect it until after the operation. Most serious and even fatal hæmorrhage may occur after the most trivial procedures, such as extraction of a tooth or incising an abscess. It must be remembered that though the tendency to excessive bleeding is usually noticed at a very early age, the child may reach the age of eight years or more before any abnormal liability to bleed is noticed. Should the patient live so long, the tendency to bleed diminishes towards middle age.

Status lymphaticus is a condition about which little is known, but which is of the greatest importance both to the surgeon and the anæsthetist. It is characterised by enlargement of the thymus, and a general increase of the lymphatic tissues of the body, which may be indicated by slight enlargement of the lymphatic glands, enlargement of the tonsils, the presence of adenoids and a palpable spleen. These patients are generally pale flabby children, frequently rickety, who in spite of an unhealthy appearance are usually thought to be quite well. The subjects of this disease are liable to die suddenly from some apparently very trivial cause; death may take place either during or shortly after the administration of an anæsthetic, or from shock after an operation, often for some comparatively slight trouble such as adenoids. Postmortem nothing to account for the sudden death is usually found, except the excess of lymphoid tissue. The exact way in which death is caused is this still a matter of doubt. The symptoms are so vague that status lymphaticus can scarcely be diagnosed though it may sometimes be suspected. Needless to say, under these circumstances the administration of an anæsthetic or any surgical operation must be undertaken with great caution.

Other general constitutional conditions such as **tuberculosis**, **syphilis**, **rheumatism**, and **gout** are not in themselves of great importance in relation to operative treatment. Their chief importance is that they may be the cause of serious visceral troubles, which will be discussed in detail later on. Of course no operation should be performed during an acute

attack of gout or rheumatism, or during the primary or secondary stages of syphilis, unless it were most urgently called for. Apart from this, and in the absence of visceral complications, there is no reason why such patients should not do well. Tuberculous patients who require surgical treatment stand even extensive operations remarkably well. Active phthisis is, however, a strong contra-indication to the operative treatment of co-existing surgical tuberculous disease, unless for the relief of some urgent symptom.

It is now necessary to consider the influence which lesions of the various viscera exercise upon the prognosis and the results of surgical operations. Very commonly when an operation is recommended the patient or his friends will ask "What is the risk?" or "Is the operation dangerous?" These are frequently difficult questions to answer. No operation is entirely free from risk, even in a young and robust individual with, as far as one can tell, perfectly healthy organs. Indeed, when a death does occur during anæsthesia, it is surprising how often the operation is of a comparatively trivial nature, such as removal of adenoids or circumcision, in an apparently healthy patient. Death is then often due to some unsuspected or undiagnosable trouble such as the status lymphaticus. The danger is naturally increased when the patient has some definite organic disease, for though he may survive the actual anæsthetic and operation, yet death may still occur after a longer or shorter interval from the additional strain thrown upon the diseased organ, or the vital powers may be so depressed that the patient dies from post-operative shock. It is thus of the greatest importance that some examination of the chief organs should be carried out before all except the most urgent operations. In the latter this examination may be reduced to a minimum, or even omitted altogether, for the disease or injury, a depressed fracture of the skull or a strangulated hernia for instance, may be such that unless quickly relieved death will surely and quickly occur. Under these circumstances any examination which will delay the operation must be avoided; any risk, however serious, has to be taken.

In young and healthy patients an elaborate investigation of all organs is not usually called for. The patient's general appearance is noted and he is questioned with reference to previous illnesses and his general health. It should, however, be an invariable rule before any operation, even of the most trifling description, if a general anæsthetic is required, that the condition of the heart and circulation should be ascertained by actual examination, and that the urine should be carefully tested, especially for the presence of sugar and albumen. Neglect of these precautions may result in a lamentable disaster.

The influence of visceral lesions upon the prognosis of operative treatment may be considered under the following two heads. (*a*) *As regards the immediate danger of the operation.* Here it is necessary to estimate the effect of the anæsthetic and the shock of the operation upon the diseased organ. We have already seen that even when serious visceral disease is known to exist, operation may be strongly indicated as the only possible means of saving the patient's life. The dangers of the anæsthetic may then be usually overcome with the help of a skilled anæsthetist, by the use of modern apparatus and methods, or by the employment of local or of spinal anæsthesia. These patients, however, may be unable to rally after the operation the diseased organ may fail, or some complication may develop which will lead to a fatal termination.

(*b*) *The effect of the lesion upon the ultimate result of the operation.* Even where no immediate danger is anticipated from the anæsthetic or the operation, the probable effect of the visceral trouble upon the ultimate result must be carefully considered. For instance, if an elderly patient is known to suffer from chronic Bright's disease, or from a serious valvular lesion of the heart, one would not recommend an operation for the radical cure of an uncomplicated hernia, for, apart from the immediate risks, the visceral disease is likely to prove fatal in the course of a few months or years. On the other hand, should such a patient have a strangulated hernia, one would unhesitatingly advise him to take the risk of the operation. In this case, while the immediate danger would not be excessive, the alternative to operation would be certain death from obstruction. The existence of visceral trouble will in many serious diseases lead the surgeon to advise palliative treatment in preference to a radical operation. These points have especially to be considered before advising extensive operations for the removal of malignant growths in elderly patients. The present writer some time ago removed an extensive growth from the floor of the mouth of a patient who had a trace of albumen in his urine. Though at the time of the operation this man appeared to be strong and in good health, yet he died only four months later of cardiac dilatation and failure secondary to the chronic renal disease.

Heart and Circulatory System. Preliminary examination of the heart and the circulatory system should be systematically carried out, chiefly on account of the danger of the anæsthetic and post-operative shock to a patient suffering from valvular disease or myocardial degeneration.[1]

In addition to an examination of the cardiac sounds, it is of the greatest importance to ascertain whether there is any hypertrophy or dilatation of the heart, and in the event of this to look for any signs of circulatory failure such as œdema, enlargement of the liver, or an unduly rapid or irregular pulse. Advanced valvular disease is an absolute contra-indication to any but the most indispensable operations. Fibroid or fatty degeneration of the myocardium is probably of at least as great importance as valvular disease and is far more difficult to detect. Before deciding upon an operation upon patients with these serious lesions, the risk of the operation and the ultimate benefit to be expected must be carefully considered. Such patients require careful anæsthetisation, but then usually take the anæsthetic well; indeed, the pulse of a patient with valvular disease frequently becomes slower and more regular when he is under the influence of an anæsthetic. During the administration the greatest care must be taken to avoid any obstruction to respiration, for a diseased heart is liable to fail with the extra stress thrown upon it by even a slight degree of asphyxia. The successful termination of the anæsthetic and the operation by no means ends the danger for such a patient, for after he has been returned to bed the pulse may gradually get weaker, and death may still occur after a longer or shorter interval from cardiac failure. The existence of cardiac disease has, as a rule, no adverse influence upon the wound, which may be expected to heal in a normal manner. In advanced cases of valvular disease, however, œdema may appear around the wound, and there then is an increased liability to infection. Quite apart from any gross lesion of the heart, the circulation

[1] Dr. Joseph C. Bloodgood (*Annals of Surgery*, 1912, vol. lv, p. 641) in a paper on "The Estimation of the Vital Resistance of the Patient with Reference to the Possibility of Recovery after Operations," insists also on the importance of measuring the blood pressure.

may be seriously depressed as the result of some chronic disease such as tuberculosis of a bone or joint with many sinuses, or from some serious acute trouble such as intestinal obstruction or peritonitis. In the latter, indeed, if for any reason delay has occurred, the pulse may be so rapid and small that it can scarcely be felt or counted; if in addition the extremities are cold, death may shortly be expected, and any operation is contra-indicated. When the circulation is less severely affected, the operation may be carried out under spinal or local anæsthesia, if a general anæsthetic is considered undesirable. Such patients often take a general anæsthetic surprisingly well, but only too frequently after the operation the pulse again fails, the heart does not respond to stimulation or infusion, and the patient dies. In addition to the condition of the heart, attention should also be directed to the character of the arteries. Extensive atheroma means that the tissues are degenerate, and that their nutrition is imperfectly carried out. A thickened arterial wall or a high tension pulse may direct the attention of the surgeon to arterio-sclerosis or to chronic renal disease.

If there is any disease of the heart or of the circulatory system, and the operation, though desirable, is not urgently necessary, the operation may often with advantage be postponed for some days or weeks, during which time the cardiac lesion is treated.

While the operation is in progress the surgeon should always observe the amount of bleeding and the colour of the blood. In this way important indications of depression of the circulation will often be brought to his notice. In severe cases of cardiac failure an extensive incision may be made with practically no hæmorrhage, and the few drops of blood which escape will be distinctly bluish in colour. These are indications for immediate attention to the condition of the patient.

Respiratory System. A patient with any recent acute lung or pleural disease is naturally a bad subject for an anæsthetic or an operation. Occasionally, however, operation may be the only possible method of treatment of some complication, an empyema for instance. Under such circumstances the operation, or rather the anæsthetic, may be accompanied by considerable risk. Speaking of these cases, Sir Frederick Hewitt [1] says: "The most hazardous cases are those in which respiratory embarrassment from recent pleurisy or pleuro-pneumonia co-exists with quick and hampered cardiac action. When the patient is slightly dusky, his temperature elevated, his breathing rapid and his pulse accelerated and sharp under the finger, the use of an anæsthetic is attended by considerable risk. This risk is greater in patients with previously fatty and dilated hearts than in others." Means for minimising this risk will be considered when the operation for empyema is described, but in very serious cases a local anæsthetic may be employed. Patients with slight chronic bronchitis, phthisis or emphysema may be expected to take an anæsthetic and to stand an operation well, provided that the heart is not secondarily affected. Obese patients with bronchitis are very bad subjects. They may be unable to breathe in the recumbent position; the pulmonary trouble may be increased by the anæsthetic and lead to failure of the heart, which is probably already weakened by fatty infiltration and degeneration. A bronchitic patient presents other difficulties to the surgeon. The continual coughing will make the patient restless and, especially after abdominal operations, will throw great strain

[1] *Anæsthetics*, 1901, p. 127.

upon the stitches. Bandages around the chest or the abdomen if tight produce much dyspnœa and discomfort, while if loose they are very liable to slip and the dressings to become displaced. An anæsthetic, especially ether, may sometimes apparently be the cause of an acute attack of bronchitis or pneumonia. The latter may be a broncho-pneumonia when it is probably due to imperfect expectoration of catarrhal secretion, or a lobar pneumonia when the inhalation may be the predisposing cause. In rare cases an anæsthetic may render active a latent tuberculous disease. In elderly patients prolonged rest in bed may lead to congestion of the bases of the lungs, a condition which is likely to develop into hypostatic pneumonia. This is a very fatal post-operative complication in such patients, and is best avoided by getting them up as soon as possible.

The condition of the upper respiratory passages should always be noted, for any obstruction to the free flow of air is pretty certain, owing to venous engorgement, to be increased during anæsthesia. When the field of operation is the buccal or pharyngeal cavity, the removal of a malignant growth of the tongue, floor of the mouth, or the pharynx, for example, blood may be drawn into the larynx and seriously obstruct breathing. Even when it causes no actual obstruction, portions of clot may be inhaled and thus be the starting-point of a septic broncho-pneumonia—a serious danger after these operations. In such cases intratracheal insufflation of ether [1] is the most satisfactory method of maintaining anæsthesia, and is most efficient in preventing the entrance of blood into the respiratory passages. Plugging the pharynx with sterilised gauze after a preliminary laryngotomy, or Crile's method of inducing anæsthesia by means of nasal tubes with subsequent packing of the pharynx may also be employed.

Tumours of the neck, especially an enlarged thyroid, may be a considerable source of danger during anæsthesia. This to a great extent is mechanical, and is the result of asphyxia brought about by the pressure of the tumour, which is increased in size by vascular engorgement, upon the trachea. These dangers and the means by which they may be overcome will be fully considered when the operative treatment of goitre is discussed.

Urinary System. An examination of the urine should be made as a routine measure before every surgical operation. Should albumen be present every endeavour should be made to ascertain its origin and its significance. If necessary the centrifugalised deposit should be examined microscopically for the presence of casts, for if the albumen is the result of any form of nephritis it must have a most important bearing upon the prognosis and the treatment. Patients suffering from Bright's disease are certainly bad subjects for operation. They may be unable to rally from the shock of a severe operation, owing probably to the imperfect excretion of toxic products. In other cases definite symptoms of uræmia may supervene or even suppression of urine, either of which is practically certain to terminate fatally. These serious complications are especially likely to occur when the operation is for some injury or disease of the pelvic or renal organs. It must also be remembered that patients with chronic nephritis are very liable to a number of serious complications. Of these cardiac dilation and hypertrophy which may terminate in heart failure is the most important. Other complications, such as bronchitis, pleurisy, pneumonia, pericarditis, and peritonitis,

[1] *See* p. 781.

are of a chronic inflammatory nature. Any of these may readily appear as the result of the extra strain of an operation upon the system. If already present they will certainly be made worse, and in either case the patient is very likely to succumb. Lastly, as the result of changes in the vascular system and the deficient excretion of toxic products, various cutaneous lesions, such as eczema, boils, carbuncles, and even erysipelas, may already be present or are likely to develop. These, in addition to a greatly increased liability to wound infection, may seriously and adversely affect the progress of the patient. The mere presence of albumen is, of course, in itself not a contra-indication to operation; in women it may be the result of a vaginal discharge, while in men it may be derived from some lesion in the urethra or the bladder. An explanation of the albuminuria should, however, in all cases be sought for. Even when chronic nephritis is known to exist, operations are not necessarily contra-indicated; such patients may do well even after severe operations. What is needed is a careful consideration and estimation of the risks to be run and the benefits to be expected. The latter will often be found to altogether outweigh the former. If possible in such a case a period of rest and treatment of the nephritis and its complications should precede the surgical treatment.

Should the operation be required for some disease of the kidneys or other portion of the genito-urinary tract, it is most necessary to ascertain the source of any albuminuria, hæmaturia, or pyuria, and to investigate the excretory functions of the kidneys. Fortunately the modern methods of radiography, cystoscopy, and catheterisation of the ureters, with examination of the urine secreted by each kidney, are of the greatest service in enabling one to estimate the functional condition of these organs.

We may here consider the question of operations upon patients who are suffering from diabetes. Such patients are very bad subjects for operative treatment, and this disease should contra-indicate any except absolutely necessary operations. The dangers may be considered in the three following groups.

(*a*) *There is a distinct danger that the patient may die of diabetic coma.* This condition usually develops as the result of mental or physical shock in the subjects of this disease. An anæsthetic or an operation is thus very likely to be the exciting cause. The liability to coma is much diminished if the disease is being treated and the amount of sugar lost is under control. Especially dangerous are those cases in which the disease is unrecognised and untreated, when death may unexpectedly follow a comparatively trivial operation. For instance, the writer knows of the case of a young man aged 20 who was operated upon for a varicocele. Next day the patient became comatose, and the urine, then tested for the first time, was found to contain large quantities of sugar.

(*b*) *The tissues of a diabetic patient are unduly liable to infection by pyogenic organisms.* The wound is thus liable to slough, suppurate, or to become the starting-point of a spreading cellulitis which is very difficult to treat. Gangrene, usually moist in character, may occur in diabetics, either spontaneously or after operation. In either case arterial degeneration and peripheral neuritis, which commonly co-exist, are probably predisposing causes. The gangrene usually occurs in elderly patients, is commonly moist in character, spreads rapidly, and almost always ends fatally.

(c) *Certain complications are likely to occur in diabetic patients* which will assuredly have a serious bearing upon the prognosis. In addition to the septic troubles mentioned above, the skin may be the seat of various lesions such as eczema, boils, or even carbuncles. Lastly it must be remembered that a diabetic is very liable to contract tuberculous disease of the lungs. It is always desirable in diabetic patients to postpone, if possible, any operation until treatment by dieting and by drugs has produced a considerable decrease in the excretion of sugar. The dangers of the operation will in this way be greatly diminished. Should the condition be regarded as glycosuria rather than as diabetes, that is when there is but a small amount of sugar and no polyuria, the actual operation risk is not serious. It must, however, be remembered that a persistent glycosuria is a grave condition and that such cases may eventually develop into true diabetes.

Alimentary System. Diseases of the digestive tract will naturally have a considerable effect upon the general health and condition of the patient. The subjects of chronic dyspepsia, and those suffering from chronic constipation, are not likely to be in a satisfactory state for a severe operation, and it must be remembered that these troubles are certain to be increased by the subsequent rest in bed. Operations should be avoided, if possible, in patients with serious organic disease of the liver such as cirrhosis, lardaceous or fatty disease. Colitis, dysentery, and other chronic intestinal disorders are also contra-indications to general operations, though in these and other similar conditions surgical treatment may be required, and successfully carried out, for the intestinal disease itself. The condition of the mouth and teeth should always be observed, and if septic or carious teeth are present they should, if time permits, be attended to before the operation. This is especially desirable if the operation is for some disease in the mouth or pharynx. Apart from its effect upon digestion and the general health, oral sepsis means that the patient has a septic focus from which organisms may be carried by the blood-stream to the wound, or indeed to any part of the body.

Nervous System. The influence of functional disease of the nervous system has been indicated while the question of temperament was under discussion. An hysterical patient is very liable to nervous attacks either before or after the operation; in the latter case these are likely seriously to interfere with the after-treatment. Necessary operative measures may be carried out in the insane with a good prospect of success, provided that there is no marked bodily disease and that there are no unclean or mischievous habits which would seriously imperil a satisfactory result. When, however, the patient is violent or maniacal, an operation has but a faint prospect of success. When there is a definite organic nervous trouble, such as locomotor ataxy for instance, none but essential operations should be carried out. These diseases may, however, run a very chronic course, and the patients often do well in spite of the disease of the nervous system. When grave symptoms are caused by some lesion of the nervous system which is amenable to surgical treatment, an operation may be successful even when the condition of the patient appears to be most desperate. He may be absolutely comatose as the result of increased intra-cranial pressure after a depressed fracture, hæmorrhage from the middle meningeal artery, or from a cerebral abscess, and yet recover after these conditions have been relieved.

PREPARATION OF THE PATIENT FOR THE OPERATION

General Preparation. It is now necessary to consider in some detail the preliminary treatment and the general preparation. It is advisable in all cases that the patient should be under observation in the hospital ward, nursing home, or wherever the treatment is to be carried out, for at least twenty-four hours beforehand. Of course in grave surgical emergencies, time is of such importance that the operation must be performed as soon as possible, at the expense of or even to the total exclusion of all these precautions. In many cases a longer period than twenty-four hours is desirable, and, as has already been indicated, when there is any adverse local or constitutional trouble ample time should if possible be allowed for its satisfactory treatment.

Immediately upon admission to the institution the patient should have a hot bath and thoroughly wash the whole body. Should the local or constitutional condition render this undesirable, he is at once put to bed and then thoroughly washed by a nurse. This will be repeated daily through the whole period of preliminary observation. During this time the condition of the teeth and mouth should also always receive attention, especially if the operation is for some disease of the upper respiratory passages. When tartar is present, or when there are septic or carious teeth or roots, it is desirable that these should receive attention before the operation. When these troubles are not present, the use of the tooth-brush, and the occasional use of some antiseptic mouth-wash such as chinosol 1 in 1000, are all that are required. Any other focus of infection such as tonsillitis, nasal catarrh, boils or other cutaneous lesions, especially if in or near the field of operation, should also receive careful attention. The bowels should be emptied by a purgative administered on the preceding day, followed by a saline aperient or soap and water enema six hours before the operation. Should the operation be for some disease of the rectum or other part of the intestinal tract, it is most desirable that the bowel shall be empty. In the former case, an operation for piles for example, a copious enema should be administered about eight hours before the operation. On the other hand the purging must not be overdone, for it is naturally a bad thing for the operation to take place while the patient has an attack of diarrhœa from this cause. Excessive purgation, too, is likely to have a serious effect in elderly patients, or in those suffering from an exhausting disease.

It is desirable that for some days beforehand only light and easily digestible food should be taken. The stomach should always be empty during the administration of an anæsthetic, and hence the time of the meal immediately preceding will depend upon the hour at which the operation will take place: it is generally agreed that the best time is the morning at an early hour. In this case a healthy adult will have had nothing after his evening meal the preceding day, with perhaps the exception of a cup of weak tea two or three hours before.

If, however, the patient's general condition is weak, or in old people, such long starvation is undesirable. These may be allowed small occasional feeds of clear soup or chicken broth throughout the night. In some cases where there is much exhaustion a little alcohol in the form of weak brandy or whisky and water may also be allowed. If the operation is to take place at any other hour of the day the last meal should, as

a general rule, be given about five hours before the commencement of the anæsthesia.

The bladder should always be emptied before the patient is brought into the operating room. Should there be any question as to this having been satisfactorily accomplished, a catheter should be passed, especially before abdominal or pelvic operations. The patient should be suitably clothed in a clean night-gown or pyjama suit; the former is usually to be preferred, and should be made to completely unbutton at the back so that it may be readily adjusted or removed as required during the operation. In weak and exhausted patients, and especially in elderly people and children, additional warmth may be secured by loosely bandaging the limbs and any part of the body which need not be exposed, over a thin covering of cotton-wool or gamgee tissue. Any false teeth must be removed before the commencement of the anæsthetic.

Asepsis. It is now necessary to consider a most important series of preparations and precautions, the object of which is to prevent infection of the wound. In other words we have to describe the means for securing Asepsis. A short sketch is all that can here be given; for fuller details the reader is referred to some such book as Lockwood's *Aseptic Surgery* (1909), from which many of the facts described below are taken.

The importance of asepsis is now universally admitted. If any wound suppurates, even to the slightest extent, it means that infection has somehow occurred; in the great majority of cases this is brought about by some failure in the aseptic precautions of the surgeon or his assistants. The universal presence of pathogenic organisms which are the cause of inflammation, suppuration, and serious complications such as pyæmia and septicæmia, has been amply proved. Any object, be it a ligature, an instrument, the hand of the surgeon or the skin of the patient, must be regarded as septic and liable to infect a wound, unless it has been specially prepared to ensure the destruction of all organisms which may be present. Infection of a wound may be brought about in any of the following ways.

(1) *Air Infection.* Though the air may contain large numbers of micro-organisms,[1] both pathogenic and non-pathogenic, this source of infection is not of great importance provided that certain precautions are taken. When the air is dry and contains much dust, many organisms will be present; if the air is perfectly still the dust and bacteria gravitate, with the result that the air does not infect culture-plates. Also when the air is saturated with moisture it is practically sterile.

Organisms are with difficulty detached from a moist surface; dust must therefore be both carefully and thoroughly removed from the operating room. Expired air, in ordinary quiet breathing, is stated to be practically free from organisms. When, however, as happens in coughing, sneezing, or talking, small particles of saliva or nasal mucus are projected, various pathogenic organisms are certain to be present. Streptococci, for instance, are always found in saliva. Particles of dust from the hair are naturally septic and can readily infect a wound. It is thus very necessary that the surgeon and his assistants should take precautions to

[1] Mr. Lockwood quotes experiments in which sterilised culture-plates were exposed for a few minutes in hospital wards and operating theatres. Among the organisms found were the Bacillus coli, Staphylococcus pyogenes aureus and albus, as well as many non-pathogenic moulds and sarcinæ. Streptococcus pyogenes was found in the air of the erysipelas ward, while the tubercle bacillus was very commonly present in the air of wards occupied by phthisical patients.

prevent this accident, which is exceedingly likely to happen on bending over a wound, especially if two heads should come into contact. It may here be mentioned that flies and other insects may be the means of conveying septic organisms and so infecting a wound.

(2) *Skin Infection.* Infection of the wound by organisms which are found either upon the surface or in the deeper layers of the skin is undoubtedly a very common cause of suppuration after operations. The wound may be infected from the skin of the patient or from the hands of the surgeon or of any of his assistants.

The surface of the human skin swarms with various cocci, bacteria, and other organisms both pathogenic and non-pathogenic, even in a cleanly individual; this is especially the case when there is any hair present to collect and retain particles of dust. When the skin is obviously dirty, or when any disease such as eczema is present, their variety and number are greatly increased. Organisms are certain, too, to be present in large numbers in any natural folds, wrinkles, or depressions, such as the axillæ, the groin, or the umbilicus. Such localities always require careful attention, and even then, owing to the numerous sweat and sebaceous glands and a liability to dermatitis, are very difficult to render surgically clean. With regard to the hands of the surgeon, the grooves beneath the nails, and any loose tags of skin, are certain to contain and shelter many infective organisms. Needless to say, rough, cracked, or chapped hands, or the presence of any septic lesion, mean many organisms which it will be difficult or impossible to destroy even by the most careful cleansing process. It is necessary to bear in mind that numerous cocci and bacteria always exist in the deeper layers of the skin. This is largely owing to the presence of the sebaceous and the sweat glands. If the surface of the skin is carefully cleansed, and perspiration subsequently occurs, these septic organisms are brought to the surface in large numbers by the secretion; their presence may also be proved if, after the skin has been prepared, material is squeezed from the sebaceous glands.

The fatty nature of the secretion also to a great extent protects the organisms and thus hinders their destruction by watery antiseptic solutions which do not dissolve fatty substances.

(3) *Infection by Instruments.* Unless careful precautions are taken, a clean wound may be easily infected by the use of instruments which have previously been employed for a septic case. Blood, pus, or other septic material may readily lodge in the serrations or joints of such instruments as forceps or scissors. Instruments are now made as far as possible entirely of metal, with only necessary grooves and ridges, in order to facilitate cleaning. After use, all blood or discharge must be removed by careful washing and brushing; many such instruments as forceps and scissors are constructed with detachable joints which allow the two halves of the instrument to be separated during the cleansing process. If not properly cleaned, even boiling may fail to effect perfect sterilisation, for the albumen of the blood will be coagulated and will thus form an envelope which is likely to protect organisms and especially spores from the action of antiseptic lotions, or even for some time from the action of boiling water.

(4) *Infection by Towels, Swabs, and Dressings.* Unless all these articles are freshly and effectively sterilised before the operation they may easily infect the wound. Towels, for instance, though fresh from the laundry and apparently quite clean, are in reality extremely septic,

partly owing to contamination by dust, but also by the water in which they were washed, probably in company with many other soiled and dirty articles. Dry gauzes and wools, even though impregnated with antiseptics, will also collect dust and thus harbour many organisms. Unless recently sterilised, gauzes should only be applied to the wound after immersion in an antiseptic lotion. Marine sponges are now practically obsolete, for, owing to their porous structure, when they have once been used their subsequent sterilisation is a matter of considerable difficulty and uncertainty. Their place is taken by swabs of absorbent material such as gamgee tissue enclosed in layers of gauze.

(5) *Infection by Sutures and Ligatures.* All materials used for ligatures and sutures are certain to be contaminated until they have been carefully sterilised. This is especially the case with catgut, which is prepared from the intestines of sheep after the mucous membrane has been more or less thoroughly removed by scraping. Raw catgut, from its origin and mode of preparation, is thus certain to contain numerous pathogenic organisms, and unless effectively sterilised is extremely likely to infect the wound. It is said that even anthrax has been transmitted to a wound by imperfectly sterilised catgut.

This material has, however, many advantages in favour of its use for buried sutures: it is strong, pliable, easy to manipulate, and is eventually absorbed and is hence very generally employed. Fortunately, though it cannot be sterilised by boiling in water, there are other very effective methods of sterilisation which render it quite safe and reliable.

(6) *Infection by Water.* There is less danger of infection from water than might have been supposed, for though ordinary tap water may contain many bacteria, cocci and other organisms are chiefly saprophytes, and hence do not grow in living tissues. Septic organisms such as the Bacillus coli and various forms of streptococci and staphylococci may, however be found, but in good tap water, such as is supplied in London, these organisms, if present, occur only in very small numbers. The water may, however, be contaminated by dirty taps or by contact with improperly prepared vessels. In the operating theatres of Guy's Hospital the water, both hot and cold, which is used for preparing lotions and saline solutions for irrigation and other purposes, is filtered through Berkefeld filters.

This water is regularly examined bacteriologically, and organisms of any description are only found on rare occasions. Cleansing or renewing the internal mechanism of the filter then results in their disappearance. If tap water is boiled for a few minutes, or if antiseptics in the proportion required for making the ordinary lotions are added, all organisms are quickly destroyed. Boiled tap water may thus be quite safely used for the preparation of lotions, or of saline solutions for infusion or irrigation. Indeed, for the former purpose boiled tap water is preferable to distilled water, which usually contains many organisms and may on this account be decidedly toxic.

(7) *Auto-inoculation.* Infection of the wound by organisms conveyed by the patient's own blood-stream may certainly occur. It is, however, unlikely, and though its frequency cannot be ascertained, it is probably a very rare cause of suppuration compared with local infection of the wound. This is shown by the rarity of suppuration after an injury which does not wound the skin—a simple fracture for instance. When it does occur there is nearly always some obvious local septic focus such as pyorrhœa alveolaris, a septic throat, or some septic ulcer or sinus.

On this account it is highly desirable that any such trouble should be recognised and efficiently treated before the operation.

It will now be necessary to consider the precautions which must be taken to guard against infection. Sterilisation may be effected either by the action of heat or by the use of chemical antiseptics. The former is the more effective method but cannot always be employed. The skin and other living tissues, for instance, can only be cleansed by the mechanical processes of washing and irrigation, and by the use of antiseptics. It must be remembered that strong antiseptic lotions may have a very serious effect upon living tissues, the vitality of which is probably already lowered by injury or disease. The skin may be irritated, or even a severe dermatitis may be produced; delicate tissues may slough or have their vitality so depressed that their power of resistance to infecting organisms is greatly diminished.

A. **Preparation of the Skin of the Patient.** Two methods must be described. (1) *By antiseptic compresses.* This method is now but seldom employed. After careful shaving for some distance around the proposed incision, the surgeon, having first carefully cleaned his own hands, then thoroughly scrubs the skin with a sterilised nail-brush and hot soap and water to which a little dilute liquor potassæ has been added. The process is then repeated with an antiseptic lotion such as lysol 1 per cent, or carbolic lotion 1 in 40. A compress, consisting of several layers of lint, which after sterilisation by boiling is soaked in the same antiseptic solution, is then applied. This is covered with a layer of gutta-percha tissue and is then bandaged in position. The compress remains in position for twelve or twenty-four hours, or even longer before the operation. In the latter case it is usually changed and a fresh compress similarly prepared applied every twelve hours. Unfortunately this treatment not infrequently defeats its own object. The mechanical effect of the brush combined with the irritant action of the antiseptic may produce severe irritation of the skin or even an acute dermatitis. When this occurs, infecting organisms are certain to be present and the operation must be postponed until the skin has recovered. It is now recognised that all irritation of the skin is harmful and that thorough washing with soap and hot water is the most effective and least irritating means of cleansing the skin. This will not destroy the organisms in the deeper layers, though the mechanical effect of the washing will, to a considerable extent, remove the secretion of the glands. Alcoholic solutions of antiseptics, such as biniodide of mercury 1 in 1000, have however a powerful action in destroying these cutaneous organisms, pr because the alcohol dissolves fatty substances and thus secures grea etration of the solution.

(2) *The Iodine Method.* Within the past few years it has also been recognised that an alcoholic solution of iodine has remarkable powers of destroying the cutaneous organisms. The strength of the solution should be between 2 per cent. and 5 per cent. The tincture of iodine (B.P.) contains $2\frac{1}{2}$ per cent. iodine and answers admirably. A solution of iodine in methylated spirit should not be used, since the iodine readily evaporates from this and causes intense irritation of the eyes of those present in the room. A most important point to remember when iodine is used, is that for its efficient action the skin must be dry. This has led some surgeons to dispense with preliminary shaving of the skin. Hair is, however, of such importance in collecting dust that shaving is

certainly desirable. It may be carried out by means of a sharp dry razor without wetting the skin, or if the razor is used after washing and lathering, the skin should be thoroughly dried with a sterilised swab and then treated with alcohol or ether before the application of the iodine solution. The sterility of the skin may be tested by examining bacteriologically a thin snip through its entire thickness from the margin of the operation incision. In one series of thirty-five consecutive cases, in which tincture of iodine was the only antiseptic used, only three on cultivation showed the presence of any organisms, and in each of these the Staphylococcus albus was found.[1]

The exact details of this mode of skin preparation naturally vary somewhat in different hospitals and with different surgeons. It is, however, generally agreed that it should, whenever possible, be carried out before the patient is removed to the operating room. By this means much mess and unnecessary loss of time may be avoided. The entire preparation, however, may in an urgent case be carried out with advantage in the operating room.

If the former method is decided upon, the surgeon, after carefully washing and preparing his own hands, shaves the skin of the patient for an area considerably beyond the limits of the proposed incision: should this be in the groin or the abdomen the pubes should always be completely shaved; it is not sufficient to remove the hair from the side of the incision only. The shaved area is then thoroughly washed with soap and hot water for at least five minutes. A boiled nail-brush should be used, but not too vigorously, and the dirty soap and water must be frequently washed away. Soft soap may be used, but ether soap or a solution of soap in spirit is preferable.[2] The skin is dried as thoroughly as possible with a sterilised swab and then washed over with ether. When this has evaporated, tincture of iodine is freely applied to the whole prepared area. Special care is directed to the umbilicus or to any skin fold such as the axilla or the groin. The prepared area is then covered with a sterilised pad or towel, which is secured in position by a bandage. The patient is now ready to be transferred to the anæsthetising room. Before the commencement of the operation the pad is removed and a final application of tincture is made.[3]

When in urgent cases the entire preparation is carried out in the operating theatre, this procedure must be modified. In a cleanly patient the skin may be shaved with a sharp dry razor, and then, after washing with ether, the iodine solution is applied. If the skin is devoid of hair the shaving may be omitted; if it is obviously dirty it must be first scrubbed with ether soap and hot water, then thoroughly dried with a sterilised pad, and finally, after treatment with ether or alcohol, is painted over with the iodine solution. When septic ulcers, sinuses, fistulæ, or granulating surfaces are present, it is impossible to sterilise them or the adjacent skin. The use of a nail-brush under these circumstances is liable to be actually harmful, as by this means infective material may

[1] See *Lancet*, 1911, vol. I, p. 733.

[2] A solution of two parts of soft soap in one of methylated spirit may be used. Ether soap (B.P.C.) has the following composition: oleic acid, ʒvij; potassium hydroxide, saturated solution, a sufficient quantity; alcohol, ʒiij; oil of lavender, ♏xx; methylated ether to ʒxx.

[3] A 1 per cent. solution of picric acid in rectified or methylated spirit has also been strongly recommended for sterilising the skin. It is applied in the same way as the tincture of iodine. This solution is much cheaper and is said to penetrate much more readily to the deeper layers of the epidermis than the iodine solution.

be rubbed into and thus infect the skin. Septic sinuses and fistulæ may be plugged with gauze, but should if possible be covered by sterilised towels or pads during the operation. Masses of granulation tissue or fungating growth may sometimes with advantage be sterilised by the use of the actual cautery.

B. **Preparation of the Operating Room.** In every properly equipped hospital or nursing institution one or more rooms are specially constructed and set apart for the performance of operations. A modern operating theatre need not be described here in detail. It should, however, be a large, well-ventilated room which can be quickly heated. The floor should be of some material such as mosaic or concrete—not of wood—which is free from cracks and joints and can readily be cleaned. The walls and ceiling should be tiled, or made of some smooth material which will not collect dust and can easily be washed. All corners and angles should be rounded, and there should be no ledges, cracks, or crevices in which dust can collect. Needless to say there must be no unnecessary furniture, only the operating table, smaller tables for instruments, dressings, and anæsthetic apparatus, and if desired, stools for the operator and the anæsthetist. These should all be constructed as simply as possible of metal and glass and should be kept scrupulously clean.

It will sometimes be impossible to move the patient, and the surgeon will then have to operate in a room in a private house. In this event all unnecessary articles of furniture, as well as all pictures, curtains, carpets, and rugs, should be removed from the room most suitable for this purpose It is desirable that these preparations should be carried out on the preceding day, so as to allow time for thorough dusting of the room and scrubbing the floor. Immovable articles of furniture should be covered over with sheets which have been sprinkled with carbolic lotion. Most modern operating rooms are provided with a small adjoining room in which the patient is anæsthetised, and another in which the surgeon and his assistants prepare for the operation. No one thus enters the operating room until he is fully prepared and is wearing a sterilised overall, cap, and mask.

C. **Preparation of the Surgeon and his Assistants.** The hands of the surgeon and his assistants are undoubtedly a very likely source of wound infection. Their preparation thus demands the greatest care. At the present day thin rubber gloves, which can be sterilised by boiling, are almost invariably worn. This, however, does not render careful preparation of the hands any the less necessary. During the operation the glove may be pricked or torn ; septic fluid will then exude through the puncture and infect the wound unless the hands have been thoroughly sterilised. Exactly the same precautions must be taken by all assistants, otherwise instruments, sutures, or dressings may be infected by contact with their septic hands. If the surgeon has any suppurating or infective lesion on the hand or fingers he ought not to operate, for it is impossible to sterilise such an area which is thus a source of great danger. The nails should be cut as short as possible to facilitate cleansing of the underlying groove. The skin of the hands must be kept smooth, for any roughness, from the repeated use of lotions or other cause, means innumerable minute cracks and depressions in which organisms may collect, and which render sterilisation a matter of great difficulty or even impossibility. The hands should be cleaned by thoroughly scrubbing them with a boiled nail-brush and hot soap and water for at least five minutes. The water must be as

hot as possible and should flow as a continuous stream or spray. If a basin is used for washing, the water should be changed several times during the cleansing process. The hands may then be rinsed in weak lysol and finally are immersed in an alcoholic solution of biniodide of mercury (1 in 1000). The gloves, which have been rendered sterile by boiling for five minutes, are now put on. The surgeon then takes an overall, a cap and a mask, all of which have been previously sterilised. The case containing these is opened by a nurse, and care is taken that neither the overall nor the surgeon's hands touch the edge of this receptacle. The overall should be of sufficient length to reach to the ankles, and it should be provided with sleeves which are not too loose and can be buttoned at the wrist. The cuff of the glove should be turned up over the sleeve of the overall so that no part of the forearm or wrist is left exposed. Short-sleeved overalls should not be worn, as they leave a considerable area of forearm uncovered which is probably imperfectly sterilised and is certain to come into contact with towels or instruments. The cap, which ought to completely cover the hair and fit fairly tightly to the head, may be placed on the head by an assistant. The mask, which consists of several layers of gauze, should cover both the nose and the mouth, and if the surgeon wears a moustache or beard these also. It is desirable that clean rubber overshoes should be worn over boots while in the operating theatre. Otherwise mud and dirt from the streets, which is swarming with organisms and can easily be disseminated as dust, will certainly be brought into the theatre.

D. **Sterilisation of Instruments.** Instruments should be sterilised by boiling them in a metal steriliser for at least five minutes, care being taken that the instruments are completely immersed. A teaspoonful of ordinary washing soda may with advantage be added to each pint of water. This slightly raises the boiling-point and also prevents the instruments rusting. Most sterilisers are provided with a perforated tray which may be removed and the instruments tipped into a sterilised dish containing carbolic lotion (1 in 20), lysol 2 per cent., or boiled water, according to the wish of the operator.

If there is no perforated tray, the instruments should be removed one by one with a pair of boiled forceps. Before the operation the instruments may be arranged upon a sterilised towel spread out upon and completely covering a small glass table set apart for this purpose. Cutting instruments are liable to be blunted by this treatment. If boiled they should be wrapped in gauze to prevent contact with other instruments, or they may be effectively sterilised by leaving them in carbolic lotion (1 in 20) for fifteen to thirty minutes, or in absolute alcohol for about the same time. Though instruments should not be needlessly prepared, all that are required or are likely to be required should be sterilised before the commencement of the operation: if any instrument is unexpectedly required the process of sterilisation is apt to be hurried and hence imperfect. After the operation the instruments must be carefully washed and scrubbed to remove all traces of blood and discharge. They are then boiled and dried before being put away.

E. **Sterilisation of Sutures and Ligatures.** Many materials have been employed for sutures and ligatures. Those in common use at the present day are silkworm gut and horsehair for the skin, and celluloid thread, silk, and catgut for uniting deeper structures. Michel's metal clips are also frequently used for bringing the divided edges of the

skin into apposition. Silver wire, though occasionally used for suturing bone, is but seldom used for approximating soft parts. All the above with the exception of catgut can be sterilised by boiling; silk, however, requires special precautions. Short lengths should be unwound from the wooden reels on which it is supplied and rewound on small glass reels or rods, taking care that the threads are nowhere more than two or three deep. These are boiled for twenty to thirty minutes immediately before the operation and are then transferred to a sterilised vessel containing 1 in 20 carbolic or other antiseptic lotion.

The sterilisation of catgut is a matter of much greater difficulty. This material is made from the intestines of sheep, and though the mucous membrane is supposed to have been scraped away this is by no means perfectly carried out. Raw catgut is thus certain to contain many organisms, and unless effectively sterilised is very likely to infect wounds in which it is used. It is destroyed by boiling in water, and hence other more complicated and lengthy means have to be employed. Catgut has the great advantage that it is eventually absorbed; it is also strong, pliant, and easy to manipulate. Thus, in spite of difficulties in sterilisation, it is a favourite material for deep or buried sutures. Most instrument makers supply catgut already sterilised in sealed tubes. If supplied by a good firm these are thoroughly reliable. The tubes should be hermetically closed; any information as to the size of the contained threads or the mode of preparation should be etched upon the glass; there should be no paper labels either within or outside. Before breaking open the tubes their outer surface should be sterilised by prolonged immersion in an antiseptic lotion. Many methods have been suggested for the sterilisation of catgut. Most of these are complicated, and the result is often uncertain. The following are simple and effective. In all cases the raw material should first be thoroughly washed in water, and then soaked in ether for twelve hours to remove all grease. Mayo Robson recommends that catgut should be sterilised by placing the washed strands in a strong metal vessel provided with a screw top containing xylol. This is immersed in boiling water for half an hour, at the expiration of which the catgut is transferred to a 5 per cent. solution of carbolic acid in alcohol.

Moynihan recommends that the catgut, which has been previously cleaned and wound on glass reels, should be boiled for twenty minutes in a saturated solution of ammonium sulphate, the boiling-point of which is 128° C. It is subsequently washed in boiled water to remove excess of the salt, and is then placed in a solution of iodoform 1 part, ether 6 parts, in absolute alcohol 14 parts. By either of these means catgut may be raised to a temperature of 100° C. or above without being destroyed. Another simple and effective mode of preparing catgut is by prolonged immersion in a solution of iodine; either of the following may be employed. (1) Iodine 1 ounce, potassium iodide 1 ounce, water 5 pints. (2) Tincture of iodine 1 part, alcohol (45 per cent.) 15 parts. In either case it should not be used until it has soaked for eight days.

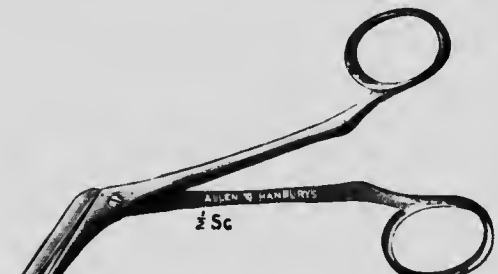


FIG. 1. A convenient form of suture forceps.

Sterilised sutures of all descriptions, and especially silk and catgut, should be handled as little as possible. The assistant who has charge of them must exercise the greatest care to ensure that they do not touch the outside of the vessel in which they are contained, and that the ends do not come into contact with any septic object as he hands them to the operator. Special forceps with smooth blades that will not fray the material (Fig. 1) should be used for their manipulation, especially for keeping the thread taut during the insertion of a continuous suture.

F. **Preparation of Towels and Overalls.** A number of sterilised towels will be required for every operation. They are arranged around the prepared area in such a way that, though this is adequately exposed, the patient and all blankets, &c., over him are completely covered. Should the operation be in the region of the thorax, head, or neck, the towels must be arranged so as to shut off the anæsthetist and his apparatus from the field of operation. This may be accomplished by fastening a towel round the patient's neck and then raising it over a hoop, or, in some cases, by securing a large sterilised pad across the patient's face.[1] All towels should be securely fastened in place by means of sterilised clip forceps. Towels and overalls should be sterilised by steam under high pressure. Unless this precaution is adopted it is found that the folds of the towels interfere with the due penetration and action of the steam. They are taken from the steriliser in air-tight cases, from which they are removed in the operating room by an assistant who has already prepared himself in the manner described above. If circumstances render it impossible to obtain towels sterilised in this way, they may be effectively prepared by boiling in water for half an hour.

G. **Preparation of Dressings, Swabs, &c.** Dressings may be divided into two classes: (*a*) those which contain no antiseptics but are sterilised by heat; (*b*) those which are impregnated with antiseptics. The former include gauze and pads which are made of gamgee tissue cut into squares of convenient sizes and enclosed between layers of gauze. These, together with absorbent wool and bandages, may be sterilised in the same manner as the towels, viz., by steam under pressure. The latter group includes iodoform, sal-alembroth, and cyanide gauzes. Though impregnated with antiseptics, these materials are liable to collect dust, and so may contain many infecting organisms. They are accordingly kept in some such antiseptic lotion as formalin (1 in 500), which soon renders them sterile. Immediately before use they are wrung out in sterilised water to remove the formalin. Sal-alembroth and salicylic wools are also occasionally used, but only as an outer covering for the sterilised dressings in actual contact with the wound. Pads and swabs, which are used for sponging, are sterilised in the same way as the towels and dressings. Before the commencement of the operation the sterilised instruments, sutures, and swabs may be arranged by an assistant, whose hands have been prepared and gloved, upon one or more small tables, the glass tops of which are completely covered by sterilised towels.

THE OPERATION

Before commencing the operation the surgeon should have carefully thought out his mode of procedure. Each assistant should have his particular duties assigned, and care must be taken that all instruments,

[1] See also the method described for operations on the Thyroid Gland, p. 620.

dressings, and other accessories which are likely to be required are quite ready. In this way only can rapidity and neatness be assured. Generally speaking, the more quickly the operation is completed the better for the patient, though of course care and thoroughness must not be sacrificed for speed. Careful planning and organisation are essential for success in modern surgery.

The Administration of the Anæsthetic. Details about the various kinds of anæsthetics and their administration will not be given here, though it is desirable that the operator should have a thorough knowledge of this most important subject. Full information may be obtained from one of the special text-books on anæsthetics. Needless to say, the surgeon should always have the fullest confidence in his anæsthetist, and, at any rate in difficult cases, should secure the services of a skilled administrator of anæsthetics. Under these circumstances the operator, after a preliminary consultation, leaves the anæsthetic and its administration entirely in the hands of the anæsthetist, who will call his attention to any unusual or serious symptoms which may arise during the course of the operation. The patient should not be anæsthetised while he is in bed. If this be done, dangerous symptoms may arise while he is being transferred to the operating room. The ideal arrangement is, that he should be anæsthetised on the operating table in a small room, specially set apart for this purpose, adjoining and opening into the operating theatre. When the patient is unconscious, the table can then be wheeled in without distracting the attention of the anæsthetist. When this arrangement cannot be carried out, the patient should be anæsthetised either upon the table in the operating room or, in the case of a nervous or sensitive patient, upon a trolley which can easily be wheeled in and the patient then transferred to the table. Bandages and pads are then removed by a nurse, the towels are arranged in the manner already described, and the skin receives its final application of tincture of iodine.

The Technique of the Operation. No particular operation will be described here, but it will be as well in this place to give a few general rules and instructions which apply to all operations. Necessary special instructions will be given in the description of each individual operation.

It will first be necessary to discuss *the position of the patient during the operation*. In the great majority of cases he lies flat upon his back. Sometimes, however, for the satisfactory exposure of the diseased parts some other position is required. The following are frequently employed :

(*a*) *The Prone Position*. The patient is here turned over so that the face looks downwards. One arm may be placed under the chest while the other rests along the opposite side of the body, which may be supported by a small pillow. This position may be adopted for operations on the vertebral column, or in certain cases of empyema where it is thought undesirable to allow the patient to rest upon the sound side of his chest.

(*b*) *The Lateral Position* is frequently employed. Here the patient is turned upon his side, left or right as the circumstances of the case demand. The arm of the side upon which he rests is placed under the chest, while the legs are flexed both at the knee- and the hip-joints. This position may be used for some operations on the perineum or anus, for empyema and for kidney operations. In the latter case an air-pillow is also placed beneath the loin to render prominent the region of the incision.

(*c*) *The Trendelenberg Position*. Here the patient rests upon his back, but the pelvis is raised above the level of the head to a height of from

a few inches to as much as two feet. All modern operating tables are provided with a mechanism by which the body is easily made to assume this position. The intestines and other abdominal viscera will then tend to gravitate from the pelvis towards the diaphragm, thus greatly facilitating operations in which a clear view of the depths of the pelvis is desirable. In an exaggerated Trendelenberg position the patient will be almost vertical. If this is maintained for any length of time, grave disturbances of the circulation may occur, and the continued pressure of the viscera upon the diaphragm may seriously embarrass the action of the heart when that organ is not perfectly healthy.

(*d*) In other operations, upon the gall-bladder for instance, it may be desirable to displace the intestines from the upper part of the abdomen and cause them to gravitate towards the pelvis. This may be effected by tilting the operating table so that the head and the upper part of the trunk are at a higher level than the pelvis.

(*e*) *The Lithotomy Position* is essential for most operations upon the rectum or the perineum. This may be conveniently arranged either by means of a Clover's crutch, or by resting the patient's hams upon two adjustable vertical supports attached to the lower end of the operating table.

(*f*) For special operations the affected part may be steadied or raised by means of sand-bags or pillows placed beneath the towels, as has been seen in the case of the kidney. Also in operations upon the gall-bladder a small cushion beneath the lower part of the thorax throws the liver forward and thus renders both the ducts and the gall-bladder itself much more prominent and easily accessible. For operations upon the hand or fingers the arm may often with advantage be abducted and allowed to rest upon a small table at the side of the operating table. As a general rule the patient should be anæsthetised in the dorsal position and then be placed in the special position required for the operation.

The skin incision should be carefully planned so as to give a good view of the deeper parts and at the same time to avoid important structures. If the incision has to be made in the neighbourhood of large vessels or nerves, it should always be made parallel to and not across them. Whenever possible, the incision, especially if upon the face, neck, or other exposed part of the body, should follow the line of natural folds or creases of the skin. In this way subsequent disfigurement is minimised and the resulting scar, if the wound heals by primary union, will be a scarcely noticeable white line. An excellent example of this is the remarkably small deformity after excision of the upper jaw where the incision follows the natural folds at the side of the nose and beneath the lower eyelid. To ensure healing by primary union, the skin should be clean cut with a sharp knife, avoiding all lacerations and irregularities. Care should be taken that the incision is not too short; a long skin incision does not, for instance, weaken the abdominal wall, and the more thorough exposure of deep parts frequently enables the operation to be completed with less injury to these more important structures. Similar rules are to be followed in the division of deeper structures. When the deep fascia is reached it should, before it is divided, be fully exposed by separating the superficial fascia and the skin on each side with a few touches of the knife. All aponeurotic and fascial layers should be divided by clean-cut incisions. Muscles ought if possible to be drawn to one side; if this is impracticable, their fibres should be separated by some blunt instrument, after the sheath has been

opened, rather than be divided by the knife. There is, however, in the great majority of cases no reason why a muscle should not be cut across, provided that the cut ends are identified and subsequently carefully united by sutures. These points are illustrated by two of the common methods of opening the abdomen. Separation of muscular fibres is often used in the "muscle-splitting" method of opening the abdomen in the operation of appendicectomy. Another method which also inflicts but little damage is to incise the anterior layer of the rectus sheath, retract the rectus muscle, and then incise the posterior layer of the sheath. The greatest care must be taken to avoid unnecessary injury to large vessels. Smaller vessels should be secured between two pairs of Spencer Wells forceps and then divided.

It is of even greater importance to avoid injury to nerves. Division of a large nerve-trunk is a serious matter, for it will certainly lead to paralysis and muscular atrophy, which in spite of suture may be permanent. Division of smaller muscular nerves should also be avoided, for such an injury will result not only in partial or complete paralysis of that muscle, but also atrophy, which together may cause considerable disfigurement and disability.

At the conclusion of the operation *all hæmorrhage must be stopped*. Each bleeding-point in the course of the operation is secured by Spencer-Wells forceps, care being taken as far as possible to clip the bleeding vessel alone without taking up masses of surrounding tissue. Small superficial vessels will be probably quickly occluded. Small or medium-sized arteries may be sealed by torsion, care being taken to give the vessels six or seven half-twists and not to twist the forceps completely off.

Other vessels will require to be ligatured with fine catgut. General oozing may be checked by irrigating with sterilised saline solution at a temperature of 130° F. Deep structures should be closed in layers, the divided edges being accurately brought together. For instance, in abdominal operations separate layers of sutures are used for the peritoneum and for each muscle or aponeurosis that has been divided. Continuous sutures of silk or catgut are employed, or celluloid thread if a stronger material is required. The cut edges of the skin are united by continuous or interrupted sutures of horsehair or silkworm-gut, or Michel's metal clips may be employed. Care must be taken that the edges of the skin are not turned in. Should this occur, epithelial surfaces are held in contact instead of the raw edges, with the result that when the stitches are removed some gaping will take place, leaving a small area which has to heal by granulation. Special care to secure accurate apposition must be taken when the incision is on the face or neck.

The question of *drainage* frequently demands careful consideration. If the operation is essentially septic, for instance opening an appendicular abscess, drainage is certainly necessary. When, however, the operation is aseptic, but a large cavity in which blood and serous exudation can collect is necessarily left, drainage is still often desirable, otherwise the cavity will probably fill up with blood-clot and coagulated exudation, which form an admirable medium for the growth and multiplication of organisms. A few cocci of a not very virulent type which would soon be destroyed by healthy living tissues may easily infect and cause suppuration in such an inert mass.

When such a space exists, as in the axilla after the removal of the

breast and axillary contents for carcinoma, or the scrotum after a radical cure for hydrocele, it is best to insert a small drainage-tube to allow such exudation to escape. Though such a wound may appear perfectly dry and free from blood at the termination of the operation, it is almost certain that some oozing will occur as the effect of the anæsthetic is passing off. A rubber drainage-tube may pass to the deeper parts of the wound between the stitches, or the original wound may be completely closed and the tube inserted through a small stab wound in close proximity to it. This method allows drainage to take place and the wound to heal completely—a point of great importance where the abdominal wall has been divided, as in an operation for acute appendicitis. For draining a large suppurating cavity, several lateral holes should be cut in the tube or a layer of gauze may be wrapped round it. Efficient drainage may also be secured by cutting the tube open and inserting a wick of ribbon gauze. For smaller cavities one or more strips of gauze may be employed, while small superficial wounds may be drained by inserting a few strands of silkworm-gut between the stitches. If a drain is employed in an aseptic wound to allow the escape of blood and serum, it may be removed at the end of forty-eight hours and then will in all probability not have to be replaced.

After-treatment of the Wound. This will depend upon the aseptic or septic character of the operation and whether drainage has been necessary. An aseptic wound which has been completely and carefully closed will heal by primary union; under these circumstances the temperature and the pulse will remain normal, and when the patient has recovered from the effects of the anæsthetic there will be no constitutional disturbance. An aseptic wound should be painless or nearly so, since inflammation is the most common cause of pain in a wound. Unless the dressings or bandages require re-adjustment, such a wound need not be dressed until the stitches are removed, which is usually done between the eighth and the tenth days. All dressings must be carried out with strict aseptic precautions. The dresser must carefully prepare his hands, and all instruments, dressings, and towels are sterilised as carefully and thoroughly as at the original operation. An aseptic wound is, when the dressing is removed, dry and free from all redness, swelling, and induration.

A septic wound will require more frequent dressing, usually every day, or if fomentations are used, these ought to be changed every four hours. If a drainage-tube has been used, the time of its removal will to a great extent depend upon the situation and cause of the suppuration. If superficial it may be removed at the end of forty-eight hours, and after cleansing and boiling be replaced. If the septic focus is deep, as in acute appendix or gall-bladder cases for instance, it may be left in situ for three or four days or even longer. In either case at subsequent dressings it should be gradually shortened, and, as the wound closes, a smaller tube should be substituted. When the suppuration diminishes the tube is omitted and a gauze drain used in its place.

Treatment of a Wound which has become Septic. Occasionally, in spite of all precautions, the wound may become infected and suppurates. Usually this points to some failure in the preliminary preparations; sometimes, however, it is due to the dressings becoming soiled or displaced, or they may be disturbed either consciously or unconsciously by the patient. When infection does occur, it is of great importance that the septic nature

of the wound shall be recognised and treated as soon as possible. Otherwise the septic process may extend deeply in and around the wound, and even invade the vessels and lymphatics. The most important information as to the occurrence of sepsis is afforded by the temperature chart, which should be carefully watched after every operation. A slight rise of temperature (99° or 100°) is not infrequently noticed immediately after operations which run a perfectly aseptic course, and hence need cause no anxiety. A more considerable rise (up to 102°) on the second or third evening is, however, of more serious import and should lead to an immediate and careful examination of the wound. When suppuration occurs, pain is usually experienced in the region of the wound. Its intensity varies greatly. It may be very severe and throbbing in character, but on the other hand it may be entirely absent or the patient may complain of discomfort only. In the latter case, organisms of comparatively slight virulence, such as the Staphylococcus albus, have probably infected a collection of effused blood. In these cases, too, there may be little or no pyrexia. If sepsis is suspected the wound must at once be inspected. The dressing must be carried out with the same precautions and care as in the case of a clean wound. The reason for this is that infection may be due to comparatively harmless organisms: the tissues are, however, in the most favourable condition for the growth of any organism, and hence the greatest care must be taken not to introduce any of a more virulent type. A septic wound will appear swollen, red, and œdematous; pus may also be exuding from the incision or stitch holes. Sufficient sutures must be removed to release all tension and to open the wound sufficiently to ensure a free exit for all pus and discharge. If necessary one or more additional incisions must be made to provide free drainage. The wound may then be gently swabbed out with sterilised saline solution or dilute antiseptics such as carbolic lotion (1 in 60) or hydrogen peroxide 10 per cent. Strong antiseptic lotions should not be used. These cannot destroy all the organisms present, and are likely to damage the tissues and thus hinder their normal reaction against the invading bacteria and their toxins. The wound must now be drained; its situation and depth will enable the surgeon to decide as to whether rubber drainage-tubes or gauze should be employed. A dressing of antiseptic gauze (cyanide, iodoform or sal-alembroth) should then be applied. If the inflammation is acute, hot fomentations may be used with advantage. Several layers of lint wrung out of hot boracic lotion or perchloride of mercury (1 in 1000) may be used for this purpose. To obtain the maximum amount of benefit, the fomentation must be applied as hot as possible and be changed frequently. Pain is relieved by the heat, pus and toxic materials are readily discharged, and the antiseptic hinders the growth of the infecting organisms. Should the wound be in the arm or leg, immersion of the limb in a metal bath containing hot boracic or other lotion may often be carried out with advantage. The lotion in the bath must be kept hot and clean; this may be ensured by allowing a continuous stream of hot lotion to flow slowly through the bath.

Constitutional symptoms may be severe, and hence general treatment is of great importance. The strength of the patient must, in severe cases, be maintained by frequent administration of small quantities of suitable nourishment, and alcohol, preferably in the form of small doses of brandy, may also be of service. Free and regular action of the bowels must also be secured. When the wound is opened up, a specimen

of the pus should be collected on a sterile swab for examination and identification of the infecting organism. Should signs of septicæmia appear or should the condition of the wound not quickly improve under the above treatment, a suitable serum (antistreptococcic or antistaphylococcic) may then be injected if the cause of the infection is known. Or, if thought desirable, a vaccine may be prepared by the bacteriologist from the actual organism.

General After-treatment. At the termination of the operation the patient is likely to be cold as the result of the necessary exposure, and after a prolonged or severe operation to be to some extent in a state of shock or collapse. He should therefore be quickly removed to bed and kept warm with the help of hot-water bottles and blankets. He is usually placed at first flat upon his back; some one must be at hand to turn the head to one side and draw the jaw forwards in the event of vomiting occurring, otherwise vomited material may be drawn down into the larynx or the lungs. There is, however, no reason after most operations why the patient should not be propped up on one side, which is more comfortable and renders the inhalation of regurgitated material less likely. Later, after recovery from the effects of the anæsthetic, he may, according to the nature and the situation of the operation, be kept in the dorsal position, be propped on his side (lateral position), or turned upon his face (prone position). Elderly patients, and those suffering from general peritonitis, may often with great advantage be propped up in the semi-recumbent (Fowler's) position. This, in the latter, aids the drainage of pus to the lower part of the abdomen, and in the former throws less strain upon the action of the heart and lungs.

Shock. Shock is a condition of the greatest importance to the surgeon for it frequently occurs, and is a common cause of death after severe operations. Much excellent work has been done in recent years with reference to its nature, cause, prevention, and treatment, but a great deal still remains to be done. Shock may be defined as a condition produced by injury in which the action of the vital organs is seriously depressed. A brief outline of the mechanism of its production is all that can be given here.[1] When shock occurs there is always a great fall in blood-pressure. This has been shown by Crile to be due to dilatation of the splanchnic veins. This leads to the withdrawal of so much blood from the systemic circulation that the blood pressure is greatly reduced. Crile has further shown that the fall in blood pressure is not due to cardiac failure, but to exhaustion of the vaso-motor centre. At first the fall in pressure may be rectified to a certain extent by the increased activity of the vaso-motor mechanism and increased action of the heart. Eventually, however, as the result of repeated violent afferent stimuli, the vaso-motor centre becomes exhausted, with the result that there is a still greater fall in blood pressure and the blood collects in the large venous trunks generally. The heart is now, owing to the small amount of blood

[1] For further information on this subject reference may be made to the following papers and lectures: G. W. Crile, "An Experimental Research into Surgical Shock and Collapse (*Trans. Coll. Phys. Philadel.*, 1901, vol. xxiii. pp. 59–82); P. L. Mummery and W. L. Symes, "The Specific Gravity of the Blood in Shock" (*Trans. Physiol. Soc.*, 1907, p. 15); P. L. Mummery, "Hunterian Lectures on the Treatment of Shock and Collapse" (*Lancet*, 1905, vol. i. pp. 696, 776, and 846); H. Cushing, "On the Avoidance of Shock in Major Amputations by Cocainisation of the Large Nerve Trunks preliminary to their Division" (*Trans. Med. Soc. Wisconsin*, 1902, p. 361; H. Tyrrel Gray and L. Parsons (*Brit. Med. Journ.*, 1912, vol. i. pp. 938, 1004, 1065, 1120).

brought to it, unable to efficiently carry on the circulation, even though for a time it attempts to do so by more forcible and rapid action. Sooner or later the heart will become exhausted and death then occurs, or insufficient blood may be supplied to the vital centres in the medulla with the same result. The essential thing in shock is thus a great fall in blood pressure brought about by failure of the vaso-motor mechanism caused by exhaustion of the vaso-motor centre owing to repeated violent afferent stimuli. Shock may follow any severe injury or operation, but is especially likely to occur if the thoracic or abdominal viscera, the testicle or urethra is involved. With regard to abdominal operations, shock is most likely to be severe when the viscera in the neighbourhood of the solar plexus, especially the duodenum and stomach, are interfered with.

Collapse is a condition closely allied to shock, from which it cannot always be distinguished; indeed, the two may occur together or shock may follow collapse. Collapse is also associated with a low blood pressure, but Crile regards this as due to inhibition of the vaso-motor c[illegible] which is the essential distinction from shock. It may be brough[illegible] by sudden loss of a large quantity of blood or by mental imp[illegible] or violent afferent impulses may produce a sudden inhibition of the centres.

Symptoms of Shock. The onset is usually sudden, though by no means always so. The pulse is rapid, weak, of very small volume, and may be irregular. The respirations are shallow and occasionally show the Cheyne-Stokes rhythm. The surface of the skin is cold and pallid, and the temperature is subnormal. There is great muscular relaxation and weakness, and though consciousness is not lost the mental faculties are dull. The pupils are moderately dilated and their reaction to light is sluggish.

Prevention of Shock. Prophylactic measures are especially called for in all cases where, from the nature of the operation or the condition of the patient, shock is likely to occur. Most important is a thorough preliminary examination, especially of the kidneys, and careful preparation extending if necessary over several days, during which the patient is got into as good condition as possible, and attention is directed to the treatment of any visceral disease. Care must be taken that the patient is kept warm during the operation, which is completed as rapidly as possible, and that he is then quickly returned to bed, where hot bottles and blankets are used to guard against chill.

It has been pointed out that shock is produced by the effect of violent afferent stimuli on the vaso-motor centre. Any means of preventing or diminishing these stimuli will thus be of service. For this reason an injection of morphia (I.M.H. gr. ¼) may with advantage be given about twenty minutes before the commencement of the anæsthesia. Crile insists on the importance of the injection of cocaine into the large nerve-trunks which supply the region of the operation. The effect of this is to block the transmission of sensory impulses and thus to lessen the likelihood of shock. Spinal anæsthesia also will have the effect of blocking afferent impulses, and may therefore be chosen in cases which are in other respects suitable in which severe shock is anticipated. The importance of this is emphasised by Tyrrel Gray and Parsons (*q.v.*).

The question often arises as to the desirability of operating upon a patient who is already in a state of shock or collapse, the result of some severe injury or acute disease. No invariable rule can be given; each individual case must be considered upon its merits. If when a patient

is first seen, after a severe railway crush of the leg or with acute general peritonitis for example, it is thought that the pulse and general condition may possibly improve, it will be well to allow an interval of some hours to elapse while he is kept warm, infused, and treated with stimulating nutrient enemata. Should it on the other hand be considered that improvement is unlikely to ensue, immediate operation gives the only chance, though possibly a faint one, of success.

Treatment of Shock. A patient suffering from shock should always be kept warm by the use of hot bottles and blankets; the foot of the bed should be raised so that the head is lower than the feet. Stimulants and other drugs administered by the mouth are of little use, for their absorption by the stomach is unlikely. Hot and stimulating nutrient enemata may, however, be employed with advantage. They should be administered through a tube introduced as far into the bowel as possible. Strychnine and other stimulants, whether given by the mouth or hypodermically, are useless in shock though they may be of service in collapse. In the former condition they only stimulate the heart when that organ is already making increased efforts to maintain the circulation with the diminished quantity of blood at its disposal. Thus, though stimulants may temporarily improve the pulse, they soon increase the tendency to cardiac failure.

Crile points out that in shock there is a deficiency in the output of the heart owing to the stagnation of the blood in the large veins brought about by the failure of the vaso-motor mechanism. He suggests, therefore, that the treatment should be directed to supplying the heart with additional fluid to compensate for the diminished intake, and to restore that peripheral resistance which has been lost as the result of the vaso-motor failure. The first of these is effected by infusion, the second by mechanical means and by the use of adrenalin.

Infusion is best carried out by allowing sterilised physiological saline solution to flow through a cannula which has been inserted into a vein, usually the median basilic. It may also be given subcutaneously, when the needle is usually inserted beneath the deep fascia into the loose tissues of the axilla, or by means of repeated or continuous rectal injections. The first method is, however, best. With a view to causing contraction of the small arteries and thus increasing the peripheral resistance, he suggests the addition of adrenalin to the saline solution. As this is rapidly oxidised by the tissues he advises its continuous administration by adding sufficient adrenalin hydrochloride to the saline to make a solution of 1 in 50,000 or 1 in 100,000 (5j adrenalin to 1 pint of saline).

The circulation may be improved mechanically by gentle abdominal massage and by firmly bandaging the abdomen and limbs over a layer of cotton-wool. Care must be taken that respiration is not impeded and that the bandages do not in any other way inconvenience the patient. Inhalations of oxygen may often be given with advantage, and Lockhart Mummery advises gentle artificial respiration which does good by drawing blood into the large veins which open into the heart and by increasing the oxygenation of the blood. Injections of atropine may also be good. If a patient remains in a condition of shock for some considerable time, plenty of fluid should be given by the mouth, and in these circumstances it may be necessary to give nutrient enemata. Should severe symptoms of shock appear during the operation, it should be completed as rapidly as possible or if thought desirable abandoned.

Feeding. The question of feeding after an operation, though naturally of great importance, will depend upon the age and actual condition of the patient, the duration of the anæsthesia, and the nature of the operation. A few general rules and instructions may, however, be given. After an operation of any magnitude the patient usually requires but little food. The thing is to give plenty of fluid, either by the mouth, by infusion, or by saline enemata. After a comparatively slight operation a little light food, such as a cup of weak tea and a little bread and butter, may be allowed at the end of six or eight hours, provided that there is no vomiting and that the patient feels inclined to take it. After abdominal or other severe operations, small quantities of hot water may be given at frequent intervals during the first twenty-four hours. At the end of that time, fluid nourishment may be allowed at regular intervals in gradually increasing quantities. Milk is often given, but is by no means essential. Some patients are unable to assimilate it, and it may cause flatulence and thus lead to much discomfort. There are a number of fluid foods, some of which are partially digested, prepared by well-known firms, which may be used with advantage; while chicken or mutton broth, or even light solid food, may be allowed in suitable cases. After the bowels have acted the nature and variety of food are gradually increased, until the patient is on ordinary diet, care being taken that all nourishment is light and easily digestible. The feeding of old people and of young children demands close attention. The former are liable to suffer from exhaustion, and hence small fluid feeds should be started as soon as possible. The latter are liable to be upset by any change of diet, and hence should be given the food to which they have been accustomed as soon as they have recovered from the anæsthetic. Should vomiting persist, or should feeds cause nausea, nutrient enemata may be desirable in these patients.

In most cases it is advisable that the bowels should act on the second or third day. It is sometimes desirable that the action should occur even earlier, while occasionally—after operations on the rectum for instance—it may be necessary to keep the bowels confined for a longer period. Drastic or irritating purgatives ought to be avoided, especially when exhaustion is present. As a general rule an ounce of castor oil is a satisfactory aperient for an adult. This may be followed by a soap and water enema, or an oil enema composed of castor oil ℥iij and olive oil ℥iij may be tried. Another useful method of getting the bowels to act is to give small doses of a saline purge, such as Mag. Sulph. ℥ij, at intervals of an hour until an action occurs. Small doses of calomel repeated hourly are sometimes employed, but it must be remembered that this drug, if not quickly successful, may set up a serious and troublesome colitis.

Vomiting. This is a very common and troublesome post-anæsthetic complication. It may occur after any general anæsthetic, even after nitrous oxide, but is especially prone to occur after ether or chloroform. It is more common after the former, but the more serious cases of persistent vomiting usually occur when the latter has been employed. In either case it is far less likely to be troublesome if the patient has been carefully prepared and the stomach is empty at the time of the administration. Vomiting after the use of ether appears to be due to the presence of the drug in the stomach, since the vomited material consists of thick mucus with a strong ethereal odour. This ether is to a great extent swallowed with saliva, but there is also considerable evidence to show that this drug is also excreted by the gastric mucous membrane. Vomiting is

also often caused after operations on the nose, mouth, and throat by the presence of swallowed blood in the patient's stomach.

Jolting, or other disturbance after the operation, is also very liable to start vomiting: the patient should thus be transferred from the operating table to his bed as quietly and gently as possible. If the vomiting does not cease after a few hours some treatment becomes necessary. A simple and effective method is to give half a pint of hot water. This will probably cause immediate vomiting, but the washing out of the stomach thus brought about is likely to remove the cause of the trouble. Bicarbonate of soda grs. xv may with advantage be dissolved in the water. In more troublesome cases it may be necessary to pass a soft tube and thoroughly wash out the stomach.

Hot strong coffee is sometimes effective in stopping vomiting, while in other cases a little champagne is quickly successful. Small doses of tincture of iodine, ℥j or ℥ij in ℥ij of hot water, given hourly for four or five hours is often very effective in obstinate cases. Hewitt recommends an enema of Pot. Brom. grs. xx dissolved in water ℥ij for persistent vomiting in neurotic patients.

Retention of Urine. This is by no means an uncommon sequela. It may occur both in men and women after abdominal operations, but is particularly common after operations on the perineum, rectum, especially hæmorrhoids, and the pelvic organs: it is also a frequent complication after operations for hernia and varicocele. This post-operative retention is usually regarded as reflex in origin. In some cases it appears to be due to unwillingness on the part of the patient to make the effort owing to the pain or discomfort of the necessary strain. In other cases the presence of dressings and bandages mechanically render micturition a matter of difficulty, especially if the bladder has been allowed to become over-distended. Lastly, when the retention persists for some days, the neurotic element is probably an important factor in its causation.

The urine should be drawn off by a carefully sterilised soft rubber catheter. Should this be necessary on more than one occasion, change of position may be successful in terminating the trouble. A male patient can be rolled over on to his side, while a female should be propped up in the sitting posture.

Pulmonary Complications. These are usually a sequela of the anæsthetic rather than of the operation; they occur more frequently after ether. Bronchitis is the commonest trouble; it is most likely to occur in patients who are predisposed to this disease. In rare cases a typical attack of lobar pneumonia may occur—the so-called "ether pneumonia." In other cases inhalation of particles of vomit, blood-clot, or septic material from the mouth or upper air-passages may set up a broncho-pneumonia. There is no doubt, however, that many cases regarded as pneumonia or pleurisy are really the result of infarction (*vide infra*). In elderly patients, the bases of the lungs, where the circulation is likely to be impaired owing to the recumbent position and the action of gravity, may become congested and eventually consolidated—a process known as "hypostatic pneumonia." This complication, which is often fatal, is best avoided by getting these patients up as soon as possible and by keeping them well propped up during the necessary stay in bed. Sometimes when vomiting has been excessive the patient may complain of a severe pain in the lower part of the chest. This is muscular in origin, and due to the excessive strain, but its situation and occurrence when a deep breath is taken may

suggest the existence of pleurisy. In rare cases where there is some latent tuberculous trouble at the apices the administration of an anæsthetic may be followed by obvious signs and symptoms of phthisis which may not have been previously suspected.

Thrombosis and Embolism. These are both conditions of great gravity which occasionally occur after operations: the latter, which is always preceded by the former, may lead to sudden death without any premonitory symptoms. Thrombosis is most likely after operations upon the abdominal or pelvic organs. The coagulation may take place at the site of the operation, but often occurs in the left femoral vein though the field of operation may be some distance away—an appendicectomy for instance. The cause of the thrombosis is often uncertain. Some cases are undoubtedly due to sepsis, but in the majority not only does the clotting take place at some distance, but the wound heals by primary union and shows no evidence of infection. Any of the following conditions may play an important part in its causation.

(*a*) Thrombosis is likely to occur after prolonged operations upon anæmic patients or those suffering from some wasting disease. (*b*) When excessive hæmorrhage has occurred either before or during the operation. (*c*) Traumatism either by contusion of the wall of the vein by rough manipulation or traction, or by the application of a ligature to a small vein close to its junction with a large venous trunk. (*d*) Tight bandaging, especially a spica bandage which may press upon the femoral or the internal saphenous veins in the groin. (*e*) Prolonged rest upon the back after an operation, especially if the legs are flexed and kept at rest by a large knee pillow. (*f*) A prolonged milk diet is stated to cause an increase of calcium salts in the plasma and thus to increase the coagulability of the blood.

The interval between the operation and the onset of the thrombosis varies from a few days to a few weeks. In a series of 66 cases collected by R. G. Anderson[1] the average interval was 13·3 days. The onset is generally sudden, though as a rule for some days before the occurrence of any local symptoms there is slight pyrexia and some malaise. The patient then complains of more or less severe pain in the leg. On examination the limb is found to be swollen and tender, especially along the course of the affected venous trunks, which may be palpable as hard cords. Later the œdema increases and the limb will then pit on pressure. The great danger of thrombosis is that the clot may become detached; it will then be eventually carried by the blood stream to the pulmonary artery, when it must produce pulmonary embolism[2] or infarction of the lung. Displacement of the clot is likely to be brought about by some sudden movement or exertion. The patient must therefore, when thrombosis is known to have occurred, be kept at rest until the clot is firmly adherent to the wall of the vein. This will take from two to three weeks in aseptic cases; but when the thrombosis is of septic origin a longer period is required, since there is considerable danger of embolism occurring during the process of softening of the clot.

The affected limb, which should be kept slightly raised on a pillow, may be loosely bandaged over cotton-wool.

Sandbags may be used to steady the leg, but splints and tight bandages

[1] *Guy's Hosp. Gazette*, New Series, vol. xix, p. 96.

[2] Reference may be made to a paper by Louis Blanchard Wilson on "Fatal Post-operation Embolism" (*Ann. of Surg.*, 1912, vol. lvi, p. 809).

should be avoided. The patient must be told of the necessity of refraining from all movement. Purgatives should not be given, but regular action of the bowels must be ensured by means of enemata. After a few weeks the swelling usually disappears and the circulation is completely restored. In the event of the swelling persisting, massage will be of service, but this method of treatment must of course only be employed in the later stages and even then with caution.

Embolism usually occurs after some movement or exertion, often of a very trifling nature such as sitting up or turning over in bed. The preceding thrombosis may have taken place in some deep vessel without any signs or symptoms and thus may have been entirely unrecognised. The sudden unexpected death which may then take place in a convalescent patient who is apparently out of danger after the operation is one of the most terrible accidents in surgery. Should the clot be of such size as to block either the whole pulmonary artery or one of its main branches, usually the left, death will almost certainly occur. Should, however, the clot be small enough to be carried into one of the smaller terminal branches, the patient may recover. In this event physical examination of the chest a few days later will probably reveal an area of solid lung and a patch of pleurisy.

When embolism occurs the patient is suddenly seized with a most acute pain in his chest and at once becomes collapsed. There is very severe and distressing dyspnœa: the pulse is feeble, fluttering, and very rapid (120–160). The face is cyanosed, and subsequently the whole surface of the body may have a greyish tinge. Occasionally there may be one or several convulsions. As the result of the obstruction to the pulmonary circulation the whole of the systemic venous system becomes excessively engorged. Venesection may therefore be carried out with advantage, and often affords great relief. The patient should be propped up in a sitting position and oxygen freely administered. This will cause an improvement in the colour and also relieves the dyspnœa. An injection of strychnine should also be given to stimulate the heart's action. In very acute cases artificial respiration should be tried when the breathing has stopped.

CHAPTER II

INFUSION. TRANSFUSION. SKIN-GRAFTING

These may be considered together here, since infusion is frequently employed after operations in the treatment of the general condition of the patient, and skin-grafting in the subsequent treatment of a granulating wound.

I. INFUSION

While this method had been occasionally made use of by several different workers for many years—*e.g.* the Littles in the cholera epidemics at the London Hospital in 1848 and 1866, and many others, sporadically, at most of our hospitals—it was Dr. William Hunter who, in 1889, by his Arris and Gale Lectures[1] again drew the attention of the profession in this country[2] to the great importance of the injection of saline fluid in sustaining life, if only sufficient fluid was employed to keep it in circulation. Further, it was Sir Arbuthnot Lane who, applying the above experiments to surgery in two brilliantly successful cases,[3] again drew the attention of the profession to the value of this method more forcibly than had been done before.

In his three lectures, Dr. Hunter, after contrasting the advantages of transfusion and infusion, arrives at the following most important conclusion: "For practical purposes all the advantages to be gained by transfusion may, I believe, be equally well and more readily obtained by infusion of a neutral saline, such as a $\frac{3}{4}$ per cent. solution of common salt (about 1 drachm to the pint)." With regard to the direct transfusion of blood, he clearly shows that the nutritive value of serum is so small that its chief value must depend upon its physical properties, and these are in no respect greater than those of a corresponding quantity of normal saline solution. With regard to the red corpuscles the same authority writes: "The greater the quantity of blood transfused, the longer are red corpuscles likely to remain within the circulation, and the more likely is their haemoglobin and the iron which it contains to remain within the system. Over this factor, however, we can exercise but little control. The quantity of blood transfusible in man can rarely be more than about 5 per cent. of the blood already in the body. And the life duration of the red corpuscles under such circumstances is

[1] *Brit. Med. Journ.*, vol. ii, 1889, pp. 117, 237, 305.

[2] About the same time the late Dr. Woolridge, in experiments unpublished owing to his untimely death, was also proving that after haemorrhage sufficient to be fatal, enough haemoglobin still remained to sustain life, if only sufficient fluid were added to keep it in circulation. Dr. H. Spencer, who successfully infused a patient the subject of post-partum haemorrhage as long ago as 1888, suggests that Golz (*Virch. Arch. Bd. xxi* and *xxix*), and Kronecker and Sander (*Berl. klin. Woch.* 1879, No. 52), were the first to suggest saline infusion and explain its action.

[3] One of the cases is published (*Lancet*, vol. ii, 1891, p. 626).

probably to be reckoned by a period of hours." After the greatest loss of blood sufficient red corpuscles always remain for the absorption of oxygen from the lungs, provided that the circulation is maintained. After a sudden loss of blood, the source of danger is not the want of red corpuscles, but the disturbance of the relation between the vascular system and its contents, or, in other words, the fall in the blood pressure to a point where the circulation is unable to be maintained. These conclusions have been amply confirmed by modern experience, so that direct transfusion of blood is now practically never employed, its place being taken by infusion of a saline solution. The chief indications are:

(1) **Acute traumatic anæmia,** such as occurs as the result of excessive hæmorrhage after operations, or after accidents where a large vessel has been divided, such as a cut throat, or as the result of a ruptured extra-uterine gestation, or post-partum hæmorrhage. The results here are particularly satisfactory. It is, of course, essential that the source of the hæmorrhage should be found and the bleeding vessel secured by ligature, or in some other way. When this is successfully accomplished judicious treatment, especially infusion, renders recovery possible, or even likely, however desperate the condition of the patient.

(2) **In cases of collapse,** other than those produced by a sudden hæmorrhage. It has been mentioned before (p. 28) that in cases of collapse we have a low blood pressure, the result of inhibition of the vaso-motor centre, in many instances brought about by the loss of fluid from the blood, a severe hæmorrhage, for example. Dr. Beddard, in "Some remarks on Transfusion and Infusion"[1] and in a clinical lecture on "Transfusion,"[2] discusses this and several other points in a very helpful way and with the authority of a physiologist as well as a physician. He thus explains this loss of fluid. "In many cases of collapse, however, the way in which fluid is lost from the vascular system is not so obvious at first sight as in the case of hæmorrhage. For instance, in cases of burn or scald it is a familiar fact that the prognosis is determined, not so much by the degree as by the area involved. Thus, a patient with one finger badly charred and another scalded slightly all over the body are both at first in a condition of shock. The patient with the severely burned finger comes out from the condition of shock and recovers; the scalded patient may or may not recover temporarily from the shock, but passes gradually into a condition of collapse and dies. Again, a patient has a blow in the abdomen which ruptures his gut, he may recover from the initial shock and even keep about for a time feeling comparatively well, then he passes into a condition of collapse. It must now be asked how have these patients lost fluid from their circulation and become collapsed.

Whenever a tissue is damaged, whether mechanically or by inflammation, it becomes œdematous with fluid taken from the vascular system. Three distinct stages can be distinguished. (1) Fluid is rapidly poured out into the damaged tissues from the vessels. An equal quantity, however, passes from the uninjured tissues to the blood. (2) During the second stage more fluid is passing to the injured tissues than can be got from the uninjured ones: hence there is now less than the normal quantity of water in the circulating blood. For a time this condition does not affect the blood pressure and pulse because it is

[1] *Guy's Hosp. Reps.*, vol. lv, p. 29.
[2] *Guy's Hosp. Gazette*, July 29, 1905.

temporarily compensated for by vaso-constriction of blood-vessels. (") In the third stage, the drain of fluid into the damaged tissues still goes on, the specific gravity of the blood rises continuously, the vaso-motor centre can no longer keep up the arterial blood pressure, which falls progressively till the death of the patient from failure of the cerebral and coronary circulation. It is very important to note that this final stage may set in with great suddenness and the patient die before anything can be done for him. Collapse may develop in exactly the same way from the continued loss of fluid by severe vomiting and diarrhœa, as seen in cholera, the summer diarrhœa of infants, ulcerative colitis, uræmia, in cases of irritant poisoning, and many other like conditions."

Thus, in cases of collapse, from whatever cause, when the patient has shrunken features pointing to loss of fluid, whatever other treatment he may require, he certainly requires infusion.

(3) **Shock.** It has been shown (p. 28) that shock is essentially due to exhaustion of the vaso-motor centre as the result of excessive afferent impulses reaching the centre: The blood thus stagnates in the large veins especially those in the splanchnic area. The low blood pressure is due, not to there being too little fluid in the vessels, but to the blood being improperly distributed. If salt solution be infused into a vein of a patient suffering from shock, it may improve the blood pressure temporarily since it increases the intake of fluid by the heart and consequently its output into the arteries. The greater part of the fluid will find its way through the dilated arteries into the abdominal veins and accumulate there, or it may pass through the walls of the capillaries into the tissues. On these grounds we should not expect infusion to be of much use in the treatment of shock. In adrenalin, however, we have a drug which raises the blood pressure by acting upon the peripheral arteries when given either subcutaneously or intravenously. Adrenalin is quickly oxidised and destroyed by the tissues. Crile therefore suggests the infusion of saline solution to which adrenalin hydrochloride has been added to the proportion of 1 in 50,000. When given intravenously the effect of adrenaline is instantaneous. Dr. Beddard recommends that it be given subcutaneously, when a dose of from 20 to 30 minims of a 1 in 1000 solution may be safely employed. Its effect upon the blood pressure comes on within a very few minutes, and disappears in about an hour, therefore the injection has to be repeated hourly until the shock has passed off.

(4) Rarer indications are **diabetic coma** and **septicæmia**; in the latter on the ground that it facilitates the removal, especially by the kidneys, of the micro-organisms and their toxins. In the former the object is to neutralise the acid intoxication by the alkali as well as to dilute the poison in the blood. With this object a solution of sodium bicarbonate is employed. The strength to use is 1 drachm of the salt to a pint of water.

(5) **In the case of certain poisons**, *e.g.* carbolic acid. Dr. Oliver of Newcastle[1] drew attention to the insufficiency of washing out the stomach when once a poison like carbolic acid has got into the blood, and to the need of infusing with saline fluid, as this is in great part rapidly excreted by the kidneys and carries much of the poison away with it. Dr. Powell describes a most successful case.[2]

[1] Professor Allbutt's *System of Medicine*, vol. ii, pt. 1, p. 1017.
[2] *Lancet*, 1898, vol. ii, p. 1326.

A woman æt. 21, who had, about three-quarters of an hour before her admission, swallowed 7 drachms of ordinary commercial carbolic, was brought in, in a state of coma and collapse. While the stomach was being washed out, the left internal saphenous vein was opened and 8 ounces of blood removed. Four pints of saline solution, at a temperature of 100° were then injected. The pulse and respiration gradually improved. Glycerine in drachm doses was given frequently to allay the burning sensation in the pharynx and œsophagus. For three days the urine was dark green, but never contained albumen. Recovery was rapid and complete.

(6) Another condition which from its urgent gravity, deserves mention here, is **gas-poisoning.**

This appears to be more common in America both in private and in hospital practice, than with us. Dr. Taylor[1] gives his conclusions from ninety cases, in twelve of which necropsies were obtained. He considers that venesection and saline infusion, usually combined, should be promptly employed. Where the pulse is vigorous, venesection followed by infusion is the remedy. Where in an unconscious patient the pulse does not justify venesection, infusion alone should be made use of. How the two remedies act is uncertain.

(7) For the **intravenous induction of anæsthesia.** This method, which is still on trial, certainly seems in some cases to offer many advantages. A 5 per cent. solution of ether appears to be more satisfactory than hedonal or isopral, which were first employed. The method is certainly convenient in operations on the head, neck, and mouth where the ordinary apparatus may be very much in the way of the operator. It is said to lessen the probability of pulmonary complications in those patients suffering from or liable to bronchitis. Also, when shock is anticipated or is already present, the saline will be beneficial and a small quantity of anæsthetic will be employed.

Intravenous anæsthesia was first employed by Burkhart.[2] Brodi,[3] who first employed the method in this country, describes the technique, apparatus, and mode of induction. He gives an account of twenty-one cases in which it was successfully employed.

Preparation of the solution. In the preparation of the solution ordinary boiled tap water may be quite safely used. Indeed, this is preferable to distilled water, which is usually far from sterile and may contain traces of deleterious materials derived from the copper stills into which it is generally condensed.

With regard to the materials to be used, Dr. Beddard regards dextrose as eminently suitable, being a normal constituent of the blood, and sufficiently non-poisonous to be injected in large quantities. A 6 per cent. solution of dextrose is theoretically isotonic with human blood-plasma. The material most frequently employed is sodium chloride, the strength of which should be 1½ drachms to the pint, or roughly one teaspoonful. This has the advantage of always being readily obtainable. Such a solution is, however, far from being non-toxic, and while this fact does not prevent its use, the symptoms of possible poisoning by a sodium salt should be remembered. "They are stimulation of the nerves and muscles from slight twitchings up to severe convulsions, pyrexia up to hyper-pyrexia, rigors, feeble and rapid pulse." It is further pointed out that certain cases are much more liable to poisoning by sodium chloride than others. "All the serious cases of sodium chloride poisoning which I have seen have been cases of uræmia, diabetic coma, or cholæmia, and it is easy to understand why. In these toxæmias

[1] *Med. Record*, July 9, 1904. [2] *Münch. Med. Woch.*, 1909, No. 46.
[3] *Brit. Med. Journ.*, 1911, vol. ii, p. 974.

the patient has lost no salts from his vascular system; he has all he ought to have, and you by treatment make a considerable addition to this amount. Therefore he is comparatively easily poisoned. But in cases of collapse, such as peritonitis, diarrhœa, and vomiting, &c., the patient, besides water, has lost large quantities of salts as well, and therefore you would have to inject very large quantities of sodium chloride to poison him severely."

Better than a solution of common salt is a physiological solution which is iso-tonic with blood-plasma. The following fulfil this requirement: Locke's solution. Sod. Chlor. ·9 grm., Calc. Chlorid. ·024 grm., Potass. Chlorid. ·042 grm., Sod. Bicarb. ·01 grm., Dextrose ·1 grm., Aqua 100 c.c. (2) Sod. Chlorid. ·9 grm., Potass. Chloras. ·03 grm., Calc. Chlorid. ·01 grm., Aq. 100 c.c. These should be used with distilled water. The following forms a physiological solution when added to tap water: Sod. Chlorid. 80 grs., Potass. Chloridi. 3½ grs., Dextrose 9 grs., Aq. Dest. ad 4 drachms. The ingredients are dissolved in distilled water and then sterilised by boiling. One tablespoonful added to each pint of boiled tap water gives a solution equivalent to Locke's solution.

In any case the fluid should be sterilised by boiling and then cooled to a temperature of 115° F. by the addition of sterilised water, or, in cases of emergency, of ordinary cold tap water. The greatest care must be taken to see that the solution is not too cold when it reaches the patient.

The method of infusing. There are three possibilities: (1) Directly into a vein; (2) subcutaneously; (3) into the bowel. The alimentary canal is often impossible for obvious reasons. When the circulation has almost failed, absorption will be too slow and imperfect to be of any real value. In less serious cases, however, when it is employed more as a precaution to guard against a comparatively slight circulatory failure becoming more severe, it may be employed with advantage. Under these circumstances it is better to slowly inject a pint, and then should the condition of the pulse render it advisable, repeat the injection after an hour's interval. The fluid should slowly flow through a soft rubber catheter passed well into the bowel. Subcutaneous injection is open to somewhat similar objections: when severe circulatory failure has occurred the fluid may not be absorbed at all. On the other hand, in less severe cases, the solution is absorbed with remarkable rapidity and the pulse quickly improves. In urgent cases then, after a severe hæmorrhage for instance, when it is essential to get fluid into the circulation with the least possible delay, the intravenous method is indicated. In other cases infusion by the subcutaneous or alimentary routes may be preferred. The rate at which fluid should be allowed to flow into a vein is an important question. Dr. Beddard, in his paper, quoted above, directs attention to the danger of over-distending the right side of the heart. "I have certainly seen cases where intravenous infusion has caused death in this way. It is difficult to say at what rate fluid can be run into a vein without this danger to the heart. That an apparently small difference in the blood-flow along the veins may make a great difference to the right heart is clearly shown by venesection. Here, in the course of several minutes, we abstract at most a pint of blood from the arm and produce a very real effect upon the condition of the right ventricle. Conversely, it is easy to understand that the injection of fluid into a vein may be

the heart. There can be no doubt that the more slowly the fluid is run in the better, and as a maximal rate I would suggest a pint in ten minutes. This rate may appear to err on the side of safety, but I do not think it does. It is necessary to remember that often when intravenous infusion is used the right heart is far from normal." He next points out that the choice of route also depends upon the solution to be used. "A solution of dextrose is not suitable for any but intravenous injection. Large quantities given by the bowel may not be retained or may set up diarrhœa, and when injected subcutaneously may cause sloughing. A solution of sodium chloride may be given in any of the three ways. It is the best to use for subcutaneous or rectal infusion. In diabetes, a solution of sodium bicarbonate should not be given subcutaneously because of its liability to produce sloughing."

Method. Now that the indications for saline infusion are known to be so numerous, and are so often followed by excellent results, every practitioner should be prepared to employ this mode of treatment, remembering the critical nature of the cases which call for it, and the suddenness with which the call is liable to come. The apparatus should be as simple as possible. A glass funnel, several feet of rubber tubing of suitable size, and blunt cannulæ and sharp-pointed hollow needles of various sizes are all that are essential. All these can be readily sterilised by boiling. If the subcutaneous method is to be employed, the skin is cleansed and a sharp needle pushed through the deep fascia into the lax tissues of the axilla. A Y-shaped junction may be used so as to permit of simultaneous infusion into both axillæ. In intravenous infusion the skin over the vein selected is first sterilised. The vessel chosen is usually the median basilic or the cephalic. Either is exposed by an oblique incision to the inner or the outer side of the biceps tendon. Where there is any difficulty in finding a vein here, owing to their collapsed state or to the arrangement not being normal, a skin flap should be turned up, or gentle pressure made on the basilic or the cephalic a little higher up, and the trunk exposed here. Or the patient's leg may be allowed to hang down and the internal saphenous opened just in front of the malleolus. Two catgut ligatures are now passed beneath the exposed vein. One is drawn to the lower angle of the wound, tied round the vein and cut short. The freed portion of the vein being raised with dissecting forceps, a small nick is made in it with scissors, care being taken not to sever it completely. The cannula is next introduced into the vein in an upward direction and tied by the upper ligature, the ends of which are left long (Fig. 2). The blood now flows down the cannula, and when it is full, the tubing, previously attached to the funnel and filled with saline solution at a temperature of 110 to 115° F. and prepared in one of the above-described

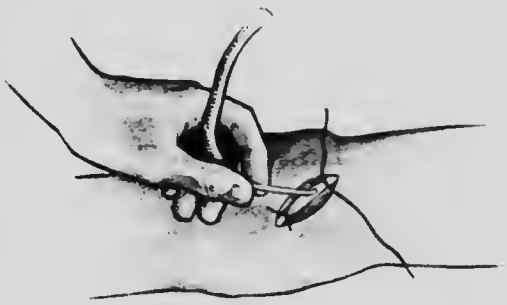


Fig. 2. Method of inserting the cannula for intravenous infusion.

ways, is fixed to it. The funnel is now raised to a height of about 4 feet, and as the solution flows it is replaced by more poured from a jug held close to the funnel to avoid the formation of bubbles. When sufficient has been infused the cannula is removed. The vein is cut completely across, and the upper end tied with the ends of the ligature which have been left long.

From four to six pints of the infusion fluid should be at hand. It should take at least from 20 to 30 minutes to inject two to three pints, the amount usually required. Occasionally five or six pints are needed: the more slowly the fluid is then infused the better. Two or three infusions of a smaller amount are often better than the single rapid injection of a large quantity. The chief guides are the return of the pulse, with increase in volume and diminution in rate (say, a fall from 130 to 90), return of colour and fulness to the face, increase in consciousness, &c. Care must be taken, while the fluid is being injected, that no air enters, and that there is no blocking of, or leakage from, the apparatus employed. The rate of flow may be regulated by the height above the patient at which the funnel is held.

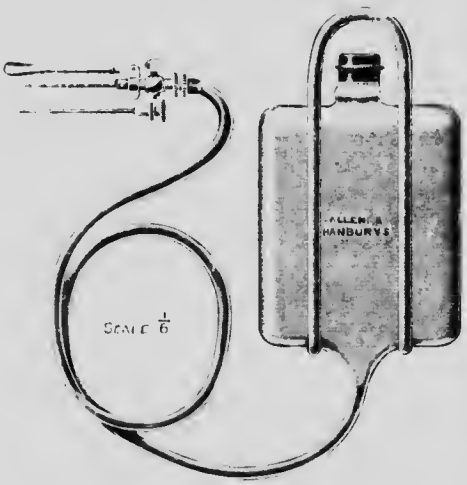


Fig. 3. Lane's subcutaneous Infusion Apparatus.

Though the apparatus described above has the advantages of simplicity and portability, it has certain disadvantages, especially for subcutaneous infusion. This is naturally a longer process, and unless great care is taken the temperature of the fluid will fall very considerably before it reaches the patient's tissues. To overcome this and other disadvantages, various other forms have been devised.

(1) The vessel containing the fluid stands in a water bath, the temperature of which is indicated by a thermometer, or, as suggested by Moynihan, is heated by a spirit-lamp placed beneath. The apparatus rests on a stand at the side of the patient's bed, the height of which can be adjusted.

(2) Lane's apparatus (Figs. 3 and 4). This consists of a rubber bag containing the infusion fluid. It can be suspended from a hook at any desired height above the bed or operating table.

(3) The principle of the "Thermos flask" has been applied to the construction of a receptacle for the fluid, which is thus kept at a practically constant temperature for a considerable time.

Mr. N. S. Carruthers, writing on this subject [1] insists on the importance of the fluid being hot, especially when children are infused for collapse after epidemic summer diarrhœa. He finds that though the temperature of the fluid in the receiver is 120°, that it may be only 75° when it reaches the needle in the course of a slow infusion. This may lead to an increase in the collapse. To remedy this he has

[1] *Brit. Med. Journ.*, 1911, vol. ii, p. 725.

designed the following apparatus. "The essential part is a vacuum flask, the neck of which is fitted with a rubber cork and three glass tubes, one long and extending to the bottom of the bottle, the other two short. The case in which the flask is held is fitted with a handle, and on each side a glass tube is securely fixed and graduated by experiment in ounces. To one of the short glasses passing through the cork a piece of rubber pressure tubing is attached to convey the saline to the patient. To the other glass tubes fitted in the cork small pieces of rubber tubing are attached, and when the bottle is filled and corked these short tubes are connected up with the graduated glasses, one on each side. The result of having them both graduated is that it matters little which tube is attached to which glass, for either will register. This simplifies the appliance somewhat.

"When the flask is inverted and the saline running, air is carried to the top of the bottle by means of the long glass tube, and, the fluid escaping into the glass tube of the opposite side, acts as a register. The register can be graduated to record the amount in the flask, or, as I prefer it, the amount the patient has received. The solution is conducted to the patient by a short length of rubber pressure tubing which prevents the loss of heat, since rubber is a poor conductor.

"This, like most appliances, is fitted with a **Y**-piece, so that it can be connected to two needles and the patient infused in two places at the same time. Ordinary infusion needles are used, and screw clips to regulate the rate of flow. The total length of the rubber tubing to each needle should not exceed ten inches. When in use the apparatus is hung on a hook, or it may be put on a suitable stand."

Fig. 4. Lane's Infusion Bag suspended from a stand, with **Y** junction and two needles for simultaneous infusion into both axillæ.

Infusion is now employed so often and in such a variety of cases that it will be well to point out that if injudiciously used it may be actually harmful. In all cases a watch must be kept on the pulse and on the general condition of the patient. Possible dangers are as follows:

(1) **Sepsis.** It is of course essential that the fluid injected shall be sterile. Care must also be taken to keep the small wound in front of the elbow aseptic. Any thick scar in front of the elbow-joint will embarrass its movements, and infection may lead to thrombosis and embolism. In subcutaneous infusion any failure in sterilising the solution or the skin may lead to extensive cellulitis or sloughing.

(2) As already pointed out, too rapid intravenous infusion may lead to **dilatation of the right side of the heart.**

(3) **Œdema of the lungs** occasionally occurs, and may be the cause of a fatal result. It is especially likely to occur when very large quantities are injected. Any development of dyspnœa is an indication for at once stopping the infusion.

(4) If too weak a solution of salt is employed the tissues will attract more fluid from the blood-vessels, the very thing that infusion is meant to correct. A weak solution is also likely to cause the breaking up of a number of the red blood corpuscles.

Transfusion. Direct transfusion of blood from a healthy individual to the patient has been replaced by infusion of a saline solution. As, however, in recent years transfusion has been employed in a few cases of pernicious anæmia, a brief account of the method will be given here.

Dr. Aveling's method, modified by Mr. Cripps, is simple, inexpensive, and has the advantage of measuring the blood sent, viz. 2 drachms at each squeeze of the bulb. The apparatus (Fig. 5) consists of two cannulæ connected by a short length of rubber tube in the centre of which is a rubber bulb, the capacity of which is 2 drachms. The skin having been cleansed, the veins exposed and probes passed beneath them, the apparatus is filled with a warm sterilised normal saline solution, and a clip placed at either end. The arms of receiver and donor being brought close together, the vein of the receiver is opened with sharp scissors, and pressure being made just below the opening in the vein, so as to prevent blood obscuring the opening, the cannula is inserted. The other cannula is then inserted into the vein of the giver, and both are held steadily by an assistant. Transfusion is then performed as follows:

"The clips having been removed from the tube at either end, the operator makes the necessary valve to prevent regurgitation by compressing with the finger and thumb of one hand, the tube between the central ball and the giver. He then

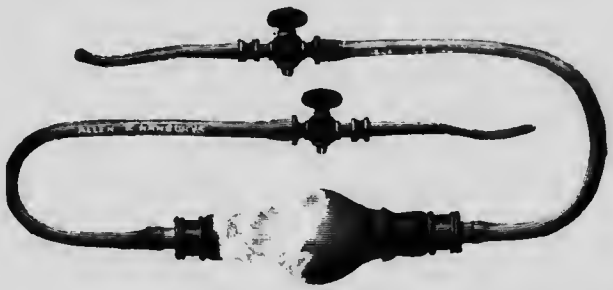


FIG. 5. Aveling's Transfusion apparatus with two cannulæ and two metal stopcocks.

slowly squeezes the ball, with the effect of driving the water it contains gently into the vein of the recipient; then, having compressed the tube between the ball and the recipient, he removes the finger and thumb from off the tube on the opposite side, allowing the ball to expand with the blood coming into it from the arm of the giver. When the ball is full the manipulation just described is repeated, and the blood passes into the vein of the receiver. In this manner, each time the ball is compressed, 2 drachms of blood are injected into the veins of the patient. Should the syringe appear to become blocked, or work unsatisfactorily, it can be detached and washed out without removing the cannulæ from the veins."

Needless to say the operation is accompanied by considerable risk, especially from thrombosis and embolism.

II. SKIN-GRAFTING

Skin-grafting is employed in the treatment of ulcerating or granulating surfaces, with a view to obtain rapid and sound healing with a minimum amount of contraction. Three methods, Thiersch's, Reverdin's, and Wolfe's, will be described.

(1) **Thiersch's method** is often called for where large open surfaces are left to heal, *e.g.* after burns, removal of the breast on wide lines for carcinoma, ulcers of the leg, extensive lupus, and the like. The following steps must be considered:

(*a*) *Preparation of the patient and the surface to be grafted.* The patient must be in a satisfactory condition, and one who can be relied upon to keep the affected parts at rest. The surface must be either a recently made wound, or, if an ulcer of any kind, one in which healing has

begun. It is useless to graft while active ulceration is going on. Above all, the surface must be aseptic. Should the raw area be covered with foul discharging granulations, there is nothing better than curetting once or twice with the aid of eucaine if needful, followed by the use of hot boracic fomentations and the occasional application of silver nitrate or pure carbolic acid. In any case the ulcer and surrounding surface must be carefully prepared. The adjacent skin must be shaved over a sufficient distance from the ulcer, and then thoroughly scrubbed and cleansed. Hot fomentations, which are changed four-hourly, are applied to the prepared area. This treatment is continued until the ulcerated surface is covered with healthy granulations, when it is fit for grafting.

(*b*) *Preparation of the area from which the grafts are to be taken.* The grafts may be taken from the skin of the arm, the forearm, or the thigh. The first two have the advantage that the skin is usually less hairy, but in extensive cases, *e.g.* burns, grafts will be required from more than one region. The surgeon should always see that the area prepared is conveniently situated in relation to the surface to be grafted. The day before the operation the selected area is carefully shaved and cleansed, and is then covered by sterilised pads which are not removed until the time of the operation.

(*c*) *The actual grafting.* The patient having been anæsthetised, the prepared skin and the ulcer are exposed with all aseptic precautions.

FIG. 6. Thiersch's skin grafting knife.

Should the former be covered with red, healthy, non-exuberant granulations, the grafts may be directly applied. It is better, however, to remove by gently curetting with a sharp spoon all the watery superficial layer of granulations until the deeper, firmer layer of newly formed fibrous tissue is reached. The healing edge of the ulcer should also be scraped away. These proceedings are followed by free oozing which must be stopped by pressure with sterilised swabs wrung out from saline at a temperature of 120°. Should removal of the pads cause fresh hæmorrhage a piece of sterile green protective, which is non-adherent, may be used to cover the surface before the pressure is applied. In troublesome cases a few drops of adrenalin hydrochloride (1 in 1000) may be poured on the oozing surface. The prepared area of skin is now moistened with sterile normal saline solution,[1] and the grafts are cut as follows: The operator, with his hand placed under the limb, stretches the skin from side to side, while assistants, if necessary, keep it on the stretch above and below. With a broad and heavy razor (Fig. 6) the grafts are now cut. The blade, which is kept wet with sterile saline solution, is placed at such an angle to the skin that when it is entered and carried along it will remove a very thin shaving of the epidermis, filmy and greyish-white, falling at once into delicate folds as it is cut and exposing, and only just exposing, the

[1] The usual strong antiseptic solutions may injure the vitality of the grafts and hence should not be used. If any have been used in the preparation of skin or instruments they must be removed by freely washing with saline solution

tops of the papillæ. It is then carried on with a rapid to and fro lateral sawing movement. Both the skin, which must be kept carefully on the stretch the whole time, and the razor must from time to time be wetted with a few drops of sterile salt solution. With practice grafts may be cut four or five inches long and one or two inches wide. They should consist of the horny and the superficial part of the malpighian layer, the tops of the papillæ being only just trenched upon.[1] When the cutting of each graft is finished, an assistant should set it free by one cut with a sharp pair of scissors. All layers of clot, oozing, or other liquid must be carefully removed from the surface to be grafted, with dossils of sterilised gauze. The grafts should then be transferred directly on the razor, or on a histological section-lifter, laid down each with their cut surface in contact with the raw area, and then gently and evenly flattened out with needles. Sir W. Watson Cheyne and Mr. Burghard give the two following useful hints: "The grafts should overlap the edges of the skin, and also each other, so that no part of the raw surface is left exposed, for granulations always spring up on the uncovered parts; furthermore, a thin scar, which may subsequently break down, is left at these points. In spreading out the graft it will be found that air bubbles collect beneath it, and also that some amount of oozing goes on, and the bubbles and clot may prevent complete adhesion of the graft. Hence, the next procedure is to get rid of them by pressure. If that be attempted by means of sponges the grafts are apt to be displaced. The following is the best plan: strips of protective about an inch in breadth, and long enough to overlap the edges of the wound, sterilised in 1 in 20 carbolic lotion, and subsequently rinsed in saline, are applied firmly over the grafted surface, beginning at the lower part. Each strip should overlap the one below, just as in the case of strapping, and they should extend well on to the skin at each end. If each strip, as it is put on, be grasped by the two ends and firmly pressed down, the pressure thus applied suffices both to expel the air bubbles and blood, and also to arrest further oozing." A dressing of iodoform or cyanide gauze and absorbent wool is then applied with firm even pressure. If the surface be on a limb, this must be kept at rest on a splint. When the oozing has been stopped satisfactorily before the grafts are applied, so that risk of their displacement on this account does not exist, the following dressing will give excellent results. Two thicknesses of sterilised gauze are cut of such a size and shape as to cover the grafted area and extend in every direction for two inches on to the healthy skin. The gauze, evenly spread out, is placed over the grafts, and is secured in position by painting its edges with collodion, none of which should come within half an inch of the wound. When the collodion has set, a warm saline fomentation is put on. Any discharge from the wound can readily escape through the meshes of the gauze and is absorbed by the fomentation which can be changed as often as is necessary without danger of disturbing the grafts. In either case the dressing on the grafted surface should be left for five or more days, if possible. Its removal must be effected with much care. If successful the grafts should have a pink colour and be adherent. If white or greyish in tint they are no longer alive.

[1] A test of the proper depth cut into by the razor is shown by the nature of the bleeding, and the rate at which this occurs. It should be minutely punctiform, very slight, and slow in making its appearance.

The surface from which the grafts were taken may be dressed with a roll of sterilised gauze, which may be removed after a week or ten days.

Should it be necessary, grafts will retain their vitality for a considerable time in normal saline at a temperature of 100, and may be conveyed in this solution to be used for a patient at some distance from the one from whom the grafts were taken.

The technique of grafting a fresh wound is in all essential points similar to the above.[1]

(2) **Reverdin's method.** While undoubtedly inferior to that of Thiersch, this method has still a place in surgery as, for example, in completing the healing of a large burn or lupus of the face. Owing to its not needing an anæsthetic it may be employed for elderly patients, or when an anæsthetic is considered undesirable. A small portion of the skin, which has been sterilised, is picked up with a needle and is quickly removed with small, sharp, curved scissors. The tiny grafts thus obtained are arranged at close intervals over the granulating surface. Otherwise, as in the case of Thiersch's grafts, granulations will spring up in the intervals between, and gradually destroy them. The epithelium from each graft may be expected to grow to about the size of a sixpence and then stop, so that unless they are sufficiently close complete healing of the area will not be attained.

A useful and convenient way of cutting these small grafts is to freeze the skin by means of an ethyl chloride spray, and then to remove small, thin portions of the frozen skin by a sharp razor. Freezing does not interfere with the vitality of the grafts, and owing to its anæsthetic action, renders the operation practically painless.

In either case a gauze and collodion dressing may be employed as described for Thiersch's method.

(3) **Wolfe's method.** Here the whole thickness of the skin and subcutaneous [1] is removed without any pedicle from the most vascular area available. While the percentage of failures is much greater than in Thiersch's method, cases occasionally present themselves in which a trial of this method is indicated, *e.g.* when a thicker covering is required than is afforded by Thiersch's method, as in the palm of the hand. When this method is successful, its results are most satisfactory. While part of such a flap may perish, enough may survive for the surgeon's purpose. Mr. Keetly thus describes Wolfe's method.[2] "When such a graft has been cut out, half a dozen Lane's tissue forceps should be attached around its edges. "Place it, raw surface upwards, on a sterilised towel and a convex surface, usually the thigh or chest of the patient. Stretch the flap in every direction by pulling at the forceps. Shave off all the fat. Stretch the flap again to take the tendency to curl up out of it. Swing it into place. Secure it with a few sutures. But cut away all the forceps with sharp scissors so as to leave no bruised skin behind, the most rigid asepsis being desirable to secure success." Mr. Kennedy, of Glasgow, has published[3] some figures which show excellently what Wolfe's method may effect in cases where it has been necessary to fill up gaps left by the removal of cicatrices from the fingers and hand.

[1] To take one particular instance. Any one who has to face the difficulties presented by a case of avulsion of the scalp will find useful information in a paper by Dr. Mellish (*Ann. of Surg.*, 1904, p. 664).

[2] *Lancet*, March 4, 1905.

[3] *Brit. Med. Journ.*, April 29, 1905.

CHAPTER III

SOME GENERAL POINTS WITH REGARD TO AMPUTATIONS, THE LIGATURE OF ARTERIES, AND THE SURGERY OF BLOOD-VESSELS AND LYMPHATICS

Owing to the improvements in modern surgery, especially the general adoption of the principles of asepsis, amputations are less frequently called for, and occupy a position of far less prominence than in former days. This is largely owing to the fact that, with modern methods, conservative treatment is possible after even very severe injuries, and also in many cases of disease, of bones or joints. Amputations, however, are still necessary in a number of conditions, chief among which are the following: (1) For severe injuries, especially bad crushes with compound comminuted fractures involving articular surfaces, or associated with injuries to main vessels and nerves. (2) In many cases of gangrene. (3) For malignant growths, especially of bone. (4) For some cases of suppuration, such as acute septic osteomyelitis with threatening pyæmia or septicæmia. (5) For advanced and intractable cases of tuberculous disease of bone or joint.

In every amputation the aim of the surgeon should be to secure a sound stump, free from disease, and capable of supporting a suitable artificial limb. The soft parts should form an ample covering for the bone and the scar should be so placed as to escape all unnecessary pressure. These ideals must be borne in mind in every amputation. In former days "set" amputations were the rule. At the present time it is usual to consider the merits of each individual case according to the situation of the disease and the position of healthy tissues in the formation of the flaps. A satisfactory stump, then, should be composed of healthy tissues; it should be painless, capable of supporting an artificial limb, and in the case of the lower extremity, able to bear very considerable pressure.

It will now be necessary to consider some of the causes of painful or otherwise unsatisfactory stumps. First of all, the scar may be *painful, tender, and prone to ulcerate*. This is especially likely to be the case if the flaps were cut too short, so that there was some tension on them as they were brought together over the divided bone. Under these circumstances the scar is likely to be adherent to the deeper structures, and is then very apt to break down. It must therefore be remembered in all amputations that the flaps must be cut long so that they come together quite loosely and without the slightest tension, and that as far as possible they must be so shaped that the scar is not subjected to pressure.

The opposite fault is, of course, also to be avoided, for if the flaps be cut too long, the blood-supply is likely to be inadequate; sloughing

may then occur and again lead to a painful and adherent cicatrix. Should the severed ends of the large nerve trunks be involved in the scar, the latter will be extremely tender and sensitive on even the slightest pressure. In other cases the ends of the large nerves may become swollen and bulbous, a condition sometimes known as a "traumatic neuroma"; such a swelling will also probably render the stump incapable of bearing any pressure. Both these troubles may be avoided by cutting the large nerves as short as possible. Pain may also be caused by chronic osteitis usually due to sepsis. To avoid this it has been advised to cut a flap of periosteum so as to provide a covering for the sawn surface of the bone.

Conical Stump. In this condition, which often renders the stump painful and useless, its extremity is shrunken and pointed so that it has a conical shape, the end of the bone projecting at the apex of the stump where the superficial tissues are tightly stretched over it. Conical stump may be the result of sloughing of the flaps, or these may have been cut too short at the operation. It not infrequently occurs in children as the result of the continued growth in length of the bone from the epiphyseal line after the operation. The treatment for this condition is re-amputation at a higher level, care being taken that the flaps are of sufficient length and that the bone is sawn through as high as possible. An otherwise excellent stump may occasionally be functionally a failure owing to stiffness or want of mobility. This is especially seen in amputations of the fingers through the first inter-phalangeal joint, where the want of any attachment of the flexor tendons may result in a stiff projecting stump which is useless or even a source of annoyance to the patient.

METHODS OF AMPUTATING

These will naturally depend upon the situation and nature of the disease requiring treatment and also upon the position of healthy tissues. The various methods will be described in detail in the descriptions of amputations in the different regions. A brief summary of the chief methods may, however, be given here:

(1) **The circular method** (Fig. 87). This is the simplest of all amputations. The skin and the superficial fasciæ are divided by a circular cut round the limb in a plane at right angles to its axis. With a few touches of the knife a cuff, consisting of skin and fascia, is turned up for a distance of about two inches in the case of the upper limb, and for three or four inches, according to its size, in the case of the lower. The muscles are then divided by a similar series of circular cuts at the level of the upper limit of the cuff. The soft parts are thoroughly retracted and the bone sawn through at as high a level as possible. The circular method is especially adapted to those situations where there is a single bone uniformly surrounded by a thick layer of soft tissues, as in the thigh and the arm. Such an amputation can be performed quickly, and gives a good covering to the end of the bone; the chief objection is that the scar necessarily is placed at the end of the stump.

(2) **The modified circular method.** Here two small, equal flaps of skin and subcutaneous tissues are cut in place of the cuff described above. A reference to Fig. 89 will make this modification clear.

(3) **The elliptical method.** This resembles the circular, but the knife instead of passing transversely round the limb is made to divide the tissues obliquely. The advantages of the modification are: the scar can be made to occupy a position where it will escape pressure; and healthy tissues on one side of a limb can be utilised when an injury has extended more on one side of the limb than the other. This method can be employed for disarticulation through a joint.

(4) **The racket incision.** This is very commonly employed for disarticulations. An incision is made in the longitudinal axis of the limb, commencing above the joint and extending vertically down to a sufficient distance below it. It is then carried in an elliptical fashion round the limb back to the point from which it originally diverged from the longitudinal incision (Figs. 16, 17 and 99). It will thus be seen that the racket incision is a combination of a longitudinal and an oval incision.

(5) **Flap methods.** Here flaps fashioned from the soft parts are employed to cover the sawn end of the bone. They are of various shapes and sizes, and can be cut according to the situation of the injury or disease, and also in such a way as to secure a satisfactory covering to the bone and a convenient position of the scar. Flaps may be equal or one may be larger than the other. They may be antero-posterior, or lateral, or intermediate between these.

In cutting flaps care must be taken that they are not pointed. They should be broadly rectangular with the angles rounded off, or V-shaped. They must be of sufficient length to come together without tension, but must not be too long, for then the blood-supply may be inadequate and sloughing is likely to occur. The tendency for the muscles to retract must also be remembered and also that the flexors retract more than the extensors.

Flaps are usually cut so that at first only skin, superficial and deep fasciæ are taken up; the knife then is made to enter the muscle obliquely so that at the base of the flap the whole thickness of the muscle down to the bone is included.

In other cases skin flaps are employed. Here the flap is composed of skin, superficial and deep fasciæ only; special care must be taken to include the latter in order to ensure a good blood-supply. To make certain of this, a few muscle fibres should be seen on the deep aspect of the flap. The muscles are then divided at a higher level by a circular sweep of the knife.

Flaps are occasionally cut by **transfixion,** *i.e.* by passing a long knife through the thickness of the limb at the situation of the base of the proposed flap and then cutting from within outwards so that the skin is divided after the other soft parts. This is a very rapid method, and, before the days of anæsthesia was on this account much employed. Though seldom made use of at the present day, when rapidity is of less importance than the certainty of a satisfactory stump, it can occasionally be made use of with advantage, for instance, when the flap contains numerous tendons and but little muscle as in the forearm (Fig. 72).

When flaps are cut by transfixion a long knife measuring one and a half times the diameter of the limb is required. In all other cases a shorter knife, not more than three or four inches in length, is all that is necessary.

In all amputations care must be taken to control the bleeding during the operation. Generally this is effected by some form of tourniquet. In some instances where the amputation is close to the junction of the limb and the trunk for example, a tourniquet cannot be employed. The means for controlling hæmorrhage under these circumstances is described in the accounts of amputations through the shoulder and hip joints. As a general rule in amputations, drainage should be secured by a tube inserted between the flaps.

LIGATURE OF ARTERIES

Ligature of an artery in its continuity is another operation which, owing to the developments of surgery, does not occupy the position of importance which it formerly held. As a test of manipulative skill, and for the knowledge of surgical anatomy for which it calls, it is a favourite examination test and must on that account receive close attention in the operative surgery class-room. It will be well therefore to give some general rules for the ligature of arteries. Generally speaking, though there are exceptions to this rule as in ligature of the posterior tibial, the incision should be made in the line of the artery. The length of the incision will depend upon the depth of the vessel to be secured. Though it must not be unnecessarily long it should be of sufficient length to allow of the ready identification of the deeper structures. This is of special importance when the artery is deeply placed, as, for instance, the lingual. Fasciæ should be divided by clean cuts with the knife; muscles should, when possible, be separated, deeper planes being reached through the intermuscular septa. If it is necessary to divide a muscle it should not be cut across, but its fibres should be separated by a blunt instrument. If the artery to be ligatured is situated in the forearm or in the leg below the knee, it is accompanied by companion veins which form a more or less complicated anastomosis around it. Any attempt to separate the veins from the artery is sure to result in injury to and troublesome hæmorrhage from the former structures. They should therefore be included in the ligature. In the larger arteries it is of the utmost importance that the companion vein should not be injured. In the case of these larger arteries the sheath should be opened by a short longitudinal incision, and the vessel cleared from this by a blunt instrument. An aneurysm needle of suitable curve and shape is then gently insinuated around the vessel, care being taken that the instrument is between the vessel and its sheath, and that it does not pierce the latter. Generally speaking, the needle should be passed from the side on which the companion vein is situated, in order to minimise the possibility of injury to this structure. The aneurysm needle should be passed unthreaded. An examination is made with the finger to ensure that the artery, and the artery alone, has been included. The needle is then threaded with a thread of the material to be employed. Carefully sterilised silk or catgut may be employed, the former is, perhaps, preferable for a large artery in an aseptic wound. In the case of a small vessel when the needle has been withdrawn, the thread is tied tightly so as to divide the internal and the middle coats. In the case of large arteries Ballance and Edmunds (*see* p. 714) advise that the thread should be tied so as to occlude the artery without division of the coats. They advise that the first thread should be tied so as to arrest the circulation. One or more further strands are then passed and again tied in a single knot so as

to occlude the artery without division of its coats. The two ends of each of the two threads are then taken and tied together so as to complete the knot.

In the living subject an artery can be easily recognised by its pulsation. In the dead body this help is, of course, absent. In this case, when there is any doubt, the artery may be recognised by compressing it between the finger and the aneurysm needle. An artery may then be recognised by the way in which it flattens out, like a ribbon, with a distinct longitudinal groove. A nerve-trunk feels like a rounded solid cord.

ARTERIORRHAPHY

It is now realised that it is possible to close wounds in arteries, or even to unite the ends of completely severed vessels, by means of sutures, without obliteration of the lumen, and without permanent interference with the circulation. The feasibility of suture of arteries has been amply proved by the experimental work on animals of a number of workers, especially Carrel and Guthrie,[1] and Watts.[2] The possibility of suture was first indicated by Murphy and Senn. It is obviously of the greatest importance to know from the clinical point of view that this procedure is possible. An injured vessel may be of such magnitude and importance that its obliteration may mean the practical certainty of gangrene, or death from disturbance to the circulation. There is still a great deal to be done with regard to the employment of arteriorrhaphy in clinical surgery, but it has been, or may be, of use under the following circumstances:

(1) Wounds of large vessels, *e.g.* the carotid, femoral, or iliacs. Thus Dr. Lund, of Boston,[3] reports a case in which he successfully sutured the femoral artery and the femoral vein in a girl æt. 14, both vessels having been perforated by a stab from a knife. Dr. Lund considers that suture of the vessels undoubtedly saved the leg and foot of the patient.

(2) A large artery may be incised for the purpose of removing an embolus and the wound subsequently sutured. Mr. Handley describes an interesting case in which he attempted the removal of an embolus from the femoral artery in the *Brit. Med. Journ.*, vol. ii. 1907, p. 702.

(3) The reversal of the circulation in a limb for threatened or actual gangrene where this is due to interference with the arterial blood-supply as in senile gangrene. In such cases it is possible that more blood could reach the extremity through the healthy vein than through the diseased artery, and that in this way extension of the gangrene could be prevented. That this operation can be carried out in dogs has been proved by Carrel and Guthrie.[4] It has also been performed on several occasions on patients with gangrene with some success.[5] It is, however, open to question to what extent and in what cases it should be employed.[6]

(4) In Matas's operation for aneurysm (*vide infra*).

[1] Johns Hopkins *Hosp. Bull.*, vol. xviii. January 1907.

[2] *Ann. of Surg.*, 1907, vol. xlvi. p. 373.

[3] *Ann. of Surg.*, 1909, vol. xlix. p. 394.

[4] *Ibid.* 1906, vol. xliii. p. 203.

[5] Hubbard, *Ann. Surg.*, 1906, vol. xliv. p. 559; Wieting, *Deutsch. Med. Woch.*, 1908, July 9; G. P. Muller, *Ann. Surg.*, 1910, vol. li. p. 256; Morriston Davies, *Ann. Surg.*, 1912, vol. lv. p. 864.

[6] A paper by Dr. Bertram Bernheim (*Am. Surg.* 1932, vol. lv. p. 195, may be consulted. Here will be found a review of the literature of the subject with an account of a number of cases.

(5) Carrel and Guthrie (*vide supra*) have shown experimentally that a portion of vein may be grafted so as to form a junction between the widely separated ends of a divided artery.

(6) For arterio-venous aneurysm, as in case described by Dr. Gilbert Kemp.[1]

The operation. In the suture of arteries the most rigid asepsis is absolutely essential. The vessel must be exposed for a distance of two inches above and below the injured spot. Hæmorrhage must be controlled by some method which avoids injury to the wall of the artery. Crile's clamps may be employed (Fig. 7) or a piece of sterilised tape may be slipped beneath the artery; an assistant then places the tip of his finger on the artery and by gently drawing on the ends of the tape controls the flow of blood. The outer connective-tissue coat is first gently clipped away, as otherwise shreds of this are certain to be drawn in between the other coats, thus preventing their exact approximation. The finest rounded needles must be used; both straight and curved should be at hand, though the former are, as a general rule, to be preferred. The material for the suture should be extremely fine silk, which should be impregnated with sterilised vaseline in order to facilitate

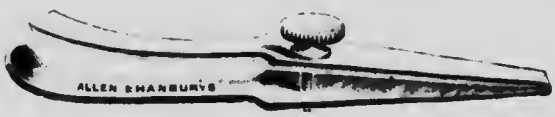


Fig. 7. Crile's artery clamp.

its passage through the vessel wall. The artery must always be handled with the utmost gentleness, any rough treatment from forceps being especially undesirable. The sutures must be passed so as to bring the surfaces of the inner coat into absolute apposition and at the same time to avoid the projection of the silk into the lumen of the vessel. This may be accomplished in one of the following ways:

(*a*) *Dorrance's method.*[2] The following description is taken from Burghard's "System of Operative Surgery," vol. i. p. 263:

"When suturing a longitudinal incision the thread is first entered about an eighth of an inch from one end of the incision, made to penetrate only the outer and middle coats, brought out again and tied, the free end being left long. The needle is now made to penetrate all the coats of the vessel from without inwards on one side of the rent and as near the edge as possible; it is then carried through the walls of the vessel on the opposite side of the rent from within outwards. It then re-enters the arterial wall from without inwards, passes across the incision and penetrates the opposite side from within outwards, thus making a mattress stitch. The suture, however, is not tied in the usual way, but is continued as shown in the diagram throughout the length of the wound; at every third loop the suture is carried back a stitch's breadth, as shown in the diagram, in order to maintain the steadiness of the approximation. On emerging at the other end of the incision the thread is passed through the outer two coats of the vessel (Fig. 8) and there is tied in a single knot. The continuous mattress suture thus formed is reinforced by a second continuous running stitch taking up the edges of the incision between the loops of the mattress suture; when this reaches the point at which the original suture commenced, the two ends are tied together and the suture is complete.

"When an end-to-end suture has to be made, the first suture is a mattress suture, the needle being passed through all coats of the vessel from without inwards on the proximal side, and from within outwards on the distal side, and back in the

[1] *Proc. Roy. Soc. Med.* (Surg. Sec.) 1913, vol. vii. p. 83.
[2] *Ann. of Surg.*, 1906, vol. xlv.

reverse direction. This gives a mattress suture with the ends projecting from the distal end; these are firmly knotted together so as to evert the ends of both segments. The remainder of the suture is completed by the continuous mattress stitch already described with the throw back at every third stitch. When this has completely encircled the vessel the end of the suture is fastened to the free end of the first mattress stitch. A continuous running stitch is carried all round, joining together the lips of the wound outside the first suture."

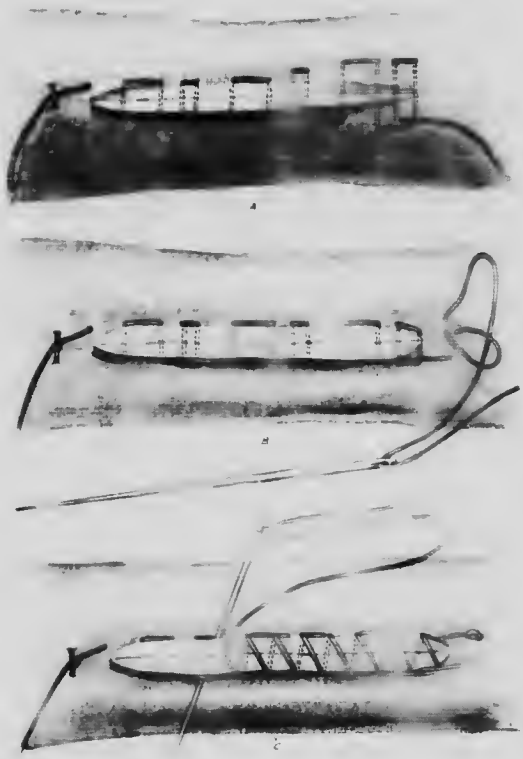


FIG. 8. Dorrance's method of suture of a longitudinal wound of an artery.

(*b*) *Dr* [illegible] the following technique for end-to-end anastomosis of vessels:[1]

"Three [illegible] fine silk are then laid at equidistant points of the circumferences of the vessels. An assistant then applies traction to two of these guides in turn, stretching the intervening [illegible] between the two sutures into a straight line, facilitating the laying of the suture, and preventing a narrowing of the lumen. If at this time the suture is weighted by a hæmostat the circumference of the vessel will be in the form of a triangle, the points of which are determined by the three [illegible] sutures, and there will be no danger of catching the opposite wall when placing the suture. The suture is a continuous overhand stitch through all the coats; the separate stitches should be drawn just tightly [illegible] suture absolute approximation, but not too tightly lest the tissues be [illegible] must be placed very close together. After the completion of the [illegible] the removal of the clamps there will often be some hæmorrhage; if this [illegible] few interrupted stitches may be inserted, but a considerable hæmorrhage [illegible] always stop under gentle digital compression."

[1] *Ann. of Surg.*, 1907, vol. xlvi, p. 358.

Matas's Operation, or Endo-aneurysmorrhaphy. This operation, since it involves the principal of arterial suture, may be described here. It was first described by Dr. Matas[1] in 1903 after an experience of four cases.

Dorrance's method of end-to-end anastomosis of vessels.

Since then it has been widely adopted, especially in America, and has given very satisfactory results. In this operation the sac, after the circulation is controlled by a tourniquet or other convenient form of compression, is laid freely open. No ligatures are applied to the main artery. The circulation in the sac is arrested and haemostasis is secured by suturing the arterial orifices found in the interior of the sac. The cavity of the aneurysm is then obliterated by inverting or invaginating the walls with the attached overlying skin. The flaps thus formed are sutured to the bottom of the cavity, so that no space is left to invite suppuration and secondary complications. Dr. Matas states that the operation is applicable to all aneurysms in which there is a distinct sac and in which the cardiac end of the main artery can be provisionally controlled. "It is especially applicable to all forms of peripheral aneurysms of the larger arterial trunks (carotid, axillary, iliac, brachial, popliteal); and, while the author has had no experience with similar lesions of the large visceral trunks, the principle suggested would appear to be applicable to aortic abdominal and other accessible forms of abdominal aneurysms."

Fig. 10. Endo-aneurysmorrhaphy. (Matas.)

The operation is based upon the following principles: (1) The sac is regarded as a large diverticulum or prolongation of the parent artery: (2) the lining membrane of the sac is a continuation of the intima which lines the interior of the artery: (3) that the sac itself when not disturbed from its vascular connections, is capable

[1] *Ann. of Surg.*, 1903, vol. xxxvii, p. 161.

of exhibiting all the reparative and regenerating reactions which characterise the endothelial surfaces in general.

The operation is described by Dr. Matas under the following heads:

(1) Prophylactic haemostasis. This may be effected by a tourniquet or Esmarch's bandage, by compression by Crile's clamps (Fig. 7), by a traction loop (*see* p. 51), or by direct pressure from the finger of an assistant.

(2) Incision of the skin and exposure of the sac. This must be thoroughly exposed by a free incision exhibiting it from one end to the other.

(3) Opening of the sac and evacuation of its contents, recognition of the type of sac, number of openings, &c. A free incision is now made opening the sac from one end to the other. The contained blood and clots are evacuated and the interior of the cavity displayed by free retraction of its edges. In a fusiform aneurysm two large openings will be seen separated by a variable distance, though often connected by a shallow groove representing the floor of the parent artery. A saccular aneurysm shows a single opening which connects the sac with the main artery. Search must also be made for the openings of branches springing from the sac, which if not sutured would give rise to troublesome haemorrhage. If there is any bleeding from the orifices as a result of the free collateral supply, the closure of these openings by suture should be at once proceeded with. Laminated clot is then cleared away by gently scrubbing the interior with sterile gauze soaked in saline solution.

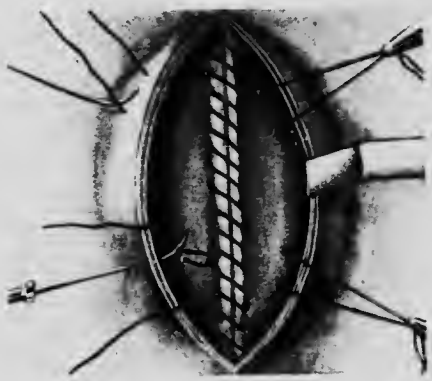


Fig. 11. Endo-aneurysmorrhaphy. (Matas.)

(4) Closure of the orifices in the fusiform type of sac (Fig. 10). The systematic closure of all visible orifices should now be proceeded with. Either silk or chromicised cat-gut may be employed. Full curved intestinal needles are best. In the larger openings the needle should penetrate at least one-sixth or a quarter of an inch beyond the margin of the orifice, and then, after reappearing at the margin, dip again into the floor of the artery, and continue to the opposite margin as in the start. When the openings must be closed quickly the dip of the needle into the floor of the vessel may be omitted, and the margins brought quickly together with a continuous suture. In all cases intima must be brought into exact contact with intima. A second row of sutures to bury the first is often advantageous.

(5) The saccular aneurysm with a single orifice. Reconstructive suture with the view of preserving the lumen of the parent artery (Fig. 12). The intrasaccular suture of the orifice not only permits of the radical cure of the aneurysm by closing its orifice but also allows the restoration of the affected artery to its functional and anatomical integrity. The same needles and materials should be used as in the previous case. The sutures should be inserted at a sufficient distance from the usually thick and smooth margins of the opening in order to secure a firm and deep hold of the fibrous basal membrane. The needle should be made to appear just within the lower edge of the margin, care being taken that when the sutures are tightened the calibre of the artery will not be encroached upon so as to obstruct its lumen, and that the threads will not be brought in contact with the blood in the lumen of the vessel. Greater care must be exercised in securing accurate co-aptation in this class of cases than in the fusiform type.

(6) Removal of constrictor and test of sutures. When all visible orifices have been closed the provisional expedient for controlling the circulation is removed. The interior of the cavity should now be perfectly dry. If there be any oozing of the capillary points these will usually be stopped by pressure and by the means adopted to obliterate the cavity.

(7) Obliteration of the sac. This is effected by turning the relaxed flaps of skin into the interior of the cavity. If the sac has not been previously dissected from its surroundings, the skin flaps will be lined on their inner surfaces by the smooth sac walls thus constituting an aneurysmo-cutaneous flap on each side. These

flaps can then be held down in the bottom of the cavity by two relaxation sutures on each side. These sutures are best applied by a large full-curved intestinal needle which should penetrate the entire thickness of the sac grasping a considerable portion of the sac wall. In this way a loop is formed, the two ends of which are carried through the skin flaps by transfixion with a straight Reverdin's needle, and then tied firmly over a pad of gauze after the flaps have been carefully in position. The edges of the skin which then come into contact in the adjusted mid-line are united by a few interrupted sutures. Where the bulging tumour previously existed there will be a depression varying in depth according to the size of the original sac; no cavity is left and there is no need for drainage. The collateral circulation, which is usually important in the vicinity of an aneurysm, is also respected, and in this way the best condition for the maintenance of a healthy nutrition in the sac and in the parts beyond the aneurysm are assured. Dr. Matas suggests that in iliac and other abdominal aneurysms the peritoneum covering the sac should be utilised in the same way as the skin in external aneurysms in the process of obliterating the sac.

Fig. 12. Endo-aneurysmorrhaphy. (Matas.)

Results of the Operation. A number of successful cases have been recorded in the various medical journals. Dr. Matas, in a paper read before the American Medical Association in 1908,[1] collected a total of 85 cases. Of these 7 died after the operation, though in 5 of these the operation was only very indirectly the cause of death. Of the remaining 78 cases there were only 2 cases of secondary haemorrhage, 4 of gangrene and only 4 relapses, all in reconstructive operations.

OPERATIONS ON THE LYMPHATICS

The operation of lymphangioplasty may be described here. This was originally introduced by Mr. Sampson Handley in 1908[2] for the relief of the condition known as "brawny arm," which not infrequently appears in the late stages of carcinoma of the breast and is the source of great suffering to the patients. Mr. Handley points out that the lymphatic obstruction is due to the permeative spread of growth cells along the lymphatics and a peri-lymphatic fibrosis which is thus produced. "The plug of cancer cells within the lymphatic, continuing to proliferate, finally splits up the lymphatic. Around the microscopic trauma thus caused a vigorous round-celled infiltration occurs, to be replaced later by a capsule of newly formed fibrous tissue, which contracts upon, and ultimately strangles, the enclosed cylinder of cancer cells. The original lymphatic vessel is replaced by a solid, microscopic, fibrous cord, and the process of peri-lymphatic fibrosis is complete." The method which Mr. Handley employs consists in introducing into the subcutaneous tissues of the affected limb a number of buried silk threads, running upwards from the wrist and terminating above in the healthy tissues in or beyond the axilla. "The operation is closely analogous to the drainage of a marshy field by lines of buried pipes." The operation is a simple one. An incision is made near the wrist. Through this a long probe provided with an eye is thrust upwards

[1] *Journ. Amer. Med. Assoc.*, vol. li, p. 1667. Dr. Matas has also published a later and more complete list of cases (*Trans. Amer. Surg. Assoc.*, 1910, vol. xxviii, p. 4). A discussion on the Surgical Treatment of Aneurysm, opened by Mr. Gilbert Barling before the Surgical Section, Roy. Soc. Med. (*Trans. Roy. Soc. Med.*, Surg. Sect., June, 1912, p. 159) may also be read with advantage.

[2] Hunterian Lectures, *Lancet*, 1908, vol. i, p. 1207.

as far as possible through the subcutaneous tissues. The point is then cut down upon. A long silk thread is threaded through the eye of the probe, which is drawn through the upper incision. The end of the thread at the lower incision is then secured by a pair of forceps to prevent it being pulled out of view. The probe is then again introduced for its whole length in an upward direction and the silk again drawn upwards. The process is repeated until the upper end of the silk reaches healthy tissues. The wounds are then all closed and the silk thread is left completely embedded. Any number of threads can be introduced by repeating the process. Stout silk threads remain unabsorbed for years, and the absence of organisation and coagulation in the interior ensure the retention of its capillary power.

The following is one of the cases described by Mr. Handley in the paper quoted above:

The patient, a woman aged 56 years, was admitted to the cancer wards of the Middlesex Hospital on January 18, 1908. In 1894 a portion of the right breast was removed at the Chichester Hospital for carcinoma. In 1896 recurrences in the breast and axilla were removed at St. Mary's Hospital. In 1903 two or three small recurrent growths were removed from the axilla. In 1905 the right arm became swollen; it slowly became paralysed, and has been the seat, during the past three years, of excruciating pain which frequently kept her awake at night. On admission there was no evidence of cancer in the body in the form of palpable tumours. The right nipple still remained intact and was not indrawn, and there was no lump in what remained of the right breast. The chest and abdomen were free from deposits. The growth was evidently an atrophic scirrhus, which had undergone an almost complete process of natural cure. The right arm and hand below the deltoid were greatly swollen. The œdema pitted slightly on pressure, though it approached the solid variety. There was complete paralysis of the limb, save that the third and fourth fingers could be moved slightly. The hand was warm and of natural colour. Flexion of the elbow was only possible through 15° or rather less.

On February 1, under chloroform, a number of silk threads, each running upwards from the wrist to the loose tissue upon the chest-wall just below the axilla, were buried in the subcutaneous tissue. The operation produced no general disturbance of note. On the next day it was obvious that the bandages were loose and the strapping on the fingers was in the same condition and had to be frequently replaced. On the 6th it was noted that the arm and hand were quite flabby and much reduced in size. The skin was much wrinkled and hung on the fingers in folds. On the 7th the patient remarked that she saw her knuckles for the first time for years. The movements of the fingers were beginning to return and she was able to grasp very feebly. On the 10th the forearm and hand began to present an almost normal appearance, but much swelling of the upper arm remained. On the 24th the limb was continuing to diminish in size though less rapidly than at first. Unfortunately measurements of the limb previous to the operation were not taken, so that no accurate record remains of its rapid and marked subsidence in the earliest days after the operation. However, between February 6 and February 24 the circumference at the wrist diminished from 7¼ to 6⅞; just below the elbow from 10¾ to 9⅝; and 8½ inches below the acromion from 11 to 9¾. The pain disappeared and flexion of the elbow increased from 15° to 110°. The movements of the hand improved so that the patient could hold a pin between the finger and thumb.

Mr. Handley also suggests that this operation will be found of use in other cases of lymphatic obstruction, such as elephantiasis.[1]

[1] *Proc. Roy. Soc. Med. Clin. Sec.*, February 1909.

CHAPTER IV

AMPUTATIONS OF THE FINGERS. OPERATIONS ON THE HAND. TENDON-GRAFTING AND TRANSPLANTATION

Practical anatomical points. I. *Positions of the joints* (Fig. 13). This has to be remembered: (*a*) in front: (*b*) behind.

(*a*) *In front.* Three sets of creases correspond here, though not exactly to the joints. Of these, the lowest crease is just above the joint, the middle is opposite to the inter-phalangeal joint, the highest nearly three-quarters of an inch below the metacarpo-phalangeal joint.

(*b*) *Behind.* It is to be remembered (1) that in each case it is the upper bone which forms the prominence, viz. the knuckle is formed by the head of the metacarpal bone, the inter-phalangeal prominence by the head of the first phalanx, and the distal one by the head of the second; (2) that the joint in each case lies below the prominence, the distal joint being one-twelfth of an inch, the inter-phalangeal one-sixth of an inch, and the metacarpo-phalangeal joint about one-third of an inch below.[1]

Fig. 13. Surface markings of the joints of the fingers.

II. *Shape of the joints.* In the distal and the inter-phalangeal the joint is concave from side to side, and presents a concavity towards the tips; in the metacarpo-phalangeal joints, on the other hand, the convexity is towards the finger-tips.

III. *The Theca.* This fibrous tunnel, which extends downwards to the bases of the distal phalanges and upwards to the palm, is lined by a synovial sheath and transmits the flexor tendons. The sheath of the little finger is directly continuous with the palmar bursa which encloses the tendons of the flexor sublimis and the flexor profundus digitorum and extends upwards into the forearm. The sheath of the thumb also extends into the forearm and usually communicates with the palmar bursa. The theca gapes widely when cut, and hence there is, especially in the case of the thumb and the little finger, a channel along which infection can easily travel to the palm and even to the forearm. Care should thus be taken to keep even such a small amputation as that of a finger perfectly aseptic. The flaps of an amputation through damaged parts should not be too closely sutured; tension should be avoided and drainage provided.

[1] The terms "above" and "below" mean nearer to and farther from the trunk.

OPERATIONS FOR AMPUTATION OF THE FINGERS

As the rule is always to remove as little as possible, the actual method adopted will always depend upon the aspect of the finger from which undamaged soft parts can be obtained. The following amputations should therefore be practised, of which the first two are the best :

(1) Long palmar flap (Figs. 11, 16 and 20).

(2) Long palmar and short dorsal flap (Figs. 18 and 20).

(3) Two lateral flaps (Figs. 17 and 20). These may be (*a*) equal; (*b*) unequal.

(4) One long lateral flap.

(5) Two equal antero-posterior flaps.[1]

Of these, the palmar flap is usually the one made use of. Though, as the hands are by far most frequently held in the prone position, a dorsal flap falls more easily into place, and gives a more concealed scar a palmar flap has the greater advantages of a scar which is not pressed upon when anything is held in the hand, of possessing finer sensitiveness in touch, and better nutrition; furthermore, this flap is available even in the last phalanx, where, from the presence of the nail, a dorsal flap is not obtainable (Fig. 14).

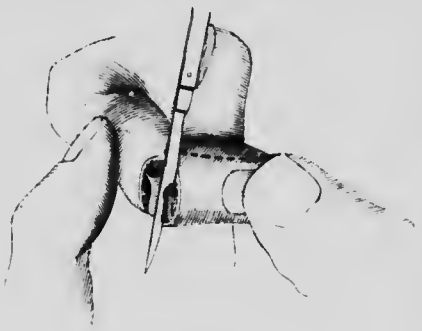


Fig. 14.

Amputation of a Distal Phalanx by a Palmar Flap (Fig. 14). *First Method.* The hand, together with the sound fingers, should be completely covered by a sterilised bandage. The hand then being well pronated and the adjacent fingers well flexed, the surgeon, having placed his left forefinger just below and behind the joint, and flexed the phalanx strongly with his thumb (a step not always easy with infiltrated tissues), cuts[2] with a slightly semi-lunar sweep and drawing the blade from heel to toe, straight into the joint. To effect this neatly, the convexity of the sweep should pass one-twelfth of an inch below the prominence or angle produced by flexion, the sweep being made by laying on the whole edge of the knife, while with the point, as this incision begins and ends, the lateral ligaments are partly cut. The joint being thus freely opened, the knife is insinuated in front of the base of the phalanx (a step which is facilitated by depressing and pulling on the phalanx), and then, being kept close to and parallel with the bone, cuts, with a steady sawing movement, a flap well rounded at its extremity about two-thirds in length of the pulp of the finger.[3]

Second Method. The hand being supinated, the finger to be operated on extended, and the others flexed out of the way, a palmar flap is cut

[1] These will produce a stump with an exposed scar.

[2] The knife in all these finger amputations should be narrow, short, and slender, yet strong.

[3] If the flap is insufficient, the head of the second phalanx must be removed. In this and in other amputations in the hand, owing to the soft parts cut through being often infiltrated and fixed, the flaps are easily made too short, from the desire of the surgeon to leave as much as possible.

by translixion, the knife being entered just below the palmar crease, the joint being then opened from the dorsum as before, and the phalanx lastly disarticulated. To cut flaps by translixion, however, is not satisfactory in amputations of the finger. Sir F. Treves sums up this question in the following words: "In no operation upon the fingers is it well to cut the flaps by transfixion. In cutting a palmar flap by this means there is danger of slitting up the digital arteries. The flap, moreover, is apt to be pointed and scanty, and to contain fragments of tendon."

Third Method. If the surgeon has no narrow knife by him, he may modify the last method by cutting his palmar flap first, but from without inwards; he then opens the joint from the dorsum, and disarticulates. As a rule no vessels require ligature. Any tendon that is jagged should be cut square.

Difficulties and mistakes in amputation of a Distal Phalanx. (1) The flap may, of course, be made too short; it is often made too pointed. I would take this opportunity of pointing out that as the bones of the hand are large in relation to their soft parts, the flap or flaps should always be cut sufficiently long. It is, indeed, a golden rule in all amputations that the flaps should be of sufficient length to fall together easily over the end of the bone and to come together without the slightest tension. If the flaps fit at all tightly it will be found when cicatrisation has occurred, that the scar is adherent, painful, or prone to ulcerate, or the bone may tend to make its way through the skin when pressure is made up in the stump. The student must then in this, his first amputation, fix upon his mind a rule which must be followed in all amputations, large or small—to measure with the eye whether the flap or flaps will be sufficient, just before each is finally cut.

FIG. 15. A. Flaps after amputation of terminal phalanx. B. Flaps after amputation through second phalanx. C. Amputation of second phalanx (Heath). In each case antero-posterior flaps have been made. In B the flexor tendon, and in C both flexor and extensor tendons, should be sutured as directed above, having been first cut long.

(2) If the phalanx be not sufficiently flexed, or if the site of the joint has not first been marked out with the nail, the latter will not be readily opened. It is very common for students, forgetting that in the case of each joint this lies below the corresponding prominence (Fig. 13), to cut above the level of the joint here, their knife sawing against the neck or head of the second phalanx.

(3) It is often difficult to pass the knife readily round the base of the phalanx, especially in cases where the blade is too broad, or where, as in well-developed hands, the base of the phalanx is strongly tuberculated.

(4) If there be any hitch in passing the knife behind the phalanx, the outline of the flap is very likely to be jagged, and sloughing may then ensue.

Amputation through, or disarticulation of, the Second Phalanx (Figs. 16, 17, 18). This, as a rule, should be performed through the phalanx, and, whenever this is possible, at or beyond its centre, so as to leave the upper half or third of the phalanx, and thus ensure the preservation of some attachment of the flexor sublimis. While the rule not to amputate a finger at the joint between the first and second phalanges, and *a fortiori* through the first phalanx, is a sound one, as there is a risk of leaving

a stump stiff and incapable of flexion, there is no doubt whatever that, where rapid healing has been secured, this amputation has been followed by the flexor tendon taking on a fresh and sufficiently firm adhesion, and so leaving a longer and, withal, a mobile stump.

In the following special cases the whole or part of the first phalanx may be left, and in all of them the severed flexor tendons, previously cut long, should be carefully stitched to the cut theca and periosteum, or into the flaps before these are adjusted. Another plan is to suture

FIG. 16. Amputations of the fingers and the thumb. The surface marking of the superficial palmar arch is also shown.

together the flexor and extensor tendons (cut long and square) over the end of the bone (Waring).

(1) In the case of the index finger the proximal phalanx will be a useful opponent to the thumb, as in holding a pen. (2) In the case of the little finger, leaving the proximal phalanx will give greater symmetry to the hand when this is fixed, and it may on this account be left. (3) In amputations of all the fingers the proximal phalanx of one should, if possible, always be left to oppose to the thumb. (4) Where a patient insists on having the proximal phalanx left, after the risk of stiffness has been explained to him. Provided that the divided flexor tendon is carefully sutured to the theca or to the extensors, the more the stump heals, and the younger the patient, the greater will be the movement gained.[1]

[1] Dr. Tiffany, of Baltimore (*Trans. Amer. Surg. Assoc.*, vol. ii, p. 826), says that he has been in the habit "for a number of years" of passing the stitches which unite the skin through the tendons and their sheaths in amputation at the joint between the first and second phalanges. "I have never failed, as far as I can remember, to secure quite as good movement as if Nature had originally made an attachment there for these tendons."

Methods. (1) By a long palmar or dorsal flap (Figs. 17 and 18) or by dorso-palmar flaps, the flaps being equal, or the palmar one the longer (Fig. 17).

(1) *By Dorso-palmar Flaps.* The surgeon, having marked with his left forefinger and thumb the spot where he intends to divide the bone, cuts between these points a short, well-rounded dorsal flap of skin; he then sends his knife across below the bone, making it enter and

Fig. 17. Amputation of the fingers and the thumb.

emerge at the base of the first flap, and cuts a palmar flap about two-thirds of an inch in length, and not pointed. The flaps are then retracted, the bone cleared with a circular sweep of the knife, and divided in the manner given below.

While long palmar and short dorsal flaps will give the best result, equal flaps, or a long dorsal flap, may be employed if there is more extensive damage to the soft parts on the anterior aspect of the finger.

(2) *By Lateral Flaps* (Figs. 16 and 17). The site where the bone is to be sawn having been marked by the left forefinger and thumb placed on the dorsal and palmar aspects of the finger at this level, the surgeon, looking over the finger, enters his knife in the centre of the palmar aspect, and carries it, cutting an oval flap, about two-thirds of an inch in length, to a corresponding point on the centre of the dorsum, and then from this point down again over the side of the finger nearest to

him, to the point where the knife was first inserted. The flaps being dissected up as thick as possible, and the remaining soft parts severed with a circular sweep, the bone is divided with the saw or bone-forceps. If the situation of the damaged tissues renders it desirable, one flap can be cut longer than the other. In using the bone-forceps the concave surface is always to be turned away from the trunk; if this precaution is taken, and the bones severed quickly with a sharp instrument, the section will be clean and not crushed. A fine saw is much the better instrument.

Amputation of a Finger, *e.g.* **second or third at the Metacarpo-phalangeal Joint** (Figs. 17, 18 and 20). This, the commonest amputation in the hand, being required for severe crushes, tuberculous disease, and some cases of whitlow, should be often practised. Before it is employed

Fig. 18. In the second finger amputation through the second phalanx is shown, the bone being divided below the insertion of the flexor sublimis. In the index finger amputation through the second phalanx by short dorsal and long palmar flaps is figured. The flaps for amputation of the index finger at the metacarpo-phalangeal joint are also shown, the straight part of the incision being placed rather to the radial side of the head of the metacarpal bone. In the thumb the flaps for amputation at the carpo-metacarpal are indicated. ** Show where the radial artery may be wounded in this amputation. Ligature of the radial artery at the back of the wrist is also represented. (*See* p. 124.)

for an injury, the remarks on the conservative surgery of the hand (*see* p. 71) should be consulted. It is usually performed by the modified oval method, the *en raquette of Malgaigne*. Lateral flaps may also be employed. Other methods, to be used according to the extent of damage to the soft parts, are described below (Fig. 20).

The hand having been pronated, the radial and ulnar arteries controlled by a tourniquet, an Esmarch's bandage, or the fingers of an assistant above the wrist, some sterilised gauze wrapped round the damaged finger, and the adjacent ones flexed out of the way or held aside with strips of sterilised gauze, the point of the knife is inserted three-quarters of an inch above the head of the metacarpal bone, sunk down to the bone itself, and then carried down in the middle line till it gets well on to the base of the phalanx; then diverging to one side, the knife is carried obliquely well below the web[1] across the palmar

[1] Cutting into the web will lead to much more haemorrhage and it may be difficult to secure the vessels. The incision should pass about half an inch below the web otherwise there will be difficulty in bringing the flaps together unless the head of the metacarpal is removed. Even then there is likely to be tension on the sutures, and thus slow and painful healing.

aspect of the first phalanx below the palm and then around the other side of the phalanx (also below the web) so as to join the straight part of the incision which lies over the head of the metacarpal bone.

Lateral Flaps (Fig. 20). In practice, especially in the country, where an anæsthetic is not always easily available, it is much preferable, because quicker, to make two separate incisions, each beginning three-quarters of an inch above the head of the metacarpal bone, and meeting again on the centre of the base of the palmar aspect of the first phalanx, well below the palm, instead of carrying the knife continuously round the finger. This method is not only quicker,[1] but it does not leave, as in the first method, a small tongue of tissue on the palmar aspect, which is a little difficult to adjust satisfactorily, and behind which discharges may collect.

Sir W. Watson Cheyne and Mr. Burghard [2] point out that where any such projection is present, as in a working man's hand with a very thick palmar skin, the removal of a V-shaped portion here, after the completion of the amputation, will cause the entire disappearance of the projection.

Whether the method by lateral flaps or *en raquette* be employed, the knife should be used boldly, the extensor tendon severed in the first incision over the head of the metacarpal bone, and the soft parts at the sides cut to the bone. Then, the finger being now extended, one lip of the cut tissue is taken up with the finger and thumb, the flaps are dissected up as thick as possible, tendons cut clean and square, the lateral and anterior ligaments severed with the point of the knife, and the joint opened by recollection of its site well below the projecting knuckle (*see* p. 57, Fig. 13).

Fig. 19. Amputation of the middle finger by lateral flaps (Heath). The neck of the bone should be more fully cleaned, the tendons separated, and the bite of the forceps pressed more securely round the neck of the bone.

Disarticulation will be facilitated by twisting the finger, first to one side, and then to the other, so as to render tight the parts which remain to be cut. On no account should the knife needlessly enter the palm. This will only lead to troublesome bleeding, especially in inflamed parts, and perhaps to the spreading of infective inflammation. A caution may be given here which applies to all amputations, but especially to those performed for accidents, where it may not have been possible to secure absolute sterilisation of the parts concerned. It is very easy for the tendons, where they are drawn down in order that they may be cut short and square, to carry up infection as they retract into their sheaths. At this stage especially it is important thoroughly to irrigate either with sterilised saline solution or with some weak antiseptic lotion, such as carbolic 1 in 40.

Where strength has to be considered rather than appearance, the

[1] Because it avoids the hitch usually met with in carrying the knife around the base of one finger between two others.

[2] *Manual of Surgical Treatment*, vol. ii. p. 512.

head of the metacarpal bone should be left, whatever be the rank in life of the patient, as the transverse ligament is thus less interfered with, the hand less weakened, and the palm not opened up.

But where appearance is the most important point, and the mutilation is to be hidden as much as possible by the approximation of the fingers, the head of the bone should be removed by a narrow-bladed saw or by bone-forceps[1] (Fig. 19). In either case the section should be made obliquely from above downwards and from behind forwards, so as to remove more on the dorsal than the palmar aspect. In such cases, after a little practice, it is not necessary to perform disarticulation, the metacarpal bone being severed after the flaps have been dissected upwards to the proper level.

Fig. 20. Different methods of amputating the thumb and fingers at their metacarpo-phalangeal joints. In the case of the thumb a long palmar flap has been made; in the index a palmar and external flap; in the middle finger a circular incision and a straight dorsal cut (a modification of the method *en raquette*) have been employed; the ring finger has been removed by two lateral flaps, and the little one by an internal and palmar flap. (Farabeuf.)

Here, too, care must be scrupulously taken not to interfere with the tissues in the palm.

After removal of the finger and the Esmarch's bandage, one or more digital vessels lying rather deeply opposite the web of the finger will require ligature.[2]

In the case of the thumb, index (Figs. 20 and 21), or little finger, the straight part of the oval incision should be placed to the ulnar side of the metacarpal bone, rather than in the dorsal mid-line, as the line of incision will be better concealed. In these cases the saw or bone-forceps should be applied obliquely from without inwards and from within outwards respectively, so as to leave no projecting bone on the radial or ulnar aspect of the hand, and, in the case of the index, to allow of the thumb being readily approximated to the second finger. It may be worth while to add the following hints with regard to the after-treatment: (1) Not to bandage the adjacent fingers too closely or too long together, otherwise a tendency to cross at their points will be noticed later on. (2) In this and all other disarticulations where, in spite of copious irrigation with sterile saline or other solution, a co-existing infective condition cannot be got rid of with certainty, the cartilage should be removed.

Tedious exfoliation is otherwise certain. As already advised, there should be no close suturing in these cases, and boracic fomentations may be employed from the first. In this and many other amputations of the

[1] With the precaution given at p. 62. A saw, avoiding splintering, is preferable.

[2] Care should be taken to secure these vessels, especially where they are enlarged in any inflammatory condition, otherwise profuse bleeding may take place a few hours after the operation.

hand, perforated zinc, which can be easily boiled, is the best material for splints.

Disarticulation by a Circular Incision with a Straight one on the Dorsum (Fig. 20). This method, a modification of the one *en raquette*, is preferred by Farabeuf as simpler and sacrificing less skin. The hand being completely supinated, and the other fingers bent out of the way, the surgeon cuts across the root of the finger in the digito-palmar fold, going down to the bone, and encroaching as far as possible on the sides of the finger. The hand being pronated, the ends of the circular incision are prolonged up to the middle line of the dorsal aspect of the finger, where a straight cut, beginning a little above the level of the joint, is drawn to and perpendicular to the first. By this means two right-angled flaps are marked out. These are raised and the bone disarticulated, by the steps already given.

Amputation by a Single Flap. Where, owing to the state of the soft parts, this method is required, Fig. 20 indicates how it may be employed.

Amputation of a Finger, together with Removal (complete or partial) of its Metacarpal Bone. This operation is easily performed by a modification of the method *en raquette* or that by lateral flaps just described.

FIG. 21. Amputation of little finger and its metacarpal by the oval method.

It is only needful to prolong the dorsal part of the former incision or the apex of the latter as far as the carpo-metacarpal joint.

Disarticulation, when the parts are much swollen, will be safely performed here by carefully prolonging back the dorsal incision in a wound kept bloodless till the joint is felt and seen, suitably manipulating the finger so as to put the structures attached to the metacarpal bone on the stretch, remembering the insertions of tendons into some of these bones, severing the ligaments of the articulations with careful touches of the knife, and not sinking this into the palm for fear of wounding the palmar synovial sac or the deep palmar arch. Wherever possible, the extensor tendons should be drawn aside and carefully preserved. In infected cases, the greatest care must be taken, *e.g.* irrigation with sterile saline solution or with a dilute antiseptic lotion.

In the case of the little finger (Fig. 21), the ulnar border should be chosen for the incision, or, if the dorsal tissues are much damaged, a palmar and internal flap may be made. In clearing the metacarpal the knife-point must be kept very close to the bone. If only a portion of the bone needs removal, this should be divided with a saw and not with bone-forceps.

Farabeuf gives the very practical hint that primary union should

[1] *Manual of Surgical Treatment*, vol. ii, p. 514.

be secured by the flaps meeting readily without tension. Otherwise the contraction of the scar will drag upon the next finger, and cause it to stick out from its fellows in a very ugly fashion.

Where a metacarpal bone is removed for sarcoma, Sir W. Watson Cheyne and Mr. Burghard[1] advise that the adjacent bones on one or both sides be removed as well, to avoid the risk of leaving disease behind. They add: "When more than one metacarpal bone is removed, it is well to take away at least one finger in order to preserve the full use of the hand. Unless this be done, the fingers are apt to be crowded together as the wound contracts, and considerable interference with their usefulness may ensue."

Amputation of two or three contiguous Fingers. When (a very rare contingency) two or more fingers require removal at the same level, *i.e.* through their metacarpo-phalangeal joints, or higher up—the modified racquet or lateral flaps may again be employed, the apex of the dorsal incision starting between the fingers when two, and over the central metacarpal bone when three, fingers have to be removed.

AMPUTATION OF THE THUMB

Amputation of Phalanges of Thumb. Very little need be said about this operation, as it is very rarely performed. Owing to its numerous muscles, the thumb is extremely mobile, and thus escapes injury. Thanks to its abundant vascular supply, trimming of the soft parts after an injury will generally leave more of the thumb to oppose to the fingers, and thus is to be preferred to any set operation. In cases of necrosis after whitlow, Mr. Jacobson has twice removed both phalanges, the soft parts consolidating usefully[1] with the aid of the periosteum that was left. For further remarks on the importance of preserving the thumb, *see* Excision of the Thumb, p. 68, and Conservative Surgery of the Hand, p. 70.

Operation. Amputation of the phalanges of the thumb may be performed, in the case of the distal one, by a long palmar flap, as in the case of a finger (Figs. 14 and 20); of the first phalanx, by antero-posterior, lateral, or a modification of the circular incision. In the latter case, a short longitudinal incision should be made on the radial rather than upon the dorsal aspect as in this way less damage will be done to the tendons. In any case the incisions should be carried well on to the phalanx to ensure sufficient flaps to cover the head of the metacarpal bone, together with the sesamoid bones, which should never be removed.

The line of the metacarpo-phalangeal joint is very nearly transverse, and lies just in front of the knuckle.

After amputation of, or through, the phalanges, the severed end of the long flexor, previously cut long, should be carefully stretched into the angle of the flaps and to the extensor, and also, if possible, into the theca and periosteum as well.

Amputation of the Thumb at the Carpo-metacarpal Joint (Figs. 16 and 22). *Indications.* This operation is rarely called for on the living subject.[2] Gunshot injuries, some growths, especially chondromata of the phalanges and metacarpal bone, epithelioma of a scar, and melanotic sarcoma occasionally call for it.

[1] This is strongly indicated in those cases where it is especially important to leave the thumb long for holding a pen or any delicate instrument.

[2] It is not infrequently used as an examination test.

Operation. The position of the joint between the trapezium and metacarpal bone, its shape, with two saddle-like articular surfaces fitting into each other by mutual coaptation, and the position of the radial artery passing over the back of the styloid process of the radius just above this joint (Figs. 18 and 63), and again, when perforating the first interosseous space, lying close to the metacarpal bone, must be remembered.

The operation is usually performed by a modification of the method *en raquette*. An Esmarch's bandage, or tourniquet, having been applied above the wrist, the hand held midway between pronation and supination, and the thumb held over-extended so as to relax the parts, the surgeon inserts the point of a strong narrow scalpel just above the joint. This lies a full finger's breadth below the tip of the styloid process. Its position can usually be made out by tracing up the metacarpal bone with one finger along its inner and the thumb along its outer margin, the thumb being alternately abducted and adducted. The knife, entering the narrow interval between the tendons of the extensor ossis metacarpi and primi internodii, should avoid *la "tabatière anatomique"* and the radial artery. Where there is much swelling comparison must be made with the sound thumb. The incision is then carried along the dorsum of the bone as far as the base of the first phalanx, where it passes (in the case of the left thumb) obliquely to the ulnar side below the web, and then around the palmar aspect of the phalanx, along the radial side, to join the dorsal incision again. Taking up first one edge of the incision and then the other, the surgeon dissects up the soft parts from the bone, keeping the knife-point close to this, especially on the inner side, where it is in close proximity to the radial artery. The extensor tendons and the short muscles of the thumb being severed, the joint between the trapezium and the metacarpal bone is felt for and opened from behind, the whole thumb being strongly flexed into the palm: the thumb is now removed by putting the remaining tissues on the stretch by twisting the metacarpal bone in different directions.

FIG. 22.

Amputation of the Thumb at the Carpo-metacarpal Joint by Transfixion (Fig. 22). The hand being held as before, and the parts relaxed by slightly adducting the thumb, an incision is made (in the case of the left thumb) from the base of the metacarpal bone rather to its palmar aspect, along its dorsum, and then obliquely to the ulnar side of the base of the first phalanx; the knife, a long narrow bistoury, is then pushed from this point, at the junction of the web with the thumb, through the thenar eminence to the point where the incision started, over the carpo-metacarpal joint. By cutting outwards, along the line indicated in Fig. 22, a flap is formed of the tissues in the ball of the thumb, the knife being kept close to the bone at first, but directed more superficially afterwards as it comes out through the skin over the sesamoid bones and base of the first phalanx, to prevent its being locked here. This flap being held back, the metacarpal bone is dissected out by keeping the knife close to it, the joint opened, and the thumb removed as before.

On the right side it is better to cut the palmar flap by transfixion first, making

the knife enter and emerge just as described above. The blade of the knife is then drawn from the base of the first phalanx obliquely across the dorsum of the metacarpal bone, from one extremity of the transfixion incision to the other. The operation is completed as before.

Whatever method is employed the radial artery should not be seen; only its digital branches should require ligature.

In practice, total removal of the thumb is one of the rarest amputations. Part of the metacarpal bone should always be left if possible. Even if stiff, it will be most useful when the fingers are opposed to it. The long flexor should always be sutured to the theca or otherwise secured.

PARTIAL EXCISION OF THE THUMB

Removal of Phalanges. Owing to the exceeding value of the thumb, a phalanx should always be preserved if possible not only in whitlow necrosis, but in the case of the first or proximal phalanx when it is the seat of an enchondroma. By this, not only is appearance saved by less shortening, but the use of the long flexor, in particular, is preserved.

Mr. Royes Bell [1] published a case in which he excised the proximal phalanx in a woman, aged 19, for a huge enchondroma of sixteen years' growth, the joints being movable. The phalanx was excised by two semi-lunar incisions over the tumour, the knife being kept close to the bone, and the joints opened. No tendons were cut. Eighteen months later the condition of the thumb was excellent, both for all general movements and for writing.

In 1897 Mr. Jacobson performed a similar operation on a patient aged 33. The first phalanx of the right thumb was removed, by a single dorsal incision, for an enchondroma of twelve years standing, and the base of the distal one resected for a similar but much smaller growth. The long flexor was stitched to the portion of the distal phalanx left. Healing was complete in three weeks; active and passive movements were then assiduously carried out. When the patient was last seen six months after the operation, the thumb was much shortened and also somewhat weaker than its fellow, but it was steadily gaining in strength and usefulness, and its movements were almost completely restored.

Removal of Metacarpal Bone. This should always be excised, wherever possible, in preference to sacrificing a part of such incalculable value as the thumb.

A straight incision, which reaches one-fourth of an inch beyond each extremity of the bone, having been made along the dorsum, the tendons are drawn aside; the distal end and joint are next cleared and opened, when the bone can be used as a lever whilst it is freed from the soft parts on the palmar aspect and then disarticulated. Removal of this, as with the other metacarpals, is sometimes facilitated by dividing the bone in the centre and then removing it in two pieces. In young subjects, the epiphysis, if healthy, should be left. If possible, the periosteum should always be preserved. The position of the radial artery, both on the ulnar side of the metacarpal bone and above the carpo-metacarpal joint, must be borne in mind.

Excision of the Phalanges and Joints of the Fingers. Only excision of joints need be alluded to here, as, save in the case of removal of the distal phalanx (or the last two in the case of the index) for necrosis, excision of a phalanx leaves a very useless finger.

Excision of an interphalangeal joint may be required in some very rare cases of "snapping" or "clasp-knife" finger, where the trouble is believed to be due to irregularity of the joint surfaces. Also in those

[1] *Lancet*, 1879, vol. ii. p. 846.

cases of congenital contraction of the finger, where the lateral ligaments are much shortened. At p. 88 it is pointed out that, in some cases of needles deeply situated in the palm, a dorsal incision and partial removal of a metacarpal bone affords the best way of getting at the foreign body.

Reduction of Dislocations of Thumb and Finger at the Metacarpo-phalangeal Joint. Excision of the Metacarpo-phalangeal Joint. The difficulty often met with in reducing a metacarpo-phalangeal dislocation in the case of the thumb has long been recognised. Mr. Battle has shown with instructive cases[1] that like difficulty, due to similar causes, may, though more rarely, be met with in the case of a finger, especially the index. Other papers by the late Mr. Davies-Colley and Mr. Symonds[2] and Mr. Jordan Lloyd[3] will repay perusal. Any, or several, of the following factors may be the cause of the above difficulty: (1) The buttonhole-like slit with which the two heads of the flexor brevis and their sesamoid bones now, in their altered relations, embrace the head of the metacarpal bone; (2) the lateral ligaments; (3) the interposition of the torn anterior or glenoid ligament, between the base of the phalanx and the head of the metacarpal bone; (4) the contraction of the numerous muscles around the dislocated joint; (5) the shortness of the leverage afforded by the dislocated bones; (6) the tendon of the flexor longus pollicis may be displaced and form a tense band to the inner side of the joint, winding round the neck of the metacarpal. The chief cause, however, is the displacement of the glenoid or palmar ligament of the carpo-metacarpal joint. This structure, which is a thick plate of fibro-cartilage, occupies the interval between the lateral ligaments with which it is continuous on the palmar aspect of the joint. It is intimately connected with the sesamoid bones, and, while firmly united to the phalanx, is but loosely attached to the metacarpal. When dislocation backwards occurs as the result of violent hyper-extension of the joint the displaced phalanx tears through the weak attachment, carrying the ligament backwards with it over the head of the metacarpal bone.

Remembering then that the anterior and lateral ligaments forming one continuous structure are the chief impediments to reduction, manipulation should be tried first and always with an anæsthetic. In the case of a finger, the displaced phalanx is well tilted back on to the dorsum of the metacarpal, in order to bring the glenoid ligament and other structures already mentioned well in front of the anterior margin of the articular surface of the phalanx before flexion is employed. This, with firm pressure of the thumbs against the base of the displaced phalanx, generally causes it to slip into place. In the case of the thumb reduction should be tried on the same lines, the whole thumb being first adducted towards the palm. The displaced phalanges may, if necessary, be grasped by special forceps to give greater leverage. Should manipulation fail, as it very likely will, one of the following operations should be employed:

(1) *Tenotomy.* A tenotome is introduced on the dorsal aspect to one side of the mid-line so as to avoid the extensor tendon. It should be carried down to the base of the phalanx and then be made to cut upwards along the neck of the metacarpal. By this means the glenoid ligament will be split longitudinally. A repetition of the manipulations will then

[1] *Lancet*, 1888, vol. ii. pp. 1222, 1271.
[2] *Ibid.* vol. i. p. 522.
[3] *Lancet*, 1892, vol. i. p. 469.

generally be successful. Occasionally the tenotomy knife is introduced on each side of the extensor tendons and, the phalanges being extended, the structures between the bones are divided transversely. In this way the short flexor is cut and unnecessary damage may be done. Should the simpler procedure fail, it is better to perform an open operation.

(2) *By a Palmar Incision.* A median incision two inches in length is made over the anterior aspect of the joint through which the head of the metacarpal is freely exposed. If the tendon of the long flexor has slipped to the inner side of the metacarpal it may be replaced by means of a strabismus hook; the tendons of the flexor brevis may be hooked aside, and the torn glenoid ligament may be drawn from between the articular surfaces by suitable hooks or forceps. After extension the head of the bone can then be replaced. If possible a few catgut stitches should be used to close the tear in the capsule; the wound is then closed and the thumb put up on a perforated zinc or a moulded splint.

(3) *By a Dorsal Incision.* The dislocation is exposed by an incision to the radial side of the dorsum of the joint. The glenoid ligament can then be replaced and any tense band be divided. The want of room and the close connection of the extensor tendons with the capsule always render this small operation one of some difficulty. The palmar incision should, as a rule, be employed.

(4) *Excision of the Metacarpo-phalangeal Joint.* This is especially indicated when the dislocation has remained unreduced for a long time. The head of the metacarpal should be exposed through a palmar incision, as described above. The soft parts are freely retracted, and the end of the displaced metacarpal having been cleared by keeping the knife-point closely applied to it, sufficient is then removed *in situ* by a narrow saw, which is preferable to bone-forceps. Free resection of the one bone will probably suffice, if sufficiently free; merely paring off the articular cartilage is likely to lead to a stiff joint. Only if, owing to the amount of matting, or previous inflammation, there be additional risk of ankylosis, should the base of the first phalanx be removed as well. Care must be taken, before this is done, to detach carefully, as completely as possible, the tendons inserted into it, together with the periosteum, and since two freshly sawn surfaces are left additional precautions must be taken against ankylosis. Any tendon accidentally cut should be sutured. The patient must be prepared for some shortening, especially if the epiphysis of the phalanx has been removed.

CONSERVATIVE SURGERY OF THE HAND

While each case requires individual consideration, it is hoped that the following hints may be of service to the surgeon when called upon suddenly, to form what is a very important decision.

(1) *The question of trying to unite a totally separated part* is alluded to at p. 78. The question of palmar hæmorrhage is considered at p. 88; and the treatment of injuries to tendons and nerves will be found under these headings respectively.

(2) After injury, except in rare cases where the combined comminution of bone injury to tendons and stripping off of skin is extreme, no *set amputation* is to be performed. In the case of a part of such incalculable value, and so well supplied with blood as the hand, the surgeon should remember Verneuil's words and not "approach these cases with the bistoury." He is to render the part as aseptic as

possible, and then to wait and watch what Nature will do towards *the ultimate restoration of usefulness*. This, of course, entails risks of suppuration, sloughing, and even worse ones, such as tetanus. Assiduous attention to the advice at p. 73 alone justifies running these risks.

Speaking generally, these cases, in which the decision has to be made between too conservative surgery and in removing too much, fall into two groups.

A. *Injuries limited to the Fingers.* Here conservative surgery is less rigidly indicated than in complicated and extensive injuries to the hand. If the injury to the finger, especially the third or fourth, be such that useful function will be lost, it will be wiser to amputate it, and not hold out any hopes of usefulness, which will only, after prolonged and tedious treatment, prove illusive. If it be the index which is most damaged, the surgeon will remember that a freely movable middle finger will steadily improve in sharing with the thumb the loss of the index. And if the head of the metacarpal bone has been removed, a new interdigital space will gradually be developed, which may be very useful for a working man.

B. *Complicated and extensive injuries to the Hand.* Here the difficulty of estimating the extent of the damage, the power of ultimate recovery in a part like the hand, and the amount of loss of function, together with the hopelessness of any really useful artificial substitute, should make conservative surgery the rule, and the surgeon should wait and see how much antiseptic baths and dressings, together with the other aids given below, will save from destruction.

(3) *Later Amputation.* But while it is a cardinal principle to preserve every inch of the hand, a single finger or a thumb alone being far more useful than the most elaborate artificial limb that can be made, and while to gain this end it is frequently advisable to trim up an injured part and to remove bone in preference to doing any set amputation, it must always be remembered that *a part may be capable of being saved, and yet ultimately be useless unless it be at least partially movable.* Again, atrophy of a part, at first promising in usefulness, may set in some time after the injury, brought largely by trophic disturbances. In either of these cases a rigid cicatricially contracted claw, or a pointed, sensitive, and shrunken part may call, later on, for amputation.

(4) Amongst the *very exceptional cases which call for primary amputation* are those where (1) one or more fingers are mangled and pulped out of all shape or recognition; (2) where all the tendons are torn through, especially if this has happened at more than one place, as in the fingers and in the palm also, and where, with these injuries, there is much opening of the joints as well as fracture of the bones and ripping off of the skin; (3) where the fingers are extensively split longitudinally; (4) another condition, which surgeons in large manufacturing centres are certain to meet with, requires grave consideration, *viz.* where a hand is [illegible] owing to its having been caught between rollers which hold but do not crush. Here, as the patient draws back, the skin is stripped off like a glove, from the wrist. If, in addition, bones are crushed, the joints opened, amputation, leaving part of one finger if the thumb is intact, or through the wrist-joint, should be performed at once; and Billroth[1] advises this step where the skin is completely stripped off without other injury, fingers entirely deprived

[1] *Lectures on Surg. Pathology and Therapeutics*. Syd. Soc. Trans., vol. i. p. 207.

of their skin almost invariably becoming gangrenous, and the result being "under the most favourable circumstances, nothing more than an unwieldy cicatrised stump."

The following case[1] is a good instance of the above:

"The hand of a little boy was caught in the rolling machine of a bakery, and the skin divided at the wrist just as cleanly as if it had been done by intention, and an entire glove of the skin taken off. When I saw it, it was held on by the tips of the fingers only. There was no injury other than that described. I felt satisfied that amputation was proper; but the patient insisted that he was willing to take the risk if amputation was not performed, and I replaced the flap, and stitched it in several places, believing that it would slough. It did slough, and he lost his fingers up to the knuckles, and the only part that was saved was a small portion of the thumb, and the metacarpal portion of the hand. This, of course, was a cicatricial surface, which I covered with grafts, and it finally healed. The boy can hold a pen in a little groove by the side of the thumb, and it is probable that the remnant of the hand will finally become useful."

The explanation of the certainty with which the stripped-off skin dies in these cases, and the uselessness of the most careful stitching, lies in the fact that not only have the vessels passing from the deep parts to the skin been torn through, but the skin itself has been submitted to an enormous strain and dragging. In such cases where it is clear the glove-like skin must go, but the deeper parts are uninjured, an attempt should be made by skin-grafting, after Thiersch's method (*see* p. 12), or by pedunculated flaps (*see* p. 74), to provide a covering and prevent the sloughing of the deeper parts.

(5) *Skin-grafting* is especially to be made use of where, after an injury to the hand, it may be possible to save one or two fingers only, or, particularly, the thumb and index finger, by taking skin, if possible, or a pedunculated flap, from the damaged hand, the opposite arm, or the abdomen. In slighter cases the large grafts taken by Thiersch's method (*q.v.*) from the arm will be employed. Dr. Schreiber[2] advises skin-grafting in smaller injuries. Thus, if the skin be torn away from the dorsum of a finger, over-extension will follow when the wound is healed unless it is grafted. On the other hand, if it be the pulp that is torn away, successful grafting will give a rounded, sensitive, fleshy end, instead of a thin, sensitive, pointed one. The surgeon must, of course, prepare his patient for disappointment. The grafts may die, and the injured part be reduced to a claw, active movement largely disappearing. Skin-grafting may also be made use of later on if one or more fingers become contracted, and division of the cicatrix leaves a gaping wound. The above remarks refer to skin-grafting for small areas on the fingers, and the back of the hand only. The case of the palm and the employment of pedunculated flaps is referred to later (*see* p. 74).

In some cases the method of *désossement* of French surgeons will be useful in supplementing or replacing skin-grafting. Supposing that in a case of severe laceration, in which it is determined to try and save the hand, one finger requires amputation, by turning out the bone removing the nail and tendons some of the soft parts thus left may be utilised in filling up any large gap below. The incision, *en raquette*, is made along the dorsum or palmar aspect according as it is desired that the soft parts of the finger should fall into place along the back or front of the hand.

[1] Dr. Gregory, of St. Louis, *U.S. Trans. Am. Surg. Assoc.*, vol. 2, p. 232.

[2] *Munch. Med. Woch.*, Aug. 9, 1892.

Mr. C. B. Keetley, whose ingenuity is well known, made use of the soft parts in a different way.[1]

A young woman had all the fingers of the right hand crushed and torn, and on the palmar surface burnt, by the hot roller of a machine-mangle. "Nearly every inter-phalangeal joint was open on the palmar aspect. All the flexor tendons of the middle and ring fingers were destroyed. But their dorsal tendons were intact. I therefore amputated the ring finger, preserving all its dorsal soft structures. These being then brought round and fixed to the previously refreshed palmar surface of the phalanges and joints of the middle finger, the extensors of the ring finger assumed the duties of flexors of the middle finger. The results, both as regards appearance and function, were surprisingly good."

(6) *Injury to Joints.* Where the tendons are uninjured, or can be sutured, where there is no extensive comminution of bone or great injury to the skin, the finger will, of course, be saved. If expectant treatment is adopted, even if the parts heal quickly, the surgeon will be fortunate if he manages to preserve for his patient half the natural range of movement of the joints affected. And, to do this, splints of perforated zinc, not of wood alone, will have to be frequently changed, the part being put up for a short time, flexed, then extended, massage assiduously employed, &c.

Probably excision of a joint which has been freely opened will restore better movement if the patient is brave and persevering. It should certainly be tried, and removal of the bones carried out sufficiently widely to prevent ankylosis, in the case of the joints of the thumb (*see* p. 68).

(7) *Injury to Tendons.* This is fully considered at p. 93.

(8) To sum up the chief points: Primary amputations, especially what may be called formal operations, are only to be made use of under the very rarest circumstances; any surgeon who makes use of them will almost always find that he has overstepped what was absolutely needful. The part should be thoroughly cleansed (with the aid of an anæsthetic) by means of turpentine and soap, with a sterilised nail-brush and lotion, these solutions, if necessary, being used continuously in an arm-bath.

A word of warning may not be out of place here. In his desire to obtain asepsis the surgeon should remember possible effects of over-strong, irritating chemicals, such as formalin, carbolic acid, &c. The vitality of the soft parts is much lowered, and in the case of the fingers, they are, on three aspects, thin and easily compressed against closely adjacent bones. The hopelessly damaged soft parts should be trimmed and drainage provided. It is only by great care here that the surgeon is justified in submitting his patient, during the attempt to save a mangled part, to the danger of infection, gangrene, tetanus, &c. If there is any doubt as to the completeness of the cleansing, the part should be kept in an arm-bath with a weak aseptic lotion constantly renewed. But it is always advisable to get the wound sweet and safe under a boracic acid fomentation and at rest as soon as possible. If any part must be amputated, a nail or bone or tendon that may be useful is to be transferred to the parts that are being saved. So, too, later on, if a surface is left, which by cicatrising slowly will lead to distortion, or if tendons exposed have fibrillated and died, an attempt must be made to cover the defect by flaps taken close by or from a distance, and replace the other by distance-sutures (*see* p. 100). Secondary

[1] *Lancet*, March 4, 1905.

operations will also include removal of any painful stumps, especially those which interfere with the approximation of the thumb to another finger.

Fig. 23 is an excellent instance of what may be effected by conservative surgery of the hand. It represents the remains of a hand, consisting of the thumb, stump of the index, and of the little finger, and also shows of how much flexion the shortened index is still capable.[1]

Fig. 23.

Value of Pedunculated Flaps in Injuries of the Hand. This method, which we owe to Dr. Fenger, is described in a lucid article by Dr. Schroeder, of Chicago. It is pointed out that Thiersch's method does not give either the elasticity or resistance which are especially needed in the palm; the resulting scar is also prone to break down. It may, however, be usefully employed on the dorsum.

Dr. Schroeder's patient was aged 30, the right hand, contracted into a fist, had been left untreated since a burn in infancy. Its functions were almost entirely lost (Fig. 24). The hand and right hip were most carefully prepared for two days. The operations were six in number.

First Operation. The cicatricial tissue was dissected off the palm, fingers, and thumb. This left a wound extending from the carpo-metacarpal joints to the distal phalanges (Fig. 25). The deformity of the thumb was corrected, but the new position was maintained with difficulty. The first finger was still flexed by the shortened anterior ligament of the first interphalangeal joint, which was ruptured in extending the finger. The hand was now placed upon the hip and incisions made in the skin as guides. The upper flap was made wide enough to cover the denuded space above the first row of digital furrows, having an anterior and posterior pedicle, the distal end of the thumb passing out through the posterior pedicle (Fig. 26). The anterior

Fig. 24.

flap passed over to the crest of the ilium. The hand was now placed under this flap, the fingers separated, and incisions made opposite the middle of the distal phalanx of each as guides. The hand was again removed and the pockets made, one for each finger, leaving attachments between the fingers for nourishment and better immobilisation of the fingers.

[1] The figure is taken from a paper on Railway Injuries by Dr. Thomson, of Fredericksburg, Texas. *Amer. Surg. Assoc.*, Vol. ii. p. 190.

The hand was now placed in position and the upper and lower flaps united, as well as the lower border of the lower flap to the fingers, and the upper border of the

FIG. 25.

upper flap to the edge of the skin of the wrist. There are several important precautions to be taken in this step, namely:

(1) Not more than a quarter of an inch of subcutaneous tissue must be taken, because a thicker flap is clumsy and more difficult to unite to the skin of the hand.

FIG. 26.

However, if more is taken it will be absorbed in time. Some subcutaneous tissue must be attached, or the vitality of the flap is endangered. (2) There must be no

tension on the pedicles. (3) The edges of the skin of the hand must be undermined for at least a quarter of an inch, so as to allow of easy approximation.

Sterile gauze was placed at the back of the hand, and gauze drains behind the

FIG. 27.

fingers. A large dressing was placed over the hand and retained by adhesive straps. A plaster case was next applied, extending from the shoulder to the glutaeo-femoral fold. At the end of three days a trapdoor was (Fig. 27) cut in the case and the

FIG. 28

dressings changed. Boric acid solution was the strongest antiseptic used in these dressings. The wound was dressed every third day.

Second Operation. This, performed on the eighth day, consisted in dividing the inner pedicle to where the thumb protruded. Part of this pedicle was united to its

former place. The flap was united to the thumb (Fig. 28). A new case was applied because of the broken condition of the old one. Dressing as before.

Third Operation. On the sixteenth day the remainder of the posterior flap was divided and the flap stitched to the radial side of hand and index finger. The flap was now nourished from the anterior pedicle and interdigital septa and the new adhesion formed.

Fourth Operation. On the twenty-second day the inner pedicle was divided and stitched to the ulnar side of the palm and little finger. The interdigital septa were divided, and the hand thus liberated. At this time the granulating wound on the hip was curetted, partly closed by undermining the skin around it, and then grafted.

Fifth Operation. On the twenty-seventh day the bridges [illegible] between the index and second and between the little and ring fingers were [illegible] united to their respective edges of the finger.

Sixth Operation. On the thirty-second day the bridge between the second and ring finger was divided, and the parts sutured as before.

FIG. 29.

Whenever an edge of flap was united to the edge of normal skin, it was necessary to dissect back the skin, freshen the edges and bevel those of the flap below, so that good coaptation would be possible and primary union assured. Dr. Schroeder with great candour states that it was not possible in any of his cases to avoid infection absolutely, but by frequent dressings and proper drainage this did not interfere with a good result. In this case the joint opened in the index finger became anky-losed. The usefulness of the hand was very much improved, the patient, three months after the operation (Fig. 29), was able to partially flex and extend the fingers. Three other cases are given. In one, also resulting from a burn a useful hand was obtained. The remaining two were due to injury. In one, where the hand had been caught between rollers, the greater part of the skin on the palm and dorsum were torn away and the flexor tendons freely exposed in the palm. A single flap was taken from the hip and its free edge united to the radial side of the thumb and upper and lower edge of the palm. A most satisfactory result followed. In the last case, after an attempt to save a very badly crushed hand had failed, the fingers and most of the skin on the palm and dorsum died: the stump was grafted from the hip. After several weeks the pedicle was lengthened, cut low down, and the flap turned up on the dorsum and sutured. The result was good, giving the patient a stump against which the thumb could be pressed.

REUNION OF SEVERED DIGITS

The question will sometimes arise as to the advisability of attempting to reunite severed portions of thumb or fingers. Many such successful cases have occurred, and the surgeon may well make the attempt, when the parts are cleanly severed, through a phalanx, especially the distal one, and when the patient is young and healthy; when the cut has passed through a joint, not through a phalanx, the outlook is far less promising. The following are instances of the parts severed:

The first, second, and third fingers cut off above a diagonal line beginning in the middle phalanx of the index finger and ending in the last phalanx of the third finger near the root of the nail. The parts had been lying in the snow for some time and were kept for two or three hours before being applied. In other cases the part has been severed longitudinally, containing in it a portion of bone split off. The time between the injury and the treatment has varied from twenty minutes to three or four hours, and the severed part has been picked out of sawdust, brought up in dirty paper, whilst in a third the patient was sent back to find it in the field in which he had been reaping.

When there is the least shred of soft parts left holding on the severed bit, even a bad compound fracture of the finger with severe laceration of the soft parts may be saved.

The age and condition of the patient, the time which has elapsed since the injury, the part affected, *i.e.* whether the index finger or the thumb, must all be considered. And, in any case, the patient should be warned that, though the attempt may succeed, the parts unite, and sensation be restored, the result may be a stiff and, therefore, comparatively useless member; indeed, on this account, amputation may eventually be required.

If it be decided to make the attempt, the part should be carefully cleansed with soap and water, antiseptics being used with caution; it is then united exactly with a few salmon-gut or horsehair sutures, enveloped in aseptic wool, and kept *in situ* with carefully adjusted splints of perforated zinc. The dressings should not be disturbed for at least three days if possible.

SUPERNUMERARY DIGITS (POLYDACTYLISM)

This congenital deformity is sufficiently common and important to require a brief notice. The condition is usually symmetrical, and there may be one or several additional digits. The chief point of importance, from a practical point of view, is the mode of junction of the supernumerary digits. This, consisting of two or three phalanges, may be joined by mere fibrous tissue; in other cases there may be a complete articulation between it and the side of an adjacent metacarpal bone, or the carpus, a metacarpal bone being usually present, in addition to the phalanges, in the latter case. Lastly, the allied condition of supernumerary phalanx may be present in cases where the terminal phalanx of a thumb or finger is bifid.

Treatment. This consists of amputation, as early as possible, with strict aseptic precautions, so as to secure primary union and a perfect scar in a part where a deformity is so noticeable, and also to prevent the risks of infection when a joint is opened. In each case the finger is removed by an elliptical incision, the flaps being cut so as to meet exactly; where the union is fibrous, this is all that is required. But

where an articular surface is present, this must be exposed after disarticulation of the finger, and sufficient of the joint chiselled or cut away with strong scissors so as to leave the surface of the bone plane and uniform; otherwise growth will continue at this spot up to adult age, and a very unsightly deformity may be produced. When the articulation is with the carpus, additional care is required in carrying out the above steps.

In the case of a bifid phalanx the treatment involves more trouble on the part of both surgeon and patient or the friends, if the result is to be satisfactory. That portion of the phalanx which is the largest, which diverges least from the straight line, and which carries the best-developed nail (if these three points coincide) is to be preserved, and the other one removed. In carrying out this step, if the phalanx be not completely bifid, it should be split down through its base with a chisel, bone-forceps, or strong scissors, and the part to be removed taken away. Any ligaments *i.e.* the lateral on the opposite side or structures which will prevent the part left from being brought into the straight line should be divided. As soon as the wound is healed, careful movements of the joints and bringing the phalanx into the straight line must be practised every few days, and a metal splint worn with a collar round the wrist, with a lateral prolongation coming up along the affected finger or thumb on the side away from that to which the phalanx projects, this prolongation admitting of being bent outwards to any needful extent; by this means the phalanx, which is at fault, can be drawn straight. But persevering daily treatment for four or six months will be required.

WEBBED FINGERS (SYNDACTYLISM)

(Figs. 30, 31, and 32)

These should always be remedied in early childhood; if left untouched, the fingers may be useful, but the annoyance of the deformity will be serious. The surgeon should not yield to pressure put on him to operate in early infancy. Simple division of the web a trifling operation is out of the question owing to the inevitable recurrence of the deformity. On the other hand, especially if extensive dissections are made in raising flaps, the loss of blood will be considerable, and not without risk both as to the vitality of the flaps and of the infant itself. No operation should be undertaken before the child is at least three years old; in cases where the union is very close, it is preferable to wait till the age of four. Where several fingers are united, quite a month should elapse between the operations on the first and second pairs.

The treatment will depend upon the condition and extent of the web. In the slighter cases there is merely an increase downwards for some distance of the normal web; there is then an objectionable deformity rather than any actual disability. In the more serious cases the fingers may be joined down to the terminal phalanx. The web may then be lax and free (Fig. 30), or close and thick (Fig. 32), or two fingers may be more or less completely joined by bony union of phalanges.

(1) The simpler methods, viz. wearing a piece of thick silver wire or fine drainage tubing through a hole made through the base of the web where the cleft should begin ("ear-ring" perforation), may first

be tried. The tubing, which has the advantage of interfering less with the movements of the hand, may be attached to a band round the wrist; the wire may be twisted in a loop round an adjacent finger.

Fig. 30. Agnew's operation for webbed fingers. The flap is dorsal, large, and single. (Keen and White: *American Text-book of Surgery*.)

When the perforation is soundly cicatrised—*i.e.* in about three or four weeks — the web should be slit up, each half split, dissected up for a little way, and the edges of the two flaps thus formed united with a few points of sterilised horsehair. The greatest care must be taken to secure primary union, for otherwise granulation and cicatrisation will inevitably lead to contraction and displacement of the finger. The fingers should be kept apart by a layer of gauze throughout the healing. This method has the disadvantage of being tedious, and the formation of epidermis round the foreign body is liable to be incomplete.

(2) If the above fail, one of the following plastic operations should be made use of:

Agnew's or Norton's[1] (Figs. 30 and 31). These can only be carried out in cases where the web is ample. In Norton's operation (Fig. 31), small triangular flaps are raised on the dorsal and palmar aspects of the base of the web which is cut then through and the flaps very carefully stitched together without tension. The object is to ensure rapid union in the upper end of the cleft, and thus no redevelopment of the web. Agnew's operation employs a single larger flap (Fig. 30) raised from the dorsum. The flap should be thick enough to avoid risk of sloughing, and somewhat narrow to avoid bulging. To prevent tension it should be sufficiently long, its base being at the level of the metacarpo-phalangeal joints, and its apex, which should be rounded, almost reaching to the base of the second phalanges. The apex is sutured to the palmar edge of the cleft, and its sides to the skin at the edge of the wound. Any redundant tissue between the knuckles that prevents their coming together should be cut away. The remaining web is then split and treated as above described. The line of the natural web should be carefully preserved.

Fig. 31. Norton's operation for webbed fingers. The flaps are small and double.

[1] On the Continent this operation goes by the name of Morel-Lavallée.

Didot's (Fig. 32). This operation was introduced for those cases in which the web is very narrow. Two narrow longitudinal flaps are dissected up as thick as possible from the palmar and dorsal aspects of the affected fingers by two incisions, one along the middle line of the dorsum of one finger and another along the mid-line of the palmar surface of the other, from a point opposite to the extremity of the web to the knuckle. By short transverse incisions at each end of the vertical ones (Fig. 32), the two flaps are marked out. These are most carefully raised (*see below*), and each flap is then folded round to cover the raw surface of the finger to which it is attached, and secured with a few interrupted sutures of fine silkworm-gut or horsehair.

Didot's, like many French operations, is most ingenious and, on paper, it looks an excellent one. But, in practice, the following objections will present themselves: (1) It is a severe operation, especially in little children. (2) It is not easy to raise satisfactory flaps in parts so small and with skin so little developed. Thus, if the flaps are too thick it is easy to injure the extensor tendons or digital nerves or vessels; on the other hand, if the flaps are too thin they slough, and infection then readily occurs. (3) The flaps are nearly always insufficient to cover the denuded surfaces unless they are submitted to such tension as may lead to sloughing. Thus in part the wounds must heal by granulation, which may lead to harmful contracting scars, or by the aid of skin-grafting, which is liable to be rendered futile by the restlessness of the patient. (4) Considerable difficulty will be met with in fitting neatly the quadrangular edges of the flaps at the roots of the fingers so as satisfactorily to re-establish the normal web.

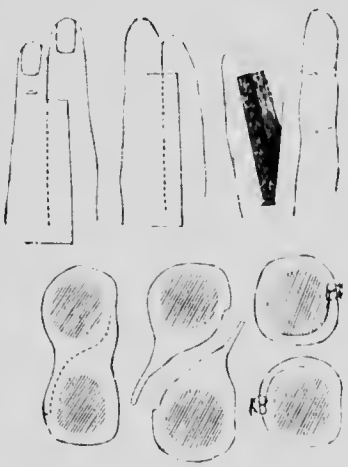


Fig. 32. Didot's operation for webbed fingers. (Reeves.)

For the above reasons the method of operating by a triangular flap is preferable (Figs. 30 and 31) wherever the web is loose enough to render this feasible.

Mr. Bidwell, in one case,[1] combined the methods of a flap from the web with one from the dorsum of one finger and skin-grafting.

In those rare cases where the union is bony, the choice lies between (*a*) leaving things as they are or (*b*) removing the bone of one of the united fingers after exposing this adequately by two rectangular flaps, dorsal and palmar. Separation of the fingers is not practicable, for there is no possibility of obtaining skin flaps to cover the raw surface. Such an attempt is almost certain to result in two deformed and useless fingers, which will probably require amputation.

After all operations on webbed fingers, especially the one introduced by Didot, there is more or less tendency for the fingers to become stiffly flexed or extended, according as any excess of scar has formed on the palmar or dorsal surface. Thus it is very common for the finger which

[1] *Lancet*, June 29, 1895.

has the dorsal flap, and in which the cicatrix lies along the palmar surface, to become flexed. This tendency must be met by persevering use of a splint, one similar to that mentioned at p. 83 being applied to the dorsal or palmar surface of the finger as required. At first it must be worn day and night, and then removed for varying periods in the day to admit of active and passive movements being assiduously practised. It will require to be worn at night for many months. In a few cases of this deformity a pedunculated flap taken from the dorsum will provide the most extensive and mobile skin in the position of the web.

CONTRACTED PALMAR FASCIA (DUPUYTREN'S CONTRACTION) AND OTHER CONTRACTIONS OF THE FINGERS

(Figs. 33, 34)

Dupuytren's contraction of the palmar fascia is usually met with in middle-aged men. Though it often appears to be due to continued slight irritation or injury, such, for example, as is caused by the frequent use of some tool or instrument, it is undoubtedly in many cases associated with a tendency to gout. The palmar fascia is triangular in shape; the apex is attached to the anterior annular ligament, while below it terminates in four processes to the four inner fingers. Each digital process consists of a central portion which joins the theca and two lateral processes which are attached to the skin of the web, the capsule of the metacarpo-phalangeal joint, and the side of the first phalanx. The contraction takes place especially in the processes going to the two inner fingers. Commencing about the transverse palmar creases, it steadily and progressively cripples the hand by drawing down the fingers, causing flexion, first at the metacarpo-phalangeal and later at the first interphalangeal joints (Fig. 33).

Operation. This may be either subcutaneous, by multiple punctures, or open, the latter being effected either by multiple transverse cuts through an open longitudinal incision or by excision of the contracted fascia.

The Subcutaneous Method. The best is Adams' operation, in which the contracted bands are divided by multiple punctures from the surface downwards. The skin must first be carefully prepared and cleansed. If thought desirable, local anæsthesia may be employed. Finding some spot where adhesion of the skin to the fascia has not yet taken place, the surgeon, avoiding the site of the vessels, passes a fine small tenotomy knife between the skin and fascia, and divides the band from above downwards, taking care not to dip the point too freely. If too much straightening is attempted at once, the punctures will gape widely and readily tear, especially where the skin and fascia are adherent. In cases of contraction of two fingers, a number of punctures—*e.g.* five to nine—may be required. It is usually easy, by operating on the palmar bands, to rectify the contraction at the metacarpo-phalangeal joint. The straightening of the contraction between the first and second phalanges is much more difficult. The digital prolongations of the fascia may be divided by punctures in the web between the fingers, extreme care being taken to avoid the digital vessels and nerves by not depressing the point, and by keeping to the middle line. But when the surgeon finds some difficulty in correcting this contraction thoroughly,

he will act most wisely by correcting the remaining contraction gradually by the use of Adams' finger-splint with rack-and-pinion movements opposite the metacarpo-phalangeal and interphalangeal joints.[1]

The splints, which should be constructed of metal to combine lightness with rigidity, should accurately fit the palm, and the length and breadth of each finger. They are secured by broad strips of soft leather. At intervals during the day the splint should be removed, and the hands well soaked in hot water, scrubbed in this with a nail-brush, and the patient assiduously practise placing the affected finger-tips on a table, and then making pressure on the dorsal surface of the fingers with those of the other hand.* The skin should be most carefully cleansed, and

A. B

FIG. 33.

an aseptic dressing applied for three or four days, when the punctures will be practically healed. The splint should be worn day and night at first, carefully padded at all pressure points. Some weeks will be required to correct the interphalangeal contraction, and in advanced cases relapses can only be prevented by the persevering use of the splint. In any occupation which entails much grasping, gloves padded on the palmar surface should be worn. If the surgeon attempts to straighten completely an advanced case of phalangeal as well as of metacarpo-phalangeal contraction, he runs the risk (1) of dividing a digital nerve, which may lead to most intolerable pain; (2) of damaging the tendons, for these bands are often in close relation with the theca; and (3) of injuring the vessels and thus producing slight gangrene of the finger-tips.

[1] Other splints will be found figured by Mr. Adams (*Lancet*, 1891, vol. ii, p. 166). If the skin has been much strained or interfered with, the straightening should be deferred for a few days.

The threefold association of the palmar fascia with the theca, the skin of the web, and the superficial transverse ligament is, as the result of the disease, rendered more intimate than ever.

To guard against a relapse the patient should, regularly and methodically, practise active and passive movements of the joints, wear the splint at night for a considerable time, and if any persistent or recurrent bands threaten to be troublesome, treat these by rubbing in oleate of mercury ointment. Should the patient be the subject of gout or addicted to alcohol he should be warned and treated accordingly. Figs. 33 and 34[1] represent a right hand crippled by Dupuytren's contraction before and five years after operation. The man was a patient of Dr. J. E. B. Burroughs, of Lee, and was operated on in 1883, the contraction of the metacarpo-phalangeal joints being straightened at once after numerous punctures made in the manner described above, while that at the interphalangeal joints was remedied chiefly by the persevering use of Adams' splint already described. In 1890 the fingers could be completely extended, were perfectly mobile, and free from the slightest tendency to contraction. It will be seen from Fig. 33B that some thickening, puckering, and corrugation of the palmar skin and fascia still persists, but this had now no power of producing contraction, the patient, a relieving officer, being able to write, &c., without any hindrance whatever. But to show the importance of persevering in the after-treatment mentioned above, when, after another four years, the patient was again seen in 1894, there was some recurrence of the flexion of the interphalangeal joints. The above advice, which had been insisted upon, had been entirely neglected. And this is very often the case, owing to patients thinking that the operation, of itself, will accomplish everything, and that no responsibility in the after-treatment rests with them.

Operation by Multiple Transverse Cuts through an Open Longitudinal Incision. This method has been advocated by Goyrand, Kocher, and in this country by Mr. Hardie, of Manchester, and Mr. Keetley. It has been recommended on the ground that mere subcutaneous division of the contracted fascia cannot be sufficient if the thickened, puckered, hardened skin is left alone, and also that intimate adhesion of the altered skin to the fascia is so general that it is difficult, if not impossible, to get the knife between the two at a sufficient number of spots for adequate straightening by the subcutaneous method. Keetley, who advocates this operation, thus describes the steps. "The limb having been elevated and an Esmarch's bandage applied, the hand and forearm, carefully sterilised, are held extended and supinated on a sterilised towel on a small table beside the operating table, with the fingers as much extended and separated as possible. A longitudinal incision is made through the skin and into the contracted fascia. If the finger is much contracted, this incision can only be completed by degrees, as the division of the bands gradually permits the unfolding of the fingers. The extent and degree of the contracted fascia are now easily seen, and it should be divided transversely and completely in many places until all resistance is removed, and nothing but shortening of the ligaments and structures around the joints remains. This should be left to be overcome by after-treatment. Here and there the skin itself may have to be freed by a

[1] The asterisks in Fig. 34 show spots where the tenotomy knife might be introduced in contraction of the palmar fascia slip going to the ring finger. The contracted band thus isolated by the punctures gradually atrophies.

touch of the knife. The skin incision is closed by silkworm-gut sutures placed close to the edges of the wound. If the above directions are strictly followed, merely a linear cicatrix will remain, such as contrasts favourably with what has been reported as the ultimate state of things after excision of the contracted fascia."

Excision of the Contracted Bands of Fascia. *(a) By Rectangular Flaps.* The skin having been, for two days at least, softened by the frequent use of soft soap and hot water and the inunction of lanoline, and carefully sterilised, a longitudinal incision is made over the contracted band from its upper to its lower limit, and then small transverse incisions are made at each end of this, so that two small rectangular flaps may be dissected up. A twofold difficulty at once presents itself: the skin is usually so adherent in places that the satisfactory making of these flaps is by no means easy, a difficulty much increased by the flexed position of the finger. A hard band of horny adherent skin may be removed by a narrow elliptical incision. The contracted fascia, when exposed, is dissected out, and the flaps united with silkworm gut or horsehair. The second difficulty is now met with owing to the contraction and adhesion of the skin which has to be united. Where union is impossible, skin-grafting[1] ought to be employed; any surface left to granulate means more or less recurrence of the trouble.

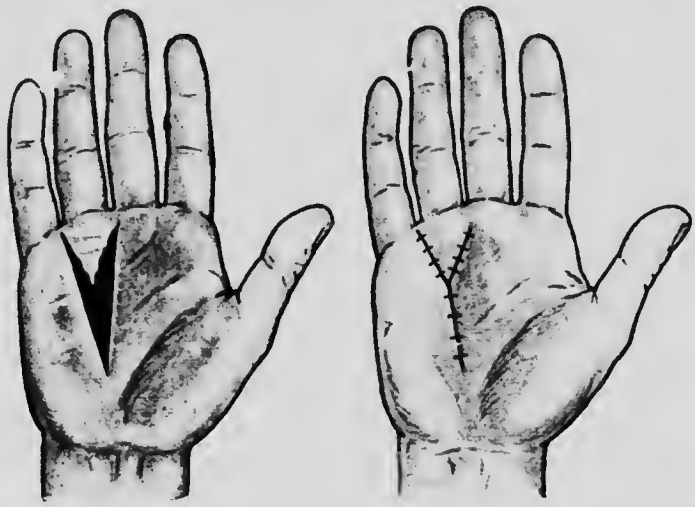
(b) By a V-shaped incision (Fig. 34). The base of the V is opposite to, a little above, and overlapping the root of the affected finger; the apex is situated in a line with the centre of the same finger, in the palm, about on a level with the transverse crease. Two diverging incisions join these points, and are carried down through the skin and fascia. The latter may be divided completely or removed entirely when the finger can be straightened. This leaves a gaping triangular wound in the palm with its apex upwards. Theoretically this should be united by careful stitching in the form of a Y. But the contracted state of the skin almost always prevents accurate stitching, and leads to some gaping of the wound, and a raw surface which may require grafting.

For the severest cases Sir W. Watson Cheyne and Mr. Burghard[2] recommend a combination of the subcutaneous method and the V-shaped incision. "In very advanced cases, where the fingers are tightly bound down to the palm, removal of the fascia by dissection cannot be performed, because it is impossible, on account of the contraction of the fingers, to get proper access to the palm so as to make the requisite incisions. Under these circumstances the best treatment is to divide the fascia in the first instance, and to get the finger as straight as possible by this means. As a rule, however, division of the fascia will not allow the finger to come quite straight, because the skin itself is contracted, and therefore the result is incomplete. The operation by the V-shaped incision may be very usefully combined with tenotomy so as to compel the straightening of the fingers. The two operations should, however, be done at different times. The result of the tenotomy is to endanger

[1] Skin-grafting has been somewhat lightly recommended in these cases as too certain to complete the healing. The following cautions may be emphasised: *(a)* Any exposed surface remaining after an open operation for contracted palmar fascia is far from being an ideal one for skin-grafting, like the smooth, level, regular surface of a large ulcer: *(b)* When the surface to be grafted is of any extent, and the hand one much employed in manual labour, the grafts may not afford a permanent protection. Plastic operations are out of question in these patients, both from a local and a more general point of view.

[2] *Manual of Surgical Treatment*, vol. i. p. 291.

the vitality of the skin at various points; this, however, very rarely sloughs, unless too great a pressure be brought to bear upon it. Hence a sufficient time must be allowed to elapse between the tenotomy and the open operation to allow these damaged portions of skin to recover, and during this time the fingers should be kept somewhat extended on a splint; three weeks' interval is usually enough." Before performing any operation the surgeon should remember that there is a considerable likelihood of subsequent cicatricial contraction. Another possible troublesome sequela is pain and tenderness in the region of the



A. B.

FIG. 34.

scar. Total removal of the contracted fascia necessarily takes away its capacity for protecting the underlying nerves.

In less severe cases, where the metacarpo-phalangeal joint is not flexed to more than a right angle, the method of multiple subcutaneous punctures should be adopted. Nowadays, with all the advantages of modern surgery, there is no excuse for the patients not coming for treatment early. In those cases, and these ought to be exceptional, where the induration is more widespread and denser, a longitudinal incision and multiple transverse section of the bands, or their total removal, should be employed. The treatment of the most severe cases has been described above. In answer to the objection that the simpler method is liable to be followed by relapses, this must be admitted, but a relapse may also follow other and more radical steps. And where relapses do follow, they are frequently due to the patients either not being duly warned, or to their neglecting the warning that the treatment may require repetition, and that, in any case, it demands imperatively that much of the responsibility for success lies with them in the after-treatment. This entails patience, assiduous attention to the employment of splints and the needful manipulations for many months, and the giving up of alcohol. Where these essentials are attended to, relapses will be comparatively infrequent.

Those who prefer the more recently advocated methods must remem-

ber the following points, viz. the age and vitality of many of these patients; the need of thorough sterilisation of the skin not an easy matter when the contraction of the fingers renders access to all the hollows and inequalities difficult; the oozing and possible need of a drain; the fact that the puckered state of the skin always makes accurate stitching difficult, leading to a raw surface and the need of grafting, of the objections to which mention has already been made, a need which is increased by the tendency of the sutures which it has been possible to insert to cut their way out owing to the necessary tension in places and the diminished vitality of the skin. Lastly, there is the swelling of the hand which may occur, especially in gouty patients, and which interferes greatly with the use of splints.

CONGENITAL AND OTHER CONTRACTIONS AND DEFORMITIES OF THE FINGERS

In addition to Dupuytren's contraction, there is a somewhat similar congenital deformity, occurring chiefly in girls, in which one finger, usually the little one, is flexed at the [illegible] phalangeal joint; there may also be flexion of the second inter-phalangeal [illegible] the first phalanx is hyper-extended on the metacarpal an important [illegible] n Dupuytren's contraction. The condition may be bilateral. The misc[illegible] co[illegible]ie in a contraction of the central slip of the prolongation of the fas[illegible] the fascia of the palm and the lateral slips are not affected. There is s[illegible] ea[illegible] interference with the usefulness of the hand, advice being sought on a[illegible] [illegible] the deformity. Palliative treatment can only be of avail in early life, when the small size of the parts renders it difficult to carry it out. If operation be undertaken, the open method with multiple transverse incisions can be easily made use of as the skin is not affected, and the hand is median, so that the digital vessels and nerves are not endangered. If the above be insufficient the lateral ligaments of the flexed joint must be divided, and tendon-lengthening may be needful; in the most confirmed cases, where ankylosis is present, the question of excision or amputation will arise.

Severe Contraction due to Injury. Here such steps as tendon-lengthening (p. 99) combined with a plastic operation may occasionally be employed with benefit.

Snap or Trigger Finger. In this curious condition full extension, more rarely flexion, of one finger is prevented and can only be attained with the help of the other hand, the finger being now suddenly flexed or extended with a snap like the closing of a blade of a pocket-knife. Some pain and tenderness are usually experienced near the metacarpo-phalangeal articulation. The pathology is uncertain. In some cases a thickened synovial fringe has been found, in others a small ganglion is present, while a large sesamoid bone is sometimes the cause of the trouble. The articular surfaces may show the changes characteristic of osteo-arthritis. The treatment is to explore and if possible to remove any cause which may be found.

Mallet Finger. In this deformity the terminal phalanx is slightly flexed and cannot be extended. It is usually the result of an injury which has either stretched the extensor aponeurosis, or torn the central slip from its insertion. If a splint is not successful a median longitudinal incision must be made, the extensor tendon is identified and the proximal end stitched to the periosteum.

NEEDLES IN THE HAND

Those who are aware of the difficulties which may accompany exploration here, and the unsatisfactory results which sometimes follow on this step, will be familiar with the need of having two skiagrams, one taken laterally and one antero-posteriorly. While on this subject two hints may be given: one is that the needle fragments may be sometimes multiple here as in the foot, the other, that skiagraphy is especially useful in doubtful cases, *e.g.* where a patient evidently neurotic complains of a hand being numb, useless, or painful, when

there is some doubt as to the presence of the needle, or when one needle fragment has been successfully removed. With regard to the operation itself, the use of a tourniquet or Esmarch's bandage is advisable. In spite of careful localisation by X-rays, considerable difficulty may be experienced in finding the needle; this may be due to its displacement by manipulations in the early stages of the operation, or to the small size or deep situation of the fragment. The wound should therefore be kept as free from blood as possible by gentle sponging, the greatest care being taken that the incision is made exactly over the situation of the needle. In the most difficult cases it may be desirable to make a further skiagraphic examination in the course of the operation. In some cases the electro-magnet, which is employed for extracting fragments of steel from the eye, may, if available, be used: though occasionally successful, this often fails as the magnet, though of great power, is unable to draw the needle through muscular fibres, especially when the direction of the former is at right angles with the latter.

Where the needle fragment lies very deeply in the palm, especially if a good deal of cicatricial tissue be present from previous operations, the needle may be removed from the dorsum by partial excision of a metacarpal bone.

A middle-aged woman, who had been operated upon three times for the removal of a needle from the palm, was admitted under Mr. Jacobson in October 1903; it was clear from the scars and contracted state of some of the fingers that an aseptic result had not always been secured. Mr. Shenton demonstrated the presence of a needle fragment lying deeply on the palmar aspect of the fifth metacarpal bone, a little above its base. The central portion of the metacarpal was removed, thus securing access through normal tissues. A rusty black needle fragment was at once seen embedded in the interossei. The wound, dressed at first with fomentations and kept well elevated, healed quickly, and the patient was again able to use her needle.

It must always be remembered that when the needle is deeply placed, there is a danger that some important structure, such as a nerve, tendon, or artery, may be injured in the operation for its removal. Suppuration, too, will be attended with serious results. For these reasons, especially in elderly patients, or those whose general condition renders an anæsthetic undesirable, it may be advisable to wait and see whether the presence of the needle causes any severe symptoms.

PALMAR HÆMORRHAGE

There are four arterial arches concerned in the arterial supply of the hand, viz. (*a*) the superficial palmar arch, formed chiefly by the ulnar artery, but completed by a branch from the radial, usually the superficialis volæ. (*b*) The deep palmar arch formed by the radial and completed by the deep branch of the ulnar artery. (*c*) The anterior and posterior carpal arches, formed by the anterior and posterior branches of the radial and ulnar. The comes nervi mediani artery is occasionally enlarged at the expense of the radial or ulnar; it then usually joins the superficial palmar arch and takes an important part in the blood-supply of the hand. The superficial palmar arch is situated beneath the palmar fascia but is superficial to the flexor tendons and the branches of the median nerve; it can be marked out by a line commencing just external to the pisiform bone, and then curving downwards and outwards across the middle third of the palm opposite the upper end of the cleft between the thumb and index finger (Fig. 16). The deep palmar arch is situated about half an inch above this; it rests against the metacarpals and interossei beneath the flexor tendons.

Treatment. This will vary accordingly as the case is seen early or later, and will also depend upon the septic or aseptic nature of the wound.

A. **Early Cases.** The bleeding[1] may be always temporarily controlled by pressure or by the use of a tourniquet. The wound will often be small, or even a mere puncture. The most desirable method is, after the skin has been cleansed as thoroughly as possible, to open up the wound and secure both ends of the injured vessel. This is far preferable to ligature of the brachial, or of the ulnar or radial arteries, for the bleeding may come from a small branch such as the superficialis volæ and not from one of the palmar arches. Another method is by the application of a graduated compress which may be tried if the wound be a small puncture and the bleeding not severe. The brachial having been controlled by a tourniquet and the wound cleansed, a compress consisting of sterilised gauze or lint, cut in pieces increasing in size from a threepenny bit to half a crown, is prepared, together with strapping, sterilised pads and bandages. The fingers are now bandaged, the compress is placed in position, covered by the sterilised pads and secured by careful bandaging. If the above precaution be omitted, so much and so painful œdema of the fingers will take place as to inevitably necessitate early removal of the compress and probable recurrence of the hæmorrhage. The arm should be kept at rest on a splint, or better still, the elbow should be fully flexed and the arm loosely bound to the side. The patient, if restless, should at first be kept under the influence of morphia. The compress should not be disturbed for three or four days.

B. **Later Cases.** If pressure has been tried but has not been successful, the wound, owing to the difficulty in rendering the skin of the palm aseptic, is likely to be infected; the hand will then be red, brawny, painful, and suppurating. If hæmorrhage still continues after the tension has been relieved by carefully made incisions it will be best to tie the brachial artery at once in the middle of the arm (p. 171) rather than to ligature the radial and ulnar in the lower third of the forearm (pp. 127, 139), and for these reasons:

(1) Ligature of the brachial will be performed through healthy and uninflamed parts.

(2) While the anastomoses round the elbow are so free and so reliable as to prevent any risk of gangrene after ligature of the main vessel, ligature of the radial and ulnar is rendered uncertain owing to (*a*) the anastomoses between the two palmar arches; (*b*) the anastomoses between these and the carpal arches; (*c*) the blood brought by the comes nervi mediani artery, which will not be stopped by ligature of the radial and ulnar; (*d*) the fact that if inflammation has set in, dilatation of the arteries will have taken place.

After early ligature of the injured vessel the wound may be infected, and secondary hæmorrhage occur. Under these circumstances an attempt again to secure the bleeding vessel *in situ* is likely to fail. Ligature of the brachial will then be indicated.

PALMAR ANEURYSM

The rarity of this disease in arteries so small in size as those of the forearm and hand is well known. Aneurysm when present in the palm is usually the result of injury, or much more rarely it is embolic in nature and co-exists with serious disease of the heart.

In a third class of case the aneurysm is an instance of localised subacute endarteritis deformans,[2] and arises without any known cause. Here other arteries *e.g.* the cerebral—are very probably also affected. The inner part of the superficial palmar arch is that chiefly affected.

Operation. If other treatment has failed, if the aneurysm continues to increase, to cause troublesome throbbing, and numbness of the fingers supplied by the ulnar nerve, it is best treated by excision after ligature of the ulnar artery above and below. The skin having been thoroughly cleansed, and an Esmarch's bandage applied above, a longitudinal incision, two or three inches long, is made over the swelling, dividing the skin, palmaris brevis, and palmar fascia. Any tendons and the ulnar nerve are carefully drawn aside. The ulnar artery is then tied with sterilised silk or catgut above and below the swelling. The sac is next snipped away with scissors, and, if needful, the deep branch of the ulnar artery is tied also. The

[1] The wound sometimes does not bleed when examined. If there is a history of much bleeding and if the depth of the wound make it probable that an artery is injured, pressure should be applied.

[2] An instructive case, treated successfully by incision of the sac with interesting remarks on the pathology and treatment of this disease is recorded by Dr. J. Griffiths, of Cambridge, *Brit. Med. Journ.*, 1897, vol. ii, p. 646.

palmar fascia should be united with a few buried sutures of fine sterilised catgut, and the skin incision closed with sterilised salmon-gut.

Movements of the thumb and index finger should be carefully commenced in two or three days, but the other fingers should be kept quiet for the first week. The wound should have healed in ten days.

While the above course is certainly the best, cases which have been recorded[1] show that ligature of the ulnar, or of the ulnar and radial, will be sufficient in palmar aneurysm, if, for any reason, the surgeon prefer to adopt this course.

COMPOUND PALMAR GANGLION
TUBERCULOUS TENO-SYNOVITIS

Tuberculous teno-synovitis occurs in two forms: (1) Where the distended sheath contains numerous "rice-grain" or "melon-seed" bodies: (2) the fungating form, in which masses of tuberculous granulation tissue exist in and project from the lining membrane. Some cases where there is a chronic serous effusion into the tendon-sheath are also tuberculous in origin. Tuberculous disease may affect any tendon-sheath, but one of the most frequent and important sites for this disease is the sheath of the flexor tendons or palmar bursa.

Practical Points. (1) There is the risk of spreading infection if the wound be not kept carefully aseptic. (2) Recurrence is very frequent, from the fact that it is difficult to remove all the "melon-seed" bodies which are often present in great abundance, or all the diseased synovial membrane. (3) A compound palmar ganglion is very often tuberculous. In these cases the disease is very likely eventually to extend to the carpus. The arrangement of the synovial sheaths of the fingers is shown in Fig. 35.

Fig. 35.

Treatment. A radical operation is strongly advised for compound palmar ganglion owing to the frequency with which this disease is tuberculous, and its consequent dangers from its surroundings. But as, in a few cases, this disease may be of a chronic inflammatory nature, and as the surgeon may not always be able to avail himself of the skilled assistance, &c., which is an absolute *sine qua non* for the radical operation, a simpler operation will be first described. It is not recommended, and any one employing it must remember that if he fails to cure the disease, he will have rendered subsequent needful steps much more difficult.

A. The parts having been rendered sterile, an incision should be made an inch above the anterior annular ligament, avoiding the median nerve, and going down into the ganglion, the opening[1] into which is not to be a mere button-hole, but must be kept free and dilated. The edges of the free opening into the ganglion being held apart by tissue forceps, all the "melon-seed" bodies must be removed, partly by pressure, partly by the use of the curette, which should explore all the

[1] A. Caddy, of Calcutta (*Lancet*, 1896, vol. ii. p. 603). The aneurysm was traumatic, and the patient 33. The radial and ulnar were tied. W. Robertson, of Glasgow (*Brit. Med. Journ.*, 1897, vol. ii. p. 1637). Here there had been no wound, but the palm had been repeatedly knocked in starting some engine gear. The patient was 18. The ulnar artery alone was tied.

cavities into which these ganglia are sometimes divided. The question of providing a second opening below the annular ligament will now arise. When the ganglion is large, and when the "melon-seed" bodies are numerous, a second opening should certainly be made. This may be done by passing a director or dressing-forceps from the upper opening under the annular ligament, and cutting down upon it through the palmar fascia, care being taken to avoid the superficial arch. This opening having been enlarged with the help of the dressing-forceps, the curette is again applied, if needful, and when, either by this means or by rubbing between the openings a strip of sterilised gauze, all the "melon-seed" bodies are detached and removed, the cavity is washed out with a sterile saline solution and then, by pressure, and the application of sterilised pads, dried as thoroughly as possible.

A small rubber drainage tube may be inserted for a few days between the upper two of the interrupted silkworm-gut sutures which close the wound above the wrist. The hand and forearm may be conveniently put up with the fingers flexed, as on a Carr's splint. Passive movements of the fingers should be started at the end of a week.

B. A more radical operation should be performed practically every case, owing to the probable tuberculous nature of the trouble and the risk of the infection extending to the carpus. It should certainly be performed when there is reason to suspect tuberculous mischief, or when the disease recurs. The ganglion having been opened by the steps given above, but with much freer incisions, its walls will certainly be found to be thick and velvety, perhaps showing vascular fringes over the tendons. In such case each of the tendons must be separately hooked up and cleaned with curved, blunt-pointed scissors and dissecting forceps, the diseased tissue being removed in as large continuous pieces as possible. To eradicate the whole of the tuberculous synovial membrane it will be needful to divide the anterior annular ligament, the position of the median nerve being first carefully noted. The four cases given below, in which this step was taken, show that no weakening of the hand need be feared. The incision must be boldly made from about one and a half inches above the annular ligament down through this structure to a point just above the level of the superficial palmar arch. Otherwise there is danger that, by insufficient exposure of the parts, persistence of the tuberculous mischief, and, ultimately, disease of the carpus, may ensue. When by the use of a blunt hook, dissecting forceps, and blunt-pointed scissors, each individual tendon has been cleaned as thoroughly as possible, the surgeon examines for the presence of bone disease, flushes out the cavity with hot sterile saline solution, followed by rubbing in of sterilised iodoform emulsion. During the operation every bleeding-point must be secured and ligatured. The use of forci-pressure is less advisable owing to the risk of damage to the tendons; general oozing is checked by the hot saline solution. The annular ligament is then united with buried sutures of catgut and the dressings are, when the wound has been closed, applied so as to exert a uniform pressure.

Two more points need reference. First, as to the use of a tourniquet. This is not of material importance. The after oozing, always free, will be especially so if this, or an Esmarch's bandage, be

[1] If on cutting into the ganglion its wall is found to be thick, velvety and vascular this operation is certain to fail.

employed. Drainage should be provided by inserting a small tube between two of the silkwórm-gut sutures which are left untied at the upper end of the wound. The tube may be removed and the wound closed after two or three days. Another and more important point is one which has not received adequate attention, and that is the condition of the sheath of the flexor longus pollicis. There are usually two synovial sheaths beneath the annular ligament, one for the flexor tendons of the fingers and the median nerve, the other for the long flexor of the thumb. The latter, which may communicate with the former, extends continuously from above the annular ligament to the base of the ungual phalanx of the thumb. It is not always involved in tuberculous synovitis of the palmar bursa. Thus in two of the cases mentioned below it had escaped. In two, fulness in the thenar eminence and thickening along the tendon below gave evidence of more extensive tuberculosis. In order to avoid dividing the short muscles of the thumb, the sheath was laid open along the phalanges, the thickened tuberculous membrane there was removed, and then, by means of a curette and strips of sterilised gauze soaked in iodoform emulsion, passed by means of sims-forceps from the opening over the thumb below to that above the annular ligament, the diseased synovial tissue was curetted and rubbed away as far as possible from that part of the sheath which lies beneath the muscles of the thenar eminence. As soon as the wounds were healed collodion dressings were employed, and over these, uniform pressure with strapping, applied especially firmly over the thumb. The cure was complete when the patients left the hospital, and remained so (*vide infra*) during the six months which had elapsed since the operation. After this operation passive movements of the fingers must be begun as early as possible to guard against matting together of the tendons. The constitutional and general treatment of tuberculosis must also be carefully carried out.

In the following four cases Mr. Jacobson divided the anterior annular ligament. "The first, in 1896, was a woman, æt. 53, who earned her living by working at fancy embroidery. Dr. Holland Wright, whose patient the woman was, sent her to me in June 1904 to show the result. This was perfect. The patient had followed her employment all the time, but there was some evidence of phthisis in the left lung. The second case was a woman, æt. 42. Though very numerous 'melon-seed' bodies and much thickening of the synovial membrane was present, this was the only case in which tubercle bacilli could not be found. When I last saw this patient, one and a half years after the operation, the hand was as good as its fellow. The third and fourth patients were sent to me by Dr. Jones, of Alton, almost coincidently, in 1903. In both the sheath of the flexor longus pollicis was markedly involved. Both were young patients, one a grocer's assistant; the other, a barmaid, had been operated upon before by a single incision above the wrist. This fact, the disease persisting, greatly increased the difficulty of the operation. In answer to my inquiries, the man wrote to me as follows about six months after the operation: 'My hand is quite strong, much stronger than when I first felt anything of it. The top joint of the thumb is still stiff, and I can't close the hand quite as well as the other. Otherwise it feels perfectly well.' With regard to the fourth case, that of the barmaid, Dr. Jones wrote about six months after the operation: 'As far as I can see, the result is as perfect as

possible. She has regained all movements of the fingers, the grip of the hand is a little weaker than on the sound side.'

"The above cases prove that, with skilled assistance, there need be no hesitation about division of the annular ligament. With regard to any treatment of the flexor sheath of the thumb, six months is insufficient to prove anything. At all events, the example is worth following. If the method prove incomplete, I should not hesitate to divide the muscle and lay open the whole of the sheath. A sound hand, at the expense of a less mobile thumb, would certainly be preferable to persistent tuberculosis, matted tendons, and invaded wrist-joint with sinuses, and secondary tuberculosis in the lungs or elsewhere. Should tuberculous teno-synovitis occur in the extensor sheaths at the back of the wrist it must be treated on the same lines, *i.e.* the sheath must be thoroughly opened up, the diseased synovial membrane clipped or scraped away, any pockets thoroughly curetted, and any bony foeus completely scraped out."

Treatment of a simple ganglion. These . dl cysts, which most commonly occur in connection with the tendon sheaths at the back of the wrist, are variously regarded as due to local teno-synovitis, colloid degeneration of the synovial membrane, or hernial protrusions of the tendon sheath, or in some cases from the synovial membrane of the carpal joints. Should simpler methods, such as the application of iodine, pressure, or incision with the injection of a few drops of pure carbolic fail, the ganglion should be excised.

OPERATIONS FOR UNION OF DIVIDED TENDONS. TENORRAPHY. TENOPLASTY

As in the case of divided nerves, the **union of divided tendons** may be **primary** or **secondary,** according as the surgeon sees the case at once or after an interval This injury is especially frequent and of great importance in the te dons of the hand and wrist.

Preliminary consideratious. (1) The diagnosis usually presents no difficulties. There will be entire loss of the movement produced by the injured tendon. Loss of power may result from injury to a motor nerve, but in this case there will probably be some anæsthesia, and electrical stimulation of the muscle will produce the lost movement. (2) When a tendon is divided there will certainly be some retraction of the proximal end owing to the tonic contraction of the muscle. Mr. A. H. Tubby[1] points out that in the case of the extensor tendons of the fingers, there will be but little retraction if they are divided at the back of the hand or fingers owing to the connection between the various tendons, their aponeurotic expansions, and their close attachment to their sheaths. If the extensors of the thumb are divided at the back of the wrist there is but little retraction ; if, however, they are divided at the back of the metacarpal the upper end may retract as much as three inches. In the case of the flexor tendons there is but slight retraction, owing to the presence of the vinculæ if they are divided over the phalanges ; there is also but little separation if the injury occurs in the palm, but if they are divided above the wrist great retraction of the upper end is to be expected. (3) It is necessary to insist upon the importance of immediate suture. If the injury to the tendon has at first been overlooked the difficulty in finding the separated ends and bringing them together is much increased owing to obliteration of the sheath and matting of the

[1] *Informities*, 1912, p. 769.

tendon to surrounding structures. Here, too, it may be pointed out that adhesions of the flexor tendons to each other or to a cicatrix will certainly prevent full extension of the fingers. (4) In all these operations careful aseptic precautions must be taken. A tendon has a poor blood-supply and, if the wound becomes infected, sloughing is very likely to occur.

For the sake of convenience, operations for the union of divided tendons may be classed under the following heads:

A. Cases where both ends can be found and where they can be easily adjusted. If the injury is recent a longitudinal incision enlarging the original wound will usually be best, but in some cases—*e.g.* where the injury is old-standing and the tendons are matted together—a flap may be preferable. Any bruised, torn, sloughy, or scarred tendon tissue is removed as cleanly and charily as possible with a sharp knife or scissors. There is no difficulty in finding the distal or fixed end of the tendon. Should the proximal end have retracted, it may be sought for by one of the methods described on p. 97. The best material for sutures is fine catgut, which will resist absorption for twenty days; sterilised silk may also be employed, while Cheyne and Burghard[1] recommend the use of very fine fishing gut. Small non-cutting curved needles should be used: needles with a cutting edge are very likely to tear through the damaged tendon.

Methods of inserting the sutures. (1) *When the tendon is round*, and either of medium or large size, the suture may be passed from before backwards through one tendon end, and then from behind forwards through the other, and the ends are knotted on the superficial surface of the tendon. Large tendons may be secured with two lateral or with one central and two lateral sutures, smaller tendons with one median suture only. As the suture is tightened the ends must be kept in exact apposition, and not allowed to override one another. In this method and in the others which follow, care must be taken not to insert the sutures too near to the tendon ends. There is a tendency for the sutures to separate and cut through the parallel fasciculi; this will certainly happen if there is any tension or if muscular contraction throws any strain on the stitches. This splitting is very likely to take place in the thin flat extensor tendons.

(2) Under these circumstances, *where the tendon is flat*, there is a strong tendency for the suture to cut its way out if inserted in the ordinary manner: one of the following methods, viz. Wolfler's, Le Fort's, Le Dentu's, which are made plain in Figs. 36 and 37, will be found preferable.

(3) *Where the tendon is round and small*, too small for the methods of Wolfler or Le Dentu, and where, owing to the size of the tendon and the tension, a suture inserted in the ordinary way will cut out, Schwartz's method may be tried (Fig. 37). A circular ligature is tightly tied round each tendon end a short distance from the cut surface; two longitudinal sutures are then passed above and below these ligatures, and thus prevented from slipping, serve to draw the ends together. An objection to this method is that the circular ligatures endanger the nutrition of the tendon ends.

(4) Cheyne and Burghard[2] advise the following method, which avoids the above drawback to Schwartz's, while it meets the tendency of

[1] *Loc. infra cit.*, p. 228.

[2] *Manual of Surgical Treatment*, vol. ii. p. 93.

ordinarily applied interrupted sutures to cut out too quickly: "The best plan is to pass the needle across from front to back through the whole thickness of the tendon quite to one edge of it and close to the line of division, and then to tie the thread over the small piece of tendon included in the loop. Although the piece of tendon below the ligature may possibly die, a secure hold is thus obtained, which may be pulled on firmly without fear of the thread cutting its way out. The same procedure should be adopted also on the opposite side of the tendon, and both the upper and lower ends should be prepared in this way, care being taken that the stitches are inserted at exactly corresponding points in the two ends, so that the tendon is not twisted when they are tied together. The ends of the corresponding threads on either side of the *division* are then tied sufficiently closely to *bring* the two cut surfaces into apposition. It is well to put in one or two stitches in the centre to reinforce the lateral ones; these will prevent the cut surfaces from being displaced laterally or curled up, and as they do not bear any strain, they may be inserted in the usual manner."

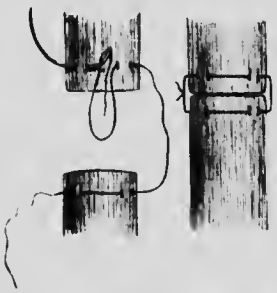
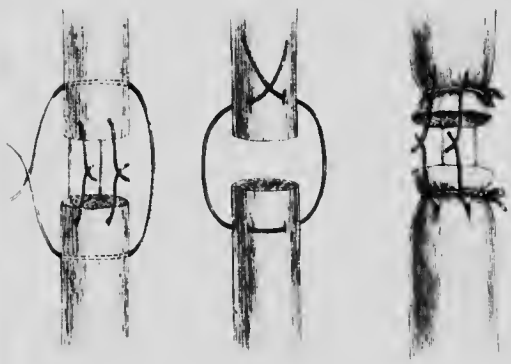


Fig. 36.—Wölfler's transverse tendon-suture (*Wien. Med. Woch.*, 1888, 5, 1). When the ends touch, the inventor calls his method "direct transverse tendon" suture, and gives it the name of "indirect" when the ends cannot be brought together, and the threads are tied and left to form guides for the development of fibrous connecting bridges.

When the divided tendons have been united and all hæmorrhage and oozing have been checked, the wound is carefully sutured. If the wound when first seen is dirty, or if after-collection of blood or serum is thought possible, a small drainage tube should be inserted. The dressings should be applied in sufficient quantity and uniformly so as to exert even pressure. If possible they should remain unchanged for seven or ten days.



A. B. C.

Fig. 37. A. Le Dentu's method of tendon-suture.
B. That of Wölfler.
C. E. Schwartz's method.
(Le Dentu and Delbet, *Traité de Chir.*, t. iii. p. 825.)

The limb must be arranged on a splint in such a position that no undue tension falls upon the united tendons, while at the same time the comfort of the patient is attended to. Moulded splints of poro-plastic or gutta-percha are best, or a perforated zinc trough, which is readily cut, fairly easily bent and moulded to any degree of flexion, and which can be boiled, will be found useful in the common cases of tendons injured about the wrist where the elbow, wrist, and fingers must be kept flexed. If wooden splints be employed, a Carr's splint is comfortable, but must be reinforced by an angular splint to maintain flexion of the elbow. Wooden splints are, however, much less efficient, in that they fail to secure the needed amount of flexion,

or the power of modifying this later on. The patient's comfort will be greatly promoted by removing the splint every two or three days and altering the angles slightly. Restlessness, while recovering from the anæsthetic, must be prevented, for contraction of the muscle may cause the sutures to tear through and the ends of the tendon to again separate; if the sutures do not hold, the parts will tend to heal in one contracted mass. Most careful attention will be needed afterwards in the employment of warily begun, and perseveringly continued, passive and active movements. In commencing movements the surgeon has, on one hand, to prevent the formation of adhesions; on the other, he must remember the risk of breaking down the recently formed union. The date must vary with each case, but, as a rule, in the case of the tendons of the fingers, passive movement may be begun, very gently so as not to strain the union, about the sixth day, and gradually increased. From the fourteenth to the twenty-first day will usually be early enough for the commencement of active movements. Soft adhesions will certainly have formed, but if the sutures have been so placed as to secure a firm hold, and if the wound has run an aseptic course, there is little risk of the union being broken down.

In cases of secondary tendon-suture, as in that of nerves, the result may be disappointing for some months; but if the tension was not extreme, and if the wound heals by primary union, the final result will probably be satisfactory, if the patient does his best to help the surgeon. This opportunity may be taken to point out that, in the treatment of incised wound of the hand or foot, the condition of the tendons should be cleared up as well as that of the vessels. Too often attention is directed solely to arresting the urgent hæmorrhage, especially if the situation of the wound does not exactly correspond to the course of a tendon. The wound heals quickly, and then attention is drawn to the loss of power. The following is a good instance:

In August, 1888, H. P., æt. 31, was seen with constant flexion of, and inability to extend, the last two phalanges of the thumb. A few months before he had been treated for severe hæmorrhage from an incised wound of the dorsum over the first phalanx and metacarpal of the right thumb. By dissection the extensor secundi internodii was found to have been divided, the upper end coming into view on following up the sheath.

The extensor brevis had been only partially divided for three-quarters of its width. When trimmed the two ends of the extensor secundi were separated by an interval of an inch on complete extension of the thumb. By the use of a stout suture, and by pushing down the upper end of the tendon, the ends were brought to within a quarter of an inch of one another; two fine sutures then brought the ends into good but not exact apposition. On hyper-extending the thumb the V-shaped notch in the partially divided extensor primi was obliterated, so no sutures were used here, the edges of the notch being merely refreshed. A splint was applied on the palmar aspect, so as to keep the thumb hyper-extended. When seen two months later, the patient had recovered complete power of extension.

B. **Cases where only one end can be found.** The distal or fixed end of the tendon can nearly always be found. The difficulty of finding the upper retracted end of one of the flexor tendons may often be extreme. Should it not come into view on slitting up the sheath for a short distance one of the following methods may be tried: (*a*) The muscular belly may be pressed down by manipulation with the fingers, or an Esmarch's bandage may be applied commencing at the elbow and passing downwards towards the wrist. (*b*) M. Felizet advises, if slitting up the sheath and methodically pressing down the muscular belly are insufficient,

that the upper end may be made to emerge into view, and further disturbance of the parts avoided, by extending the adjacent fingers. By this step, what M. Felizet terms the little fibro-serous vincula, which tie together adjoining tendons, are drawn upon and pull wn the upper end of the severed tendon into view. (*c*) When the s ting up of the sheath would have to be very extensive, and might involve danger to important structures, Cheyne and Burghard advise that a second incision be made over the tendon well above the wound, and the sheath opened; from this incision the tendon is pushed down by means of sinus forceps until the divided end appears in the original wound. (*d*) In cases where difficulty is experienced in finding the distal end, *e.g.* in secondary operations for divided tendons at the wrist where the proximal end is likely to be fixed by adhesions, the same writers advise as follows: "A better plan than dividing the annular ligament is to cut into the palm and expose the tendon well on the distal side of the division; then, by pushing a probe up the sheath, the point at which adhesion has taken place may be found, and an attempt made by forcing the probe upwards through the adhesions, to make it protrude into the wound, and form a guide along which the tissues can be turned aside until the end is reached." (*e*) The only alternative to these methods is to make a prolonged dissection upwards, dividing the sheath, the annular ligament, and the muscles, but taking the greatest care not to damage vessels or nerves, until the proximal end is found and freed. If, after careful search, it is still impossible to find the upper end, the lower end may be attached to a neighbouring tendon by **tendon-anastomosis.** This may be effected by one of the three following methods: (*a*) By fixing the severed end *in a button-hole* made by splitting an adjacent tendon longitudinally (Fig. 38). (*b*) **Anastomosis by bifurcation or splitting of an adjacent tendon.** Schwartz describes a case where the proximal ends of two of the extensors of the thumb divided at the back of the metacarpal could not be found. The tendon of the extensor carpi radialis longior was split longitudinally; the outer division was separated below and sutured between the peripheral ends of the divided extensors of the thumb (Fig. 39). The following case[1] is a good example of this method, and of one means of employing sutures so as to prevent tension:

Fig. 38. Buttonhole method of tendon-anastomosis. Method of MM. Tillaux and Duplay. (Duplay and Reclus, *Traité de Chir.*, t. i, p. 825.)

An oblique cut with a bread-knife divided the common extensor of the index and middle finger, and the extensor indicis, the central end of the latter retracting so far that it could not be reached, unless by slitting up its sheath. The ends of the common extensor were united by fine sutures. The peripheral end of the extensor indicis was attached to both ends of the sutured tendon from the extensor communis to the index finger. The strongly stretched extensor tendons of the second and third fingers were now fixed (to prevent retraction by muscular action) by sutures past 2 cm. higher up, through skin and tendon sheath, and tied over a strip of gauze.

[1] Fillenbaum, *Wien. Med. Woch.*, Nos. 29 and 30, 1885.

These were removed on the fifth day. Passive movement was begun on the sixteenth day. Six months later the man had perfect use of his fingers.

The back of the hand is the most favourable situation for the anastomosis of tendons, as they are here united by fibrous expansions. Thus a neighbouring tendon can be relied upon to render active the peripheral end of another tendon whose central end cannot be found. Furthermore, it is on the back of the hand, and especially near the knuckles, that operations on tendons give the best results. Retraction is less here than elsewhere, owing to the presence of connecting bands and expansions to the joint capsules; there is less bleeding; the skin is thinner, and its greater mobility renders less harmful the formation of any adhesions. But while tendon anastomosis is especially applicable to the extensors, the following case, in which Mr. F. T. Paul[1] joined the tendon of the flexor longus pollicis to the index tendon of the flexor profundus, shows that it may also be employed in the case of the flexors.

FIG. 39. Tendon-anastomosis by splitting or bifurcation of an adjacent one. Method of M. E. Schwartz. (Dentu and Delbet.)

A boy, æt. 7, had sustained a severe cut across the ball of the right thumb. There was no power over the last joint, and consequently no power of holding anything—*e.g.* a pen in the usual way. An incision over the flexor longus revealed the distal end of the tendon in good condition and firmly attached to the scar. The central end was sought for, but though the incision was prolonged an inch above the annular ligament could not be found. Under these circumstances it was decided to form an anastomosis between the terminal end of the cut flexor and the side of the index tendon of the flexor profundus; a step which, if successful, would give the patient power of flexing the thumb and forefinger together, and thus of holding articles between them. The free end of the thumb tendon was inserted into a notch made in the side of the index tendon, where it was fixed by two or three sutures. A year later it was found that not only had the boy the combined power of grasp hoped for, but that, under training by a skilled pianist, he was obtaining independent movement of the thumb and forefinger. The fact that, while the boy had only one muscle between the two digits, he could yet flex them separately, was entirely due to the training of the extensors. Thus, if told to bend the thumb alone, he would fix the forefinger by its extensor, and then flex the thumb, or the reverse.

C. **Cases where both ends can be found, but it is impossible to adjust them.** This difficulty is usually met with in some cases of secondary tendon suture, or after the removal of a growth which has become adherent to a tendon. The following methods are available:

(1) **Tendon Lengthening.** (*a*) *Method of Trnka* (Fig. 44). This may be tried in the case of large tendons. The longitudinal incision must not be carried too near the end of the tendon, and to prevent the displaced slip becoming detached by any tension that it may be called upon to bear it should be secured above as well as below by several fine sutures (Fig. 44a).

[1] *Liverpool Med. Chir. Journ.*, 1895, p. 500.

(*b*) *Method of Czerny* (Fig. 40). Czerny in a case in which one of the extensors of the thumb had been divided, filled up the gap by splitting the peripheral end to the required extent and reversing it, suturing the lower end of the displaced slip to the divided central end. If this method be employed, a circular suture should be inserted at the angle where the slip is turned down so as to prevent its being torn away. Should this happen, the separated portion of the tendon is almost certain to slough. A transverse incision is made between one or two inches above the free end of the proximal part of the tendon, according to the size of the gap to be filled. The incision only goes across half of the tendon, and from this point the latter is split vertically downwards as far as a point from a quarter to half an inch from the cut end. The flap is then turned down, care being taken that it is not detached, and to meet any future tension at the angle sutures are passed and securely tied as described above. If necessary a similar flap may be turned up from the distal portion of the tendon. Under these circumstances the two flaps should be cut long enough to overlap, so that sutures can be placed between their contiguous sides. Here, as in all cases when newly united tendons are submitted to some tension, the parts must be kept fully relaxed for a sufficient time, active and passive movements begun very gently, and increased very gradually. Where many tendons *e.g.* the flexors of the wrist have been lengthened, it may be wise to defer active movement for a fortnight.

FIG. 40. Tendon lengthening by Czerny's method. (Duplay and Delbet.)

In the method of Hibbs (Fig. 45) a longitudinal slip is turned down as in Czerny's method; further lengthening is then obtained by splitting this slip in a similar fashion, the transverse incision being made on the opposite side of the tendon to the first, and the longitudinal incision extending upwards towards the first transverse cut (Fig. 45). The angles require careful strengthening by sutures.

(*c*) The tendon may be lengthened by some method requiring a second transverse division of the tendon. Some other method should, if possible, be adopted, for there is a strong tendency for the separated portion to slough. When the tendon is thick and rounded, Anderson's method may be employed. The gap that remains between the two ends of the tendon having been carefully measured, each tendon is split accurately in the middle line, care being taken not to bring the split too near to the end of the tendon. At the two ends of the above incision section of the opposite halves of the tendon is made, as in Fig. 41.

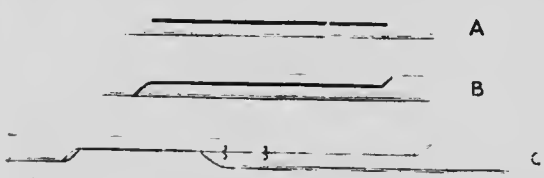


FIG. 41. One method of tendon lengthening. A. Tendon split longitudinally. B. Section completed by incisions at ends of fissure. C. Divided tendon elongated and sutured. (Anderson.)

(*d*) *Tendon lengthening by zig-zag incisions* (Fig. 42). Poncet has shown that this method may be successfully employed in cases where, owing to the tension, the sutures threaten to cut through.

In the first case, that of a boy whose tendo achillis had just been severed,

M. Poncet, in order to diminish the tension so as to allow the ends to come together made, on the upper portion of the tendon, two cuts in zigzag fashion, each passing a little more than half across the width of the tendon. Marked elongation of the tendon followed, and the ends were then easily sutured without tension. The boy was allowed to walk on the twenty-eighth day, and left the hospital about seven weeks after the injury, walking being almost perfect.

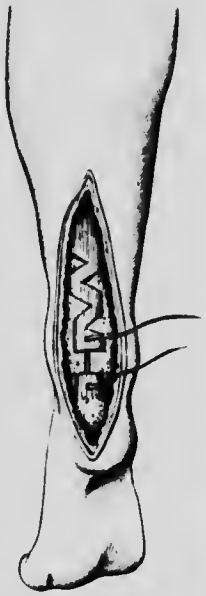


Fig. 42. Tendon-lengthening by zigzag incisions. (Poncet.)

While this method is especially applicable to the tendo achillis owing to its size, M. Poncet has also used it in the case of the extensor indicis. The incisions should always pass through at least half the width of the tendon: there is no risk of the tendon sloughing if all precautions are taken to avoid infection of the wound.

(*c*) *Tendon lengthening by means of osteotomy.* M. Poncet has also made use of the following ingenious method for uniting a severed tendo achillis (Fig. 43):

Forty days after the injury (by an axe) the wound was healed, but the ends of the tendon were 3 cm. apart, and the lameness was very disabling. A U-shaped flap having been turned upwards from the back of the heel, a slice of the os calcis containing the insertion of the tendon, was detached vertically by a saw; when quite loose it was glided upwards, and the lower part of it fixed to the upper part of the sawn surface with an ivory peg. The ends of the tendon could now be brought into close apposition without undue tension. The result was perfect.

(2) **Distance sutures.** (*a*) *Distance sutures alone.* In some cases, where the ends of the tendons could not be adjusted, the widely separated ends have been joined by suture loops which have appeared to diminish muscular tension, and to help in directing the process of repair. Cat-gut and fine silver wire have been employed, but mercurialised silk (*see* footnote, p. 106) is recommended by Mr. Tubby as the most satisfactory material.

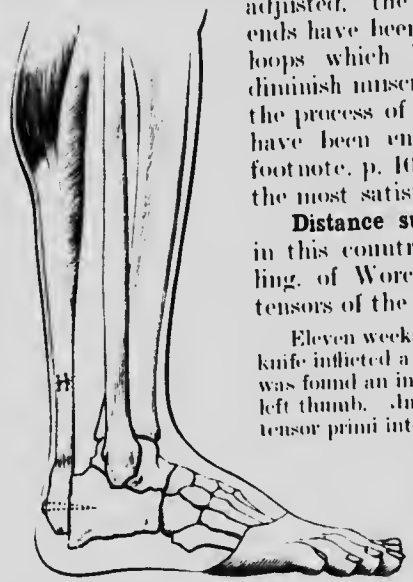


Fig. 43. Suture of tendo achillis by partial detachment and sliding upward of the os calcis. Poncet's method. (Duplay and Reclus.)

Distance sutures seem to have been employed in this country as long ago as 1899, by Mr. Gostling, of Worcester,[1] in a case of injury to the extensors of the thumb.

Eleven weeks before, while the patient was pruning, his knife inflicted a wound, the scar of which, an inch in length, was found an inch above the base of the metacarpal of the left thumb. Just below this scar the distal ends of the extensor primi internodii and extensor ossis metacarpi pollicis could be easily felt, but the proximal ends could only be indistinctly made out, five inches off, on the back of the forearm. The left hand was seriously crippled, the thumb being flexed and adducted into the palm. An incision exposed the distal ends at once, but the synovial sheath was blocked for three-quarters of an inch by scar tissue. This was cut through and the sheath slit up until the proximal ends of the tendons were found. All four ends were smoothly rounded off, and no adhesions had formed. As the ends were five inches apart it was impossible to bring them nearer together than three-quarters of an inch. The

[1] *Lancet*, vol. ii, 1890, p. 767.

ends having been pared, the corresponding ends were united by two catgut sutures. The wound healed by primary union, and six months later all the movements of the thumb were perfect.

M. Glück, who has employed the method of distance sutures with marked success in several cases, used it in one instance not for filling up a gap in a tendon, but for replacing an end which was lost.[1]

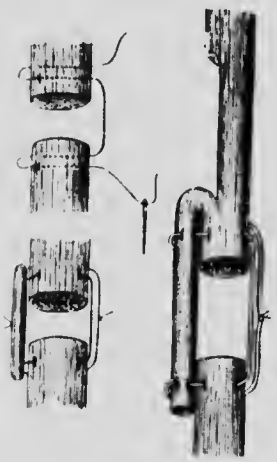


Fig. 44.

A boy had the tendons of the extensor indicis and the extensor communis divided as the result of an injury. The central ends were tied with loops of silk which were carried to their points of insertion and fixed by means of a steel needle. The first trial failed, the sutures tearing out. A second operation succeeded. When the needle was removed, at the end of four weeks, both the middle and terminal phalanges could be extended.

In another case in which the two ends of the flexor tendons of the middle finger were widely separated after an injury, M. Glück[2] was able to remedy a gap of 10 cm. by the substitution of threads of silk and catgut. Healing by first intention and perfect restoration of movement followed. It was thought that in this case a gradual substitution of the catgut by connective tissue took place. In other cases the foreign body employed remains long encysted in a sheath of connective tissue. In all these operations strict asepsis is, of course, essential.

(3) **Tendon-grafting.** Here a portion of another tendon, from the same patient, in cases where there has been an extensive injury, as in a partially crushed hand, or a tendon from an animal is made use of.

Mr. Mayo Robson[3] successfully grafted four and a half inches of a flexor tendon from a finger too much smashed to save, on to the dorsum of the hand, so as to form a new extensor for the index finger, the tendon of which had been completely torn away. The proximal end was stitched to the belly of the extensor communis, where the missing tendon had been originally attached, the distal end being fixed to the small portion left near its insertion into the phalanx. The case, which is an excellent instance of conservative surgery, ended in recovery with a most useful hand. During extension of the index the new tendon could be felt to move under the skin.

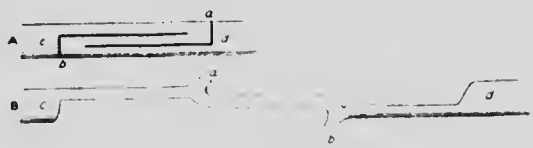


Fig. 45. Method of Hibbs.

Grafts from tendons of animals are extremely likely to slough or to be absorbed. Even if no suppuration occur the grafts, in all probability, only act as conductors for new fibrillæ as in the case of distance sutures.

Dr. Rochet, of Lyons, has described a case in which he successfully practised a method of tendon-grafting, which he called autochthonous, the graft being taken from one of the divided tendons themselves (Fig. 46). This method is especially applicable to the flexor tendons of the fingers.

[1] *Semaine Medicale*, 1892, p. 198.
[2] *Loc. supra cit.*
[3] *Clin. Soc. Trans.*, vol. xxii, p. 291.

The patient had, two months before, suffered division of the flexor tendons at the root of his right index finger. The two lower phalanges were constantly extended, all power of flexion being lost. At the operation an interval of 6 cm. was found between the divided ends which by no means could be reduced to less than 2 cm. To fill this gap an incision was made over the lower part of the middle phalanx and the base of the last, just where the flexor profundus emerges from between the two slips of the sublimis. Dr. Rochet divided the former, and then, returning to his first wound, drew the piece of the flexor profundus, which was now cut above and below, upwards to fill the gap, the attachments of the tendon to the sheath yielding readily. The lower end of this tendon-slip was then sutured to the distal end of the flexor sublimis, and its upper end to the proximal ends of the flexor sublimis and profundus directly to the former tendon, and latterly to the later. Lastly, the small slip of the flexor profundus, which had been left attached to the last phalanx, was sutured to the two slips of the flexor sublimis a little above its insertion into the phalanx. On the fifteenth day some power of flexion was already present. Eventually the second phalanx could be flexed as freely as that of the other hand. Flexion of the third phalanx was more limited, this not passing beyond a very obtuse angle.

Fig. 46. Autochthonous tendon-grafting. (Rochet.) To the right is seen the gap between the tendons found on exploration: to the left the manner in which it was filled up.

Dr. Rochet observes that it would be possible to carry out this method by taking the graft from the proximal portion of the divided tendon without interfering with its insertion or making a fresh wound.

M. Desquin has devised another method of tendon-grafting, by which the use of a flexor tendon was restored.

A carpenter, æt. 25, had the right middle finger in permanent extension, owing to the severance of the flexor tendons by broken glass thirteen months before. A free incision having been made along the course of the tendons in the finger and in the palm, an interval of 4–5 cm. was found between the divided ends of the superficial tendon, while it was impossible to find the deep tendon. By strong traction on the central end of the superficial tendon, it could be brought into contact with and sutured to the phalangeal end. This could only be done by strongly flexing the finger, and it would have been impossible to unite the superficial parts over the strongly flexed tendon. Returning to the wrist, therefore, the operator divided the tendon with a small piece of muscle adhering. The finger was then extended and the tendon just divided stitched to that for the index finger, so that the flexor for the latter, on its contraction acted upon both fingers. The result was perfect.

Resection of bone in aid of tendon-suture. It will suffice merely to allude to this method, which can only rarely be justifiable. K. Lobker[1] seems to have been the first to make use of it. In a case of long-standing division of the tendons above the wrist, portions of the radius and ulnar were resected. The result was only a partial success, and the bones took three months to unite firmly. Mr. R. P. Rowlands has used this method most successfully.[2]

TENDON SHORTENING

This may be occasionally called for in some cases of acquired talipes calcaneus, where the tendo achillis is elongated. As these cases are

[1] *Centr. f. Chir.*, 1884, No. 50.

[2] *Lancet*, Oct. 21, 1905.

usually due to infantile paralysis a careful examination of the electrical reaction of the calf muscles should be made before the operation. When these muscles are completely paralysed and have undergone fatty degeneration, shortening of the tendo achillis is useless. Conversely, if the electrical examination shows that there is some healthy muscle tissue left, it is well to postpone the shortening of the tendon till as much good as possible has been obtained by a systematic course of electrical treatment, combined with massage of the calf muscles. In suitable cases the tendo achillis may be shortened by one of the following methods:

(1) **Willet's method.**[1] "A Y-shaped incision, some two inches in length, is made over the lower end of the tendo achillis down to the tendon. At the lower or vertical point of the incision the dissection is continued until the tendon is fully exposed over its superficial and lateral surfaces for the space of one inch in length, its deep connections being left undisturbed. The tendon is now cut across at the point of junction of the oblique portion of the wound with the vertical. Next the proximal portion of the tendon is raised, with its superficial connections to the integument undisturbed, to the extent of fully three-quarters of an inch, by dissecting along its upper surface, *i.e.* by reversing the dissection made upon the distal segment. A wedge-shaped slice of the tendon is now cut off from both segments, that from the proximal being removed from the deep surface, whilst from the distal it is taken from the superficial; in both instances the face of the wedge-shaped portion removed being at the point where the tendon has been divided. The heel being now pressed upwards, the proximal portion, including both skin and tendon, is drawn down and placed over the distal, thus bringing the prepared cut surfaces of the tendon into apposition. In this position they are held by an assistant whilst four sutures, two on either side, are passed deeply through the integument, then through both portions of the tendon, and again out through the integument, and fastened. When the operation is completed, the united edges of the wound assume a V-shaped appearance, owing to the angle of the proximal portion being now attached to the terminal point of the distal portion of the original incision."

(2) **Z-shaped method.** This is described in the operations on the lower extremity.

(3) **Ollier's method** of tendon shortening without interrupting its continuity.[2] When the tendon is laid bare it removes with a very small knife, the central part. A window having been thus made, the upper and lower ends are brought together with sutures, and the lateral bands, folding upon either side, contribute to the joining of the two ends.

FIG. 47.

Where the tendon is narrow, instead of making a window, M. Ollier adopts the plan shown in Fig. 47. In either case sutures of fine sterilised silk should strengthen the spot where the folded portions join the main tendon.

TENDON-TRANSPLANTATION, MORE ESPECIALLY IN RELATION TO ITS EMPLOYMENT IN INFANTILE PARALYSIS

It will be convenient to study here, owing to their association with operations on tendons, the surgical treatment of infantile paralysis,

[1] *St. Bartholomew's Hospital Reports*, vol. xvi. p. 309.
[2] *Traité des Résection*, vol. ii, p. 473.

spastic paralysis, and the so-called ischæmic paralysis, though most of these concern the lower extremity. Arthrodesis, or the artificial stiffening of frail joints, which has often to be combined with transplantation of tendons in infantile paralysis, will be considered in the surgery of the lower extremity (*q.v.*).

The object of tendon-transplantation is to reinforce a paralysed muscle by attaching to its tendon one or more tendons of adjacent healthy muscles. This mode of treatment deserves most careful consideration owing to the great frequency of infantile paralysis, especially in our large towns; the lifelong crippling which it entails, including, not infrequently, it should be remembered, amputation in early adult life on account of established trophic ulcers; the expense involved by mechanical treatment, extending, as this usually does, over a lifetime; the limited amount of good which other operations *e.g.* tenotomy—usually effect; and the fact that transplantation of tendons, of itself not a severe operation, can be employed early in life, when the muscles on which additional work is placed have not yet reached their full development, and when at the same time the paralysed muscles have not yet had time to undergo those secondary changes which are so baffling to the surgeon. On the other hand, it is necessary to point out the discredit which will fall upon this method if the conditions which surround it, owing to the pathology of the disease which may call for it, are forgotten, if too much is expected of it, if operations be performed indiscriminately, if no definite plan is formulated, based on very careful previous examination, before any transplantation is undertaken, and if the need of unremitting after-attention for long periods be lost sight of.

As long ago as 1882 Nicoladoni [1] recorded a case of paralytic talipes calcaneus in which he reinforced the tendo achillis with the two peronei, with a good result. Drobnik, of Posen, published in 1892 [2] the first series of cases, sixteen in all. Dr. Milliken [3] and Dr. E. H. Bradford,[3] Surgeon to the Children's Hospital at Boston,[4] were amongst the pioneers in this work in America. In this country, first Mr. R. J. Jones, of Liverpool, and, later, Mr. A. H. Tubby, have brought this method of treatment of a very disheartening disease prominently before the profession in the *Medical Annual* for 1889 and the *Liverpool Medico-Chirurgical Review* 1899, p. 270, and more recently in their "Surgery of Paralyses," 1903. The credit of whatever time proves to be of real value in the account that follows must be given to these writers especially.

PRELIMINARY POINTS IN TENDON-TRANSPLANTATION [5]

"Before it is decided to perform the operation the case must be carefully studied, and a definite plan of procedure formulated. The electrical reactions of the muscles should be previously ascertained, and an attempt made to estimate the strength of those which it is intended to transplant. In the case of the foot all secondary conditions, such for instance as contraction of the plantar fascia should be remedied. For mechanical reasons it is advisable to select the reinforcing tendon from a muscle whose line of action is as nearly as possible parallel with that of the muscle to be reinforced. For instance, in a case of paralytic valgus it may be better to graft a strip of the tendo achillis into the tibialis posticus rather than to bring the tendon of the peroneus longus across the front of the ankle, and into the tibialis posticus. It is also important to remember that muscles which before the operation appear to be hopelessly paralysed, exhibit after the operation signs of returning strength. The operation is rarely called for when only one muscle is paralysed, nor should it be

[1] *Arch. f. klin. Chir.*, Bd. xxvii, S. 660.
[2] *Zeit. f. Chir.*, Bd. xliii, S. 473.
[3] *New York Med. Record*, Nov. 28, 1896.
[4] *Ann. of Surg.*, Aug. 1897.
[5] Tubby and Jones, p. 159.

lone when nearly all the muscles round a joint are implicated. The latter cases are uitable only for arthrodesis (*q.v.*, operations on the lower extremity), and, indeed, there is a fear that an indiscriminate use of transplantation may lead to unsatisfactory esults, and so bring the operation into undeserved discredit. A great point is the hoice of cases."

The selected muscle should belong, if possible, to the same group as the paralysed one, because it is nearest, and restoration of voluntary function is thus more quickly and perfectly secured. "The reinforcing tendon should be carried as directly as possible to the paralysed muscle, and not bent round at an angle, a manœuvre which has the effect of considerably lessening the transfer of power. For instance, if the peroneus brevis were used to reinforce the extensor communis digitorum, the former should be attached to the latter above the ankle, and not below and in front of the external malleolus. When an opponent of a paralysed muscle is selected, it gives emphasis to this principle, namely, that by selecting one of the opponents of a paralysed muscle we not only reinforce that weak muscle, but we lessen the antagonism which exists between the two groups. And by transferring, for example, the insertion of the peroneus longus in a case of paralytic talipes valgus from the outer to the inner border of the foot, we effect an equality between the forces acting upon the two borders." Mr. Tubby[1] mentions the following methods of tendon-transplantation:

FIG. 48. The peroneus longus tendon has been drawn through and fixed on to the back of the tendo achillis. The ends of the peroneus tendon are sewn on to the back of the tendo achillis at D and E, having been first drawn through the tendon at C. (Tubby and Jones.)

A. Intermediate Methods. (1) The tendon of a healthy muscle is completely cut across near its peripheral extremity, and its central end is inserted into the paralysed tendon (Figs. 48 and 49).

FIG. 49. Tendon-grafting for relief of paralytic talipes calcaneus by insertion of the peroneus longus tendon *a* into the tendo achillis at *b*. At *c* is seen the distal end of the peroneus longus. (Tubby and Jones.)

(2) The central end of the divided healthy tendon is attached to a strip from the distal part of the paralysed tendon.

(3) The healthy and the paralysed tendons are divided, the central end of the active one is joined to the distal end of the paralysed, and the proximal end of the paralysed is joined to the distal end of the active. This is the "complete interchange" method.

(4) The paralysed tendon is cut across, and its distal end is sutured to that of a healthy muscle.

(5) A strip is taken from the central part of a healthy tendon, and is attached directly to the undivided paralysed tendon (Figs. 51 and 52).

(6) A strip from the central part of the healthy tendon is joined to a strip from the distal part of the paralysed tendon.

This method gives better results than others, because the continuity of the healthy tendon is not destroyed completely, and its action is fully conserved. Moreover, as the continuity of the paralysed tendon is not interrupted, if some recovery takes place later in the apparently paralysed muscle, or if any power remains in it, aid is given to the reinforcing strip from the healthy tendon.

B. The Immediate Method. Here the healthy tendon is divided and is then directly attached to the periosteum.

This method has been strongly advocated by Lange, of Munich, who ascribes many of the failures in tendon-grafting to subsequent stretching of the paralysed and degenerated tendon.[2] Where the distance between the sound tendon and its new insertion is too great, this surgeon employs artificial tendons of silk (Fig. 50). He reports fifty-six cases. In only two was the result unsatisfactory. In a case of paralysis of the quadriceps extensor, where attempts to correct the deformity by suture of the sartorius had failed, Lange brought the semi-tendinosus and biceps forward under the skin, after freeing them from their insertions. The ends were now found to be so far above the patella that it was impossible to suture

[1] *Deformities*, vol. ii, p. 626.

[2] *Münch. Med. Woch.*, April 1900, Jan. 7, 1902, and *Med. Record*, vol. v, No. 3, pp. 143-145.

them to the ligamentum patellæ. A serviceable silk tendon was provided by the passage of a number of silk threads through the tendinous ends of the transplanted muscles above, and the periosteum of the tubercle of the tibia below, giving eventually excellent power of extension. Several of the artificial tendons were eight inches long. When, some months after the operation, the transplanted muscles began to act, and render the silk cords constantly tight, these steadily increased in thickness. It is probable that the increase in size was due to the formation of fibrous tissue around the silk.

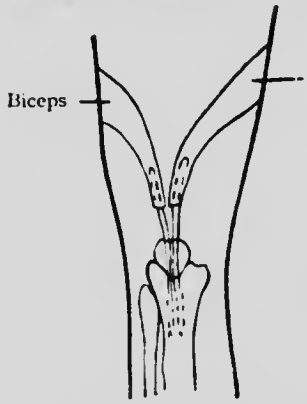


Fig. 50. Länge's method of artificially elongating the transplanted hamstring tendons by silk sutures, so as to effect a junction with the tubercle of the tibia. (Tubby and Jones, after Länge).

Of this method Mr. Tubby says: "There is no doubt that the immediate method of Länge marks a great advance over the older methods and has rapidly displaced them."

Before the operation all secondary deformities, such as contraction of fasciæ, must be remedied. The importance of electrically testing the muscles has already been emphasised. Care must be taken to select such tendons as will improve function and diminish deformity. Mr. Tubby insists on the necessity of a clear conception of the relative importance of the functions of the part. He also points out that the operation should be employed in the stationary stage of infantile paralysis when it is quite certain that the trouble is otherwise irremediable.

Technique of the Operation. Needless to say the most careful precautions must be taken to avoid sepsis. "In many cases a single incision will suffice, but it sometimes happens that, to avoid a single large incision, two smaller ones are made, *e.g.* when the peroneus longus is transferred to the inner border of the foot. In this case one incision is made over the front of the fibula, and a second over the scaphoid.[1] By burrowing through the subcutaneous tissues of the dorsum of the foot with a director, a channel is made for the passage of the tendon to the scaphoid. It is curious to remark that no adhesion of the transplanted tendon takes place to the subcutaneous tissue doubtless from the endothelium on its surface: hence we learn the necessity of handling the tendons very carefully." As regards the actual method to be adopted Mr. Tubby remarks: "If we use the intermediate method, it is generally conceded that the best results have been obtained by one of two procedures. Either joining a strip of the reinforcing tendon to one taken from the paralysed one, or, better still, laying the strips side by side and firmly uniting them. Undoubtedly, however, the most reliable results are reached by Länge's direct periosteal implantation."[2] Great care must be taken to avoid any twisting of the tendon or bending it at an angle. Mr. Tubby advises that sterilisable electrodes should be at hand in case it should be thought necessary to ascertain the condition of the muscles. This may also be determined by inspection. "Thus a healthy muscle is dark red, and its tendon glistening white; a paralysed muscle and tendon are yellow-white, a partially paralysed muscle is mottled, red and yellow,

Fig. 51. Operation for relief of paralytic talipes equino-valgus. The inner part of the gastrocnemius and tendo achillis is split off at *a*, *a*, and divided at *b*. (Tubby and Jones.)

[1] Needless incisions for exploration should be avoided. These cases, long the subjects of trophic lesions, are not ideal ones for securing primary union. Further, any incisions required should not be too long; the scars are undoubtedly liable to become keloid, a result which may interfere with the after-treatment, and the pressure of boots.

[2] When Länge's method is employed, the silk for artificial tendons should be prepared as follows: "The skein of silk is undone and soaked for half an hour in ether, and then for a few minutes in alcohol. It is then boiled for one hour and placed for a week in a solution of 1 in 1000 biniodide of mercury. It is finally wound on glass reels and always kept in this solution."

...d the tendon is white. The last-named muscles will respond partly to stimuli, ...d cannot be regarded as entirely useless.

After-treatment. "The parts are kept absolutely at rest in the new position for at ...st six weeks, in plaster of Paris. The greatest danger of relapse is when this is ...ken off, so that suitable supports should be employed both ... night and day to limit the movements. And here no ...d rules can be given; experience alone is useful. Move... nts must be limited at first, and then very gradually in... ased. The nutrition of the muscle of the transplanted ...don should be maintained at its highest point by very ...eful massage, and by weak electric currents, and efforts ... made to re-educate the transplanted muscle and tendon ... their new function."

Details of the various operations will be found in the description of the operative treatment of the different forms of talipes in vol. ii.

Infantile Spastic Paralysis, or Cerebral Paralysis of Childhood.[1] The two authors from whom the above quotations have been made group their cases into (1) infantile hemiplegia; (2) cerebral diplegia; (3) spastic paralysis. In cerebral diplegia, while rigidity and paralysis are associated, rigidity is the more striking feature; in the hemiplegic form paralysis preponderates, the rigidity being secondary to it. Again, in the hemiplegic form, the arm is more affected than the leg, but this is not so with the diplegic form.

Fig. 53. Tendo-transplantation for the relief of talipes valgus. The peroneus brevis, *a*, is divided and inserted into the tibialis anticus, *c*, at *e*. At *d* is seen the distal end of the peroneus brevis, and *b* marks the peroneus longus. (Tubby and Jones.)

The following facts are of chief interest to the surgeon: (*a*) The upper limb, when affected, is more seriously implicated than the lower. (*b*) The lesion of the upper limb is more permanent. (*c*) The power of dorsi-flexion of the hand and the simultaneous extension of the fingers is lost. (*d*) The movements are performed without precision, spasmodically and slowly. (*e*) The power of the thumb is often lost.

The disabilities of the lower limb are generally: (a) Contraction of the knee. (*b*) Extension of the foot. (*c*) Internal rotation of the femur, with adduction. (*d*) Rigidity.

The cerebral diplegic form is by far the most serious, as we have to deal here with both arms and legs. Clinically this group may be divided into: (*a*) Cases with and without severe mental complications. (*b*) Complete and partial disability of the hands. (*c*) Complete and partial disability of the limbs. (*d*) Cases associated with athetotic movements.

Fig. 52. The second stage of the operation for the relief of paralytic talipes equino-valgus. The inner half of the gastrocnemius and tendo achillis *a* is brought forward and united either to the tibialis posticus *b*, or the periosteum of the scaphoid. The third stage consists in division of the outer half of the tendo achillis in order to relieve the equinus. (Tubby and Jones.)

A. The classes of cases which are and are not adapted to treatment. "A suitable case for treatment is a child or young adult of fair intellectual development, who has had no fits for three or four years. Such a case may be brought with the following conditions: The feet are in a state of talipes equinus or equino-varus. The knees are flexed owing to the tightly contracted hamstrings, and they knock together on account of the ad-

[1] Though the lesions of this disease also are chiefly met with in the lower extremities, they are dealt with here for convenience' sake. For a full description of the deformities due to this hitherto most unpromising disease, readers are referred to Messrs. Tubby and Jones's *Surgery of Paralyses*, and to Mr. Tubby's *Deformities* (1912) from which this account is taken.

duction of the thighs. The thighs are flexed and inverted, and the tensor fasciæ femoris, sartorius, and ilio-tibial band are rigidly contracted.

B. The classes of cases which are entirely unsuited for treatment are the idiotic, the microcephalic, and the violently irritable diplegic who is subject to fits, active athetotic movements and convulsions, and the patient who has no control over the sphincters. Another class of case which is not hopeful for treatment is where the affection of the hands is of such a character as to promise but slight hope of their assistance to the lower limbs during walking with crutches. That is to say, if the paralysis is complete, or if spasm of the hand and arm never relaxes, treatment is of little avail.

It is important to recognise the length of treatment required. Active treatment may be required for many months, and it is therefore unwise to undertake a case in the hospital for a month or two, and then to send it to a miserable home, where neglect will be the inevitable consequence. Even after active treatment has ceased, massage, skilfully directed exercises, with careful and thorough education of the muscles in acquiring new movements, must be carried out for some years. It is therefore necessary to secure the co-operation of intelligent parents, anxious to do all they can for their child and willing to face all the trouble involved in careful training.

FIG. 54. Transplantation of the sartorius into the patella at *a* to reinforce a paralysed quadriceps. The distal part of the divided sartorius is seen at *b*. (Tubby and Jones.)

The principles upon which operative treatment is advised are as follows: (1) A constantly over-stretched paralysed muscle tends to become progressively weak and degenerate. By tenotomy they are placed in a state of rest and may then recover. (2) Excessive deep reflexes are characteristic of this disease; it is therefore of the greatest importance, if possible, to limit this excitability. The tension of a muscle is reflexly dependent upon the tension of its tendon. If the tendon of a tightly contracted muscle is divided, the stimuli which it sends to the cord, and which are thence reflected to the muscles, abate. The vicious circle is thus broken, and the muscle is no longer tonically contracted.

Thus, in spastic talipes equinus, division of the tendo achillis will enable the pointed condition of the foot to be remedied, and prevent over-stretching of the paretic extensors which are in this way placed in a state of rest and therefore in a position of recovery. Again by division of the tendo achillis, the reflex excitability of the calf muscles has been largely abolished; and not only so, but the authors believe that the removal of this excessive reflex excitability of the cord permits of that quiescence of the nerve centres so essential to the welfare of these children.

Treatment. This falls into the following divisions: A. Operative and B. post-operative. (1) Treatment of the upper extremities; (2) Treatment in the case of the lower extremities.

(1) *Treatment in the case of the upper extremities.* The most pronounced deformities here are flexion of the elbow, pronation of the forearm, and flexion of the wrist and fingers. The operative procedures consist of tenotomy, tendon transplantation, and lengthening of tendons. In all cases it is best to commence by relieving the spasm of the flexor tendons at the wrist, remembering that in spastic conditions there is danger of over-correction. Mr. Tubby recommends (*a*) lengthening the tendons of the flexor sublimis and profundus at the wrist by the Z-method. (*b*) In order to overcome spasm of the carpal flexors, transplantation of the flexor carpi radialis and the flexor carpi ulnaris to the dorsal surface of the bases of the second and fifth metacarpals, as originally suggested by Mr. R. Jones. When the tendons are not long enough, Lange's method of prolonging them by strands of silk may be employed. Great care must be taken to avoid matting of tendons or much stiffness may result. To relieve the flexion of the elbow and excessive pronation of the forearm Mr. Tubby describes an operation for converting the pronator radii teres into a supinator by transplanting its tendon behind the radius, through an incision in the interosseous membrane, to the outer side of the radius.[1]

The after-treatment consists in educating and training the limb in its new

[1] This operation is described by Mr. Tubby in the *Brit. Med. Journ.*, Sept. 7, 1901, and with several important modifications, in *Deformities* (1912), vol. ii, p. 729.

position. Passive movements are at first limited, so as not to stretch the bands of union unduly, and after the sixth week they are more extensive. At the latter date active movements are begun. The principles which should guide them are as follow: (*a*) The movements should be practised slowly without excitement. (*b*) They should be made interesting to the patient. (*c*) Those movements which are opposed to the direction of the deformity should predominate. (*d*) Those presenting the greatest difficulty should be chiefly practised.

(2) *Treatment in the case of the lower extremities.* The following series of operations on the hip, knee, and ankle may be required, and are performed, if necessary, in stages. Open operation is always indicated. The adductors of the thigh are first dealt with. The adductor longus is exposed through a longitudinal incision and three-quarters of an inch of its tendon is excised. The limb is abducted and the adductor brevis and the gracilis are treated in the same way. If needful, the horizontal part of the adductor magnus and the pectineus are divided; in fact, every tissue which limits free abduction; the sartorius, tensor fasciæ femoris, and ilio-tibial band are divided in the same way. The knee is then dealt with by longitudinal incisions, one on either side usually sufficing. By burrowing under the subcutaneous tissue, and retracting the skin, the various bands of fascia can be reached and divided as well as the hamstrings. Finally the tendo achillis is elongated by the Z-method (*q.v.*) and the patient is then secured comfortably in Jones's abduction frame with the knees straight and the feet at right angles. At the end of three months the splint is taken off during the day and the movements are regularly practised. A little later, when the patient has been taught to stand unsupported, walking is begun with crutches. At first the nurse must take great care that the limbs are not approximated. The limbs must be kept abducted at night, and massage of the muscles, with active and passive movements of the different joints and adduction of the limbs must be assiduously practised. In from twelve to twenty-four months, with careful supervision and after-treatment, and with the intelligent co-operation of the parents, the child should be able to walk a considerable distance, aided by sticks, and this with perfectly straight limbs, and toes and heels on the ground. Later on, many cases will manage to walk with one stick only, and others will be able to dispense with all kinds of artificial aids.

FIG. 55. Muscle-transplantation for the relief of paralysed quadriceps by reinforcement of the paralysed muscle from the biceps and sartorius. At *a* a slip is brought forward from the biceps; at *b* the proximal part of the sartorius is brought forward and the muscular slips *a* and *b* are inserted into the patella at *c*. The distal portions of the biceps and sartorius are shown at *d* and *e*. If the sartorius be paralysed, the semitendinosus may be used instead. (Tubby and Jones.)

The conclusions of Messrs. Tubby and Jones have been given at length because of the pains which they have taken to develop the different operations and the authority with which they speak upon orthopædic subjects. But it is right to state that there is another side to this question, and that other opinions are less favourable. In this country neither Mr. Keetley nor Mr. Jackson Clarke speaks highly of the result in their books on *Orthopædic Surgery*. And it must be remembered that both are men of large experience and well-known fairness.

From America, where every fresh operation is at once tested largely and with much zest, we have warnings not to expect too much from tendon-transplantation in infantile paralysis.

Thus Dr. Hibbs, speaking at a meeting of the New York Academy of Medicine, from an experience of 150 cases operated on at the New York Orthopædic Hospital said: "Where sufficient time is allowed to elapse, the ultimate compared with the immediate results are as a rule very disappointing. In itself tendon-transplantation practically never fulfils expectation, and is only a help to the use of apparatus. It is not an independent orthopædic measure; it does not prevent deformity, but may be used as an adjunct to facilitate the use of apparatus, and thus enable the orthopædic surgeon to use any possible bit of force which the patient can exert. The operation undoubtedly deserves a place in the armamentarium of the orthopædic

surgeon, but has nothing like the marvellous effect which is sometimes claimed for it."[1]

Later opinions are, however, more favourable. Thus Dr. R. W. Lovett, of Boston (Sixteenth International Congress of Medicine, section 7, p. 12), says, "In some instances the results are brilliant, in some the extent and character of the paralysis prevent us from obtaining as good functional results as we would desire. We know of no case in our series made worse by operation. Under these conditions we now regard the operation in *suitably selected cases* as one strongly to be recommended to patients and in the great majorty of such cases as one followed by most satisfactory results."

The method must therefore be still regarded as *sub judice*. All will allow that the results of treatment of infantile paralysis are amongst the least creditable to us. If tendon-transplantation does no more it may at least do good by attracting, with its glamour of a new operation, more attention to a neglected subject. Whether the results claimed by some are verified in the future depends not so much on perfection of technique—already largely arrived at—as on a wise selection of cases, more careful attention to after-treatment, in which the patient and friends must share a larger responsibility, and, above all, to medical men ceasing to look upon these cases as ones in which nothing can be done and allowing them to drift on until, early childhood past, the mischief is advanced and confirmed, and not only the tendons to which too much attention has been directed but the ligaments, joints, bones, fasciæ, and skin are all concerned. Finally the literature of this subject, which has rapidly increased, would gain greatly in value if those reporting cases of operation would do so in more detail and with greater accuracy, and also would give us the later as well as the earlier results, telling us especially how far tendon-transplantation does away with that worst of all sequelæ of infantile paralysis, viz. the trophic ulceration, which is so liable to set in in late adolescence and early adult life, and which may call for amputation of the thigh.

[1] *Med. News*, April 12, 1902.

CHAPTER V

OPERATIONS ON THE WRIST

I. EXCISION OF THE WRIST-JOINT

This operation is not often performed. Extensive tuberculous disease, with abscesses and sinuses, is practically the only indication. The conditions needful for success and the reasons for it often failing may first be considered.

(1) Whether the tuberculous disease begins in the synovial membrane or in the bones it extends rapidly, not only to the wrist-joint, but to the two rows of carpal bones and the bases of the metacarpals, along the complicated synovial membranes,[1] which bring all these bones into contiguity with each other. The disease thus extensive, is also most obstinate, and is often further complicated by other tuberculous lesions, and, in adults especially, by a tendency to phthisis. Thus partial operations are useless and often worse than useless. Lord Lister[2] was the first to insist on the importance, and to show the possibility, of removing every trace of the disease, including the ends of the radius and ulna, the two rows of carpal bones, and the bases of the metacarpals (Fig. 58).

(2) From the close relation of the flexor and extensor tendons in front and behind these complicated joints, and from the numerous grooves on the bones, it is most difficult to extirpate the disease without disturbing the tendons. The tendon-sheaths too may be extensively invaded by the disease. However stiff the wrist may be left, flexion and extension of the fingers are absolutely needful for the operation to be a success; hence it is imperative that, throughout the prolonged operation, the tendons should be disturbed as little as possible, a direction very difficult to follow, since the sheaths are frequently tuberculous, and the necessary manipulations during the operation may easily lead to the tendons sloughing, and thus to a useless "fin-like" hand.

(3) Passive movement of the fingers should be begun as early as

[1] The arrangement of these, usually five in number, must be remembered, and their close proximity to each other. (*a*) The membrana sacciformis of the inferior radio-ulnar joint, which also lines the upper surface of the triangular fibro-cartilage. (*b*) That of the wrist-joint proper, passing from the lower end of the radius and the inter-articular fibro-cartilage above to the bones of the first row below. (*c*) The common synovial membrane of the carpus, the most complex of all, extending transversely between the bones of the two rows and sending upwards two vertical prolongations between the scaphoid and the semi-lunar and the semi-lunar and cuneiform, and downwards three prolongations between the four bones of the second row usually, but not always communicating with the inner four carpo-metacarpal joints. (*d*) A separate membrane for the joint between the pisiform and the cuneiform. (*e*) Another separate one between the trapezium and the first metacarpal. Fig. 56 shows a variety of this arrangement in which seven synovial sacs are present.

[2] *Lancet*, 1865, vol. i, p. 308.

possible, and most perseveringly maintained. Owing to the unsatisfactory character which this operation inherited by the very poor results to which it attained before the days of aseptic surgery, and owing to the unsatisfactory conditions, both general and local, with which the surgeon is called upon to deal — the established tuberculous trouble, often not isolated in the wrist-joint, the joint itself and tendons, it may be, riddled with sinuses, and the fingers swollen and stiff—excision of the wrist has not found the favour with English surgeons which it perhaps deserves.

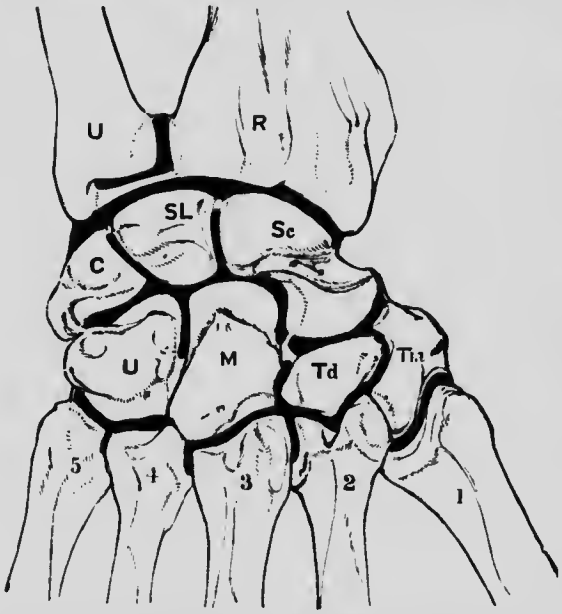


Fig. 56. The bones and the seven synovial sacs which enter into joints about the wrist. The seventh, that between the cuneiform and pisiform, is not shown. (MacCormac.)

In spite of the above disadvantages and difficulties, it is much to be desired that, as no less than the saving of hand and fingers is at stake, this operation should, with the advantages of modern surgery, be persevered with, and that all cases, whatever the result, be fully published.

Two methods only will be described. Excision of the wrist is not a common operation; it must be a difficult one; and the operating surgeon will do well to make himself familiar with, and to practise, one method. The two methods given below bear the names of surgeons who are authorities on the subject—(1) Lord Lister's, introduced to the profession as long ago as 1865; (2) that of the late M. Ollier, whose name stands second to none as an authority on excision of joints, and who has done more than any other surgeon to place excision of the wrist on a sound basis. The second method may be recommended as the less complicated of the two. In young children, owing to the weakness of the ligamentous and other fibrous single structures, the single longitudinal dorsal incision of van Langenbeek or Boeckel—for they are practically the same—may suffice.

(1) **Lister's Operation** (Figs. 57, 58). In this method two incisions are required, one on the radial side of the dorsum, the other on the inner side of the wrist. Before the operation the fingers are forcibly moved so as to break down any adhesions. An Esmarch's bandage or tourniquet should be employed. The radial incision, angular in direction, is then made, as in Fig. 57. This incision is planned so as to avoid the radial artery and also the tendons of the extensor secundi internodii and extensor indicis. It commences above at the middle of the dorsal aspect of the radius on a level with the styloid process. Thence it is at first directed towards the inner side of the metacarpo-phalangeal joint of the thumb, running parallel in this course to the extensor secundi internodii; but on reaching the line of the

radial border of the second metacarpal bone, it is carried downwards longitudinally for half its length, the radial artery being thus avoided, as it lies a little further out. The tendon of the extensor carpi radialis longior is next detached, together with that of the extensor brevior, while the extensor secundi internodii, with the radial artery, is thrust somewhat outwards. The next step is the separation of the trapezium from the rest of the carpus by cutting forceps applied in a line with the longitudinal part of the incision, great care being taken of the radial artery. The removal of the trapezium is left till the rest of the carpus has been taken away, when it can be dissected out without much difficulty, whereas its intimate relations with the artery and neighbouring parts would cause much trouble at an earlier stage. The hand being bent back to relax the extensors, the ulnar incision should next be made very free by entering the knife at least two inches above the end of

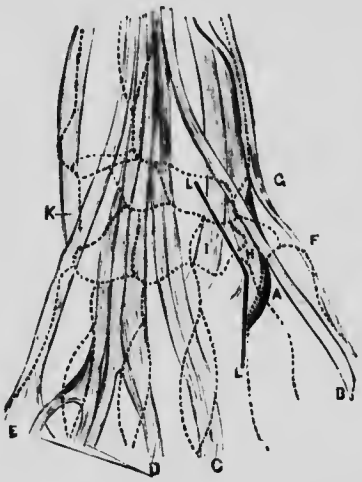


FIG. 57. A, Radial artery. B, Extensor secundi internodii pollicis. C, Extensor indicis. D, Extensor communis. E, Extensor minimi digiti. F, Extensor primi internodii. G, Extensor ossis metacarpi. H, Extensor carpi radialis longior. I, Extensor carpi radialis brevior. K, Extensor carpi ulnaris. L, L, Line of radial incision. (Lister.)

FIG. 58. Parts removed in excision of the wrist. (Lister.)

the ulna immediately anterior to the bone, and carrying it down between the bone and the flexor carpi ulnaris, and on in a straight line as far as the middle of the fifth metacarpal bone at its palmar aspect. The dorsal lip of the incision is then raised, and the tendon of the extensor carpi ulnar is cut at its insertion, and its tendon dissected up from its groove in the ulna, care being taken not to isolate it from the integuments, which would endanger its vitality. The finger extensors are then separated from the carpus, and the dorsal and internal lateral ligaments of the wrist-joint divided, but the connections of the tendons with the radius are purposely left undisturbed. Attention is now directed to the palmar side of the incision. The anterior surface of the ulna is cleared by cutting towards the bone so as to avoid the artery and nerve, the articulation of the pisiform bone opened, if that has not already been done in making the incision, and the flexor tendons separated from the carpus, the hand being depressed to relax them. While this is being done, the knife is arrested by the uneiform process, which is clipped through at it base with bone-forceps. Care is taken to avoid carrying the knife further down the hand than the bases of the metacarpal bones, for this, besides inflicting unnecessary injury, would involve risk of cutting the deep palmar arch. The anterior ligament of the wrist-joint is also divided, after which the junction between carpus and metacarpus is severed with cutting forceps, and the carpus is extracted from the ulnar incision with sequestrum-forceps, any ligamentous connections being divided with the knife. The hand being now forcibly everted, the articular ends of the radius and ulna will protrude at the ulnar incision. If they appear sound, or very superficially effected, the articular surfaces only are removed. The ulna is divided obliquely

with a small saw, so as to take away the cartilage-covered rounded part over which the radius sweeps, while the base of the styloid process is retained. The ulna and radius are thus left of the same length, which greatly promotes the symmetry and steadiness of the hand, the angular interval between the bones being soon filled up with fresh ossific deposit. A thin slice is then sawn off the radius parallel with the articular surface.

For this it is scarcely necessary to disturb the tendons in their grooves on the back, and thus the extensor secundi internodii may never appear at all. This may seem a refinement, but the freedom with which the thumb and fingers can be extended, even within a day or two of the operation, when this point is attended to, shows that it is important. The articular facet on the ulnar side of the bone is then clipped away with forceps applied longitudinally.

If the bones prove to be deeply carious, the forceps or gouge must be used with the greatest freedom. The metacarpal bones are next dealt with on the same principle. If they seem sound, the articular surfaces only are clipped off, the lateral facets being removed by longitudinal application of the bone-forceps.

The trapezium is next seized with forceps and dissected out without cutting the tendon of the flexor carpi radialis, which is firmly bound down in the groove on the palmar aspect; the knife being also kept close to the bone so as to avoid the radial. The thumb being then pushed up by an assistant, the articular end of its metacarpal bone is removed. Though this articulates by a separate joint, it may be affected, and the symmetry of the hand is promoted by reducing it to the same level as the other metacarpals.

Lastly, the articular surface of the pisiform is clipped off, the rest being left if sound, as it gives insertion to the flexor carpi ulnaris and attachment to the anterior annular ligament. But if there is any suspicion as to its soundness, it should be dissected out altogether; and the same rule applies to the process of the unciform.

The only tendons divided are the extensors of the carpus, for the flexor carpi radialis is inserted into the second metacarpal below its base, and so escapes. Only one or two small vessels require ligature. Free drainage must be given. The hand and forearm are put up on a special splint with a cork support for the hand, which helps to secure the principal object in the after-treatment—viz. frequent movements of the fingers—while the wrist is kept fixed during consolidation. Passive movement of the fingers, whether the inflammation has subsided or not, is begun on the second day and continued daily. Each joint should be flexed and extended to the full extent possible in health, the metacarpal bone being held quite steady to avoid disturbing the wrist. By this means the suppleness gained by breaking down the adhesions at the time of the operation (*see* p. 113) is maintained.

Pronation and supination, flexion and extension, abduction and adduction, must be gradually encouraged as the new wrist acquires firmness. When the hand has acquired sufficient strength, freer play for the fingers should be allowed by cutting off all the splint beyond the knuckles. Even after the hand is healed, a leather support should be worn for some time, accurately moulded to the front of the limb, reaching from the middle of the forearm to the knuckles, and sufficiently turned up at the ulnar side. This is retained *in situ* by lacing over the back of the forearm.

(2) **Ollier's Operation**[1] (Fig. 59). No surgeon speaks with greater weight on excision of the wrist than the late celebrated surgeon of Lyons: none have had so much operative experience, and no one worked so hard in order to bring the operation into better favour, and to insist on the necessity of attention to minuteness of detail both during the

[1] M. Ollier claimed that by his method, which must be, as far as possible, subperiosteal, not one attachment of the tendons need be lost. By other methods the attachments of the extensors of the carpus, those of the flexor carpi ulnaris and radialis, and perhaps that of the supinator longus, are, he maintains, usually sacrificed.

performance of the operation and in the after-treatment. Finally, M. Ollier not only had unrivalled experience in the excision of this joint,[1] but he has repeatedly, either himself or by his pupils, placed his results before the profession.[2]

M. Ollier, having tried several different incisions, recommends the following. At first sight the number (three) appears complicated, but it will be remembered that the third — that over the radial styloid process is merely for drainage. With a view to simplify as much as possible what must in any case be a very complicated operation, a single dorso-radial incision, the chief or metacarpo-radio-dorsal one of Ollier, may be employed.[3] From respect and in justice to that excellent surgeon, his operation is given in detail. Much of it refers to advanced cases of disease. It should be the object of all concerned to antedate this stage. The parts having been made evascular by an Esmarch's bandage, and all adhesions broken down, the hand is supported, extended, and pronated by a sand pillow.

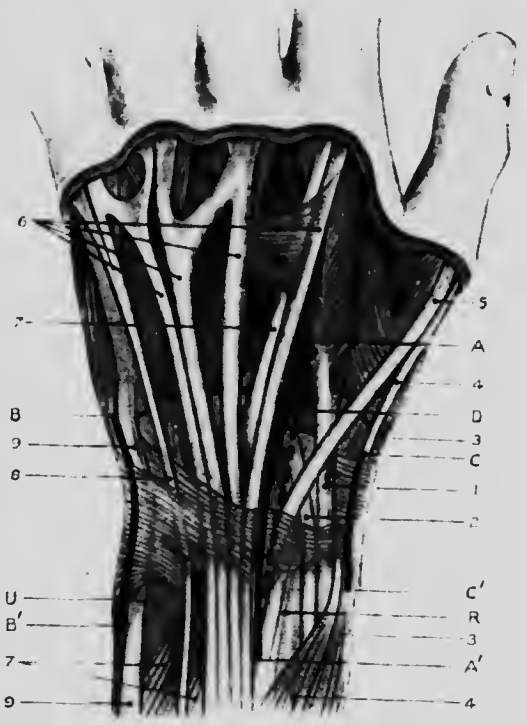


FIG. 59. The tendons concerned in excision of the wrist. A A′, B B′, C C′, The three incisions usually employed by M. Ollier. D, the incision of Boeckel, sometimes described as Langenbeck's, the two being practically identical. R, Radius. U, Ulna. 1 and 2, Radial extensors of the carpus. 3. Extensor ossis metacarpi pollicis. 4, Extensor primi internodii. 5, Extensor secundi internodii. 6, Extensor communis. 7, Extensor indicis. 8, Extensor minimi digiti. 9, Extensor carpi ulnaris (Ollier.)

First stage. Incision of Skin and Ligaments. The surgeon, comfortably seated, makes the first and chief incision, metacarpo-radio-dorsal, starting from a point in the centre of a line drawn between the two styloid processes, and running downwards, at first vertically and then somewhat obliquely outwards

[1] *Traité des Résections*, 1888, t. ii, p. 448; *Résections des grandes Articulations*, 1895.

[2] M. Ollier himself, *loc. supra cit.* *Congrès Franc. de Chir.*, 1894, p. 872; and *Résections des grandes Articulations*, 1895. M. Cangolphe, "Tumeur blanche du Poignet," *Tr. de Chir.*, 1896, t. iii, p. 595; Dr. Mondan, "La Tuberculose du Poignet," *Rev. de Chir.*, 1896, p. 186.

[3] This method of excision by a single dorso-radial incision was first employed by Boeckel and Langenbeck. Kocher (*Text Book of Operative Surgery*, 1911) describes a mode of excision through a single dorso-ulnar incision, extending from the middle of the fifth metacarpal upwards over the middle of the wrist joint, and from thence along the middle of the back of the forearm.

along the outer side of the extensor indicis, and ending below over the second metacarpal bone at the junction of its upper two and lower thirds. A subcutaneous branch of the radial nerve having been, if possible, avoided, the incision is carried down to the periosteum and dorsal ligaments, great care being taken not to injure the extensor indicis and the extensor carpi radialis brevior. The extensor indicis is first recognised, but its sheath should not be opened as the incision is deepened. It should be drawn aside with a blunt hook so as to expose the tendon of the extensor carpi radialis brevior, the insertion of which it conceals. The periosteum over the base of the third metacarpal is next incised so as to admit of the detachment of the last-mentioned extensor, together with its periosteal sheath, which constitute the radial lip of the deeper part of the wound. The incision is then prolonged upwards along the forearm according to the amount of bone to be removed, and over the annular ligament outside the partition common to the extensor indicis and communis. A little higher up the incision passes between the extensor indicis and the extensor secundi internodii, these tendons being drawn respectively inwards and outwards. In the highest part of the incision the periosteum over the lower end of the radius should be divided. This incision should be four inches or more in length, so as to avoid needless bruising of the soft parts, and to give adequate access to the disease. The ulnar incision is next made, starting about one inch above the styloid process of the ulna, and ending below over the base of the fifth metacarpal bone, the incision being kept rather towards the palmar surface so as to leave the tendon of the extensor carpi ulnaris above in the dorsal lip of the wound. The incision should be made carefully so as not to injure a filament of the ulnar nerve which crosses it, and thus not compromise the sensibility of the little finger. The incision is deepened down to the cuneiform and unciform. A third incision, for drainage only, is made about an inch long over the styloid process of the radius. It should be made now, before the landmarks have disappeared.

Second stage. Removal of the Bones. This is facilitated by division of the posterior annular ligament, which allows of easy separation of the tendons. The radio-carpal joint having been opened, the periosteal and ligamentous connections of the carpus are gradually divided, and, the carpus having been made to project more and more above, the flexor tendons are safely detached and held aside in front. It does not matter which of the carpal bones is taken first, whether those that lie beneath the radio-dorsal or the ulnar incisions; as soon as one is removed the extraction of the others becomes easier. The great aim of the surgeon is to remove each diseased bone completely. Being very friable they are easily crushed, and any diseased part that is left adherent is liable to cause a focus of infection and tedious suppuration.

Each bone should be turned out of its periosteal and ligamentous adhesions with a periosteal elevator or gently seized with small forceps and any adhesions carefully divided. The pisiform usually, and often the trapezium, may be left, and the uniform if sound. Otherwise, if difficulty be met with in shelling out this bone, the process may be cut through, the bone itself turned out, and the process subsequently taken away. The lower ends of the radius and ulna are now examined, each from the incision over them, and dealt with according to the amount of disease present. Thus in some cases erasion with a sharp spoon or

gouge may be sufficient. In others the ends may be removed, a small saw being so used as to form a new articular end. The styloid processes should always be left, if possible; and even when all the articular cavity of the radius must go, some of the expanded end of the bone should be left so as to furnish a solid support for the hand. The periosteum all round each bone, and lateral ligaments, should be carefully retained when healthy. In young subjects the operator must be careful not to leave a caseating sequestrum in the epiphysial line above a section of bone which is apparently healthy. The same remarks apply to the treatment of the four inner metacarpals, which alone are usually diseased. The bases of any of these which require removal must be most carefully shelled out of their fibrous coverings, or the tendons and deeper palmar arch may be damaged. If more than gouging is required, the section is better made with a fine saw than with cutting forceps.

Question of Preserving the Periosteum. This step has been objected to on account of its increasing the risk of leaving tuberculous mischief behind. M. Ollier strongly advocates the subperiosteal method. Though riddled with fistulæ and infiltrated with tuberculous granulation-tissue, the periosteum should be preserved, as much as is possible, after thorough curetting. This will aid in making the connection between the metacarpus and the forearm strong and not flail-like, while it will also help in the preservation of the carpal tendons. Professor Ollier meets the above objection by a thorough use of the curette until only the actual fibrous tissue of the capsule, ligaments, and periosteum is left. The operation is a tedious and difficult one, requiring the minutest care throughout to avoid injury to important structures, and to get away all the diseased tissue.

Third stage. Toilette, Cauterisation, and Drainage. M. Ollier attaches great importance to these points.

Toilette. The tendons usually lie buried in tuberculous granulation-tissue extending upwards and downwards to a varying degree. Every infected tendon-sheath must be slit up, and the tuberculous material followed into every nook with scissors and curette. Each tendon must be individually drawn up with a blunt hook and inspected. To render the deeper ones accessible they should be pushed up from the palm and, if it be needful to get directly at the flexor tendons, one or two incisions should be carefully made in the palmar surface.

Cauterisation. M. Ollier advises the use of the actual cautery to the most affected spots, with the view (1) of helping to eradicate the disease; (2) to prevent hæmorrhage; and (3) to obviate the risk of tuberculous infection from the wound.

Drainage. Drains of gauze should be freely employed between the different incisions, not only to prevent collections of fluid, but to keep the incisions open in case further curetting should be called for. The dressings should be voluminous and firmly applied, so as to distribute the free oozing through a large amount of material. The Esmarch's bandage, which should have been put on high up in the forearm so as to admit of the application of the above-mentioned dressings, is then removed, and the limb put on a Lister's splint, while the wrist is kept extended. Another very efficient splint which can be more readily sterilised is one recommended by Mr. R. Jones, of Liverpool. It consists of a simple anterior bar of sheet iron with two ⊣-shaped extremities. These are bent round and grasp the limb just below the elbow-joint above and just above the metacarpo-phalangeal joints below. The part on which the hand rests

should be bent at an angle of about forty degrees, so that the hand be kept extended. "If any one wishes to grip powerfully the wrist is first instinctively extended. One cannot effectively grip with the hand in the flexed position." The first dressing should be left on, if possible, for eight or ten days. If needful the incisions must be kept open with drains for three or four weeks, that any suspicious granulation-tissue may be repeatedly attacked with the sharp spoon, &c.[1]

After-treatment. This must be begun a day or two after the operation, and be persevered with for six or nine months, the patient lending an untiring aid throughout the whole of this time. A day or two after the operation the finger-joints should be moved daily, care being taken not to disturb the wounds, and especial attention should be given to the metacarpo-phalangeal joints, which are liable to escape attention. Moreover, the thumb and index finger must be kept well apart. About eight or ten days after the operation, or as soon as the parts are sufficiently solid, careful movement of the wrist may be begun. There is a persistent tendency for the tendons to remain adherent in their sheaths, only to be overcome by persevering, assiduous movements, with the help of nitrous oxide gas from time to time. Galvanism, faradism, friction, massage, are all of service when the wound is healed. If the surgeon wishes for a good result in the case of hospital patients, he will not allow them to leave too early. As M. Ollier points out, and as his cases show, in addition to excellent movements of the fingers, extension and flexion, abduction and adduction of the hand on the carpus should be very largely recovered by long-continued perseverance. Extension of the fingers and wrist is more slowly regained than flexion, owing to atrophy of the dorsal muscles and matting of their tendons.[2]

Even if the other fingers are stiff, mobility and power of approximation of the thumb and index will be much more useful than any artificial limb.

The following is one of the cases of excision of the wrist by Ollier's method previously referred to:

Mrs. D., æt. 37, was sent to Mr. Jacobson in January 1896, by Dr. Wood, of Dover, with tuberculous disease of the right wrist. There was characteristic swelling on both aspects of the wrist, the fingers were stiff and extended, and the hand useless, but there were no sinuses. The age and the personal history of the patient were also favourable. Excision was performed by an extension of Ollier's median dorsal incision. The pisiform and the trapezium were left. Thin slices of the articular ends of the radius and ulna were removed, but it was only needful to treat the bases of the four inner metacarpals by vigorous curetting. Two lateral incisions were made for drainage. The wounds healed quickly. After-treatment could not be satisfactorily carried out owing to the irregular attendance of the patient. In November 1898, Dr. Wood wrote: "There is some undue prominence and mobility of the end of the ulna. Pronation and supination are perfect and painless. The hand can be flexed and extended to about half the normal amount. The movements of the thumb are perfect. The movements of the fingers at the interphalangeal joints are perfect, but there is some stiffness at the metacarpo-phalangeal joints which prevents her from 'making a fist.' Generally, she has a thoroughly useful, though at present not a strong hand."

This rigidity at the metacarpo-phalangeal joints was due, in part, to too much

[1] The above remarks refer only to cases of advanced tuberculous disease. When excision is performed early before the stage of sinuses, &c., as should always be the case, it will often be possible to eradicate the tuberculous disease at the time of the operation; the dressings will be few, and the after-use of the curette only occasionally needed.

[2] It has been suggested that some of the loss of power in the fingers and wrist depends on the tendons remaining too long after the removal of the diseased bones, and that shortening of the tendons should be practised. M. Ollier only recommends shortening of tendons when the fingers tend to be obstinately flexed; he advises in this case shortening of the dorsal tendons by his method given at p. 104.

attention being given to the interphalanged joints, and to the patient being lost sight of too soon. It is rigidity at the former joints which prevents a good result being an excellent one, entailing, as it does, a certain degree of open claw, instead of a closed fist.

Question of Amputation in Tuberculous Disease of the Carpus. As has been stated above, tuberculous disease of the carpus more rarely occurs alone and isolated than any other tuberculous joint affection. Thus the existence and degree of other tuberculous lesions, the extent of the disease in the wrist, the age and vitality of the patient, the personal and family history, the presence of albuminuria and lardaceous disease, are some of the chief points which will help in deciding the above question. M. Ollier has recorded seven cases in which, owing to the existence of a cough, hæmoptysis, and suspected or actual disease of the apices, he advised amputation, but performed resection owing to his advice being rejected. The results were not encouraging. While excision of the wrist deserves a trial on a larger scale than it has hitherto received, it should only be attempted in patients whose vitality is sufficient, and who are not handicapped by serious disease elsewhere. Where amputation is decided on it must be through the forearm.

Excision of the Wrist for Injury. This will be still more rarely required. Partial excision may be indicated in rare cases of dislocation of the wrist which are otherwise irreducible, in some cases of unreduced separation of the lower radial epiphysis, and possibly in some of compound fractures of the lower extremities of the radius.

Excision of Wrist for Gunshot Injury. The first step will be to render the wound aseptic if possible, to remove any shattered fragments, or to perform a partial excision (according to the amount of damage), and provide sufficient drainage. If the wound suppurate it should be irrigated; and, if the infection prove intractable, the wrist excised. M. Ollier[1] gives an instructive case of primary partial excision (first row of carpal bones and the ends of the radius and ulna) for a gunshot injury in a lad, æt. 13. The shot had "balled," and the extensor tendons were severely damaged. The case was kept under observation for seven years, and the last report ends: "As far as the daily use of my hand goes, I might say that I have never had a wound."

These injuries are most likely to occur in military surgery. In former days, when the projectile was large and the velocity slow, injuries of joints were extensive and serious, and likely to require amputation. Excision on the whole gave poor results. Thus Gurlt (quoted by M. Ollier), in examining into the results obtained by the German surgeons in the Franco-German War, only found one good result, eight moderately good, six bad, and one very bad.

The conditions of modern warfare have so altered, and the arrangements for treating the wounded have so improved that the experiences of surgeons in the South African War as to the treatment and prognosis of these injuries are of very great interest.

Mr. Makins[2] does not mention any case of injury to the wrist-joint, but at p. 237 the words occur: "I never saw any troublesome results from perforation of the carpus."

Colonel Hickson, R.A.M.C.,[3] writes as follows:

[1] *Traité des Résections*, t. ii, p. 494.

[2] *Surgical Experiences in South Africa*, 1899-1900.

[3] *Reports in Surgical Cases in the South African War*, 1899-1902. Edited by Surgeon-General W. F. Stevenson, C.B. In the present war the prognosis in these and other similar injuries is much less favourable, the special conditions greatly increasing the danger of infection and suppuration.

"Only ten examples of wounds of the wrist-joint have been collected. When produced by the hard-cased bullet, injuries of this joint appear to be almost invariably pure perforations, healing quickly under a scab when aseptic, and causing little or no permanent limitation of movement. In two of the recorded cases fragments of the carpal bones were removed, the injuries having been caused by revolver or Martini-Henry bullets. No case necessitating amputation has been noted, and there is only one recorded instance of excision of the wrist-joint. The case in question, one of my own, in which the bullet, considered to be a ricochet, completely shattered the left wrist-joint, disorganising the carpus, and fissuring the lower end of the radius. The wound was very septic. At first the injury seemed to call for amputation, but complete excision was carried out as an alternative."

"Convalescence was prolonged, the arm-bath being constantly used for weeks, but he eventually recovered. At the time of invaliding, the movements of the fingers were fair, but those of the wrist very limited."

Causes of Failure after Excision of the Wrist. These are mainly: (1) Persistent sinuses and discharge set up by remaining foci of infective tuberculous granulations, caries, or necrosis. Sir W. Fergusson[1] showed a specimen in which all the bones were supposed to have been removed by a single incision on the ulnar side. The pisiform, trapezium, and part of the unciform had been left. The movement of the fingers was good, but sinuses remained on both sides communicating with a bare piece of radius. Death took place from phthisis. (2) Matting and sloughing of tendons and consequent stiffness of fingers. (3) Phthisis or other tuberculous visceral disease.

OPERATION IN CASES OF OLD MAL-UNITED COLLES'S FRACTURE AND SEPARATION OF LOWER EPIPHYSIS OF RADIUS

In some cases of Colles's fracture, where the fracture has not been reduced and the hand is therefore greatly disabled, if the patient's age and vitality be satisfactory operative steps will lead to great improvement. A long incision is made over the radius on the dorsum, and the line of union exposed by retraction of tendons, division, and separation of the periosteum. The union is then dissected through from behind downwards and forwards, the fragments completely detached and placed in correct position. As their surfaces are broad they will remain in position without the aid of wire, &c. As the fracture is now compound and the patient probably no longer young, splints must be kept on for about four weeks, and some support given afterwards. Passive movement of the fingers should be begun at once, and the wrist moved, carefully, in about ten days. **In separation of the lower epiphysis,** which has been overlooked, deformity and arrest of the growth of the radius are very likely to follow. This condition must be treated on similar lines, with a view of rectification of the displaced parts. If this step is not taken or fails, removal of part of the lower end of the ulna may be required later on, in order to keep the articular surfaces at their proper levels, and to prevent radial displacement of the hand.

AMPUTATION THROUGH THE WRIST-JOINT

(Figs. 60, 61, 62)

The value of this operation has been a good deal disputed. It has been thought by some that it possesses no particular advantage; the length of the stump is of no great consequence; the flaps with the numerous tendons in them may not heal readily. Others have gone further, and said that the long stump is found by instrument-makers

[1] *Path. Soc. Trans.*, vol. viii, p. 391.

difficult to fit with an artificial hand. That this is certainly not always the case is shown by Mr. H. Bigg[1] from two cases, one a commander R.N., the other an artisan in the Woolwich Arsenal, both of whom, after being fitted with artificial hands, were able to engage actively in their respective employments.

As the above objections are scarcely sufficient, and as this amputation preserves, if the parts heal quickly, good pronation and supination, it should be practised whenever opportunities arise. These, however, as is shown below, will not be numerous.

Indications. (1) Extensive injuries (gunshot and otherwise) of a hand not admitting of the preservation of any fingers, and in which the damage of soft parts does not necessitate amputating through the forearm. On this subject reference should be made to the section on "Conservative Surgery of the Hand," p. 71.

(2) Some cases of tuberculous disease of the carpus, where sufficient skin and soft parts are healthy, but which are too far advanced, or are rendered by age, condition of health, &c., unsuitable for excision.

(3) Cases of failed excision. But in carpal disease the soft parts are often so much damaged by sinuses and other results of the disease that the surgeon is driven to amputate higher up; and where this may not be the case, the articular surfaces of the radius and ulna, owing to disease, have to be removed, the operation thus ceasing to be correctly amputation through the wrist-joint.[2]

(4, 5, and 6) More rarely still, for the results of palmar suppuration, gangrene, or burns.

(7) Some cases of malignant disease, *e.g.* epithelioma. All the above are rare.

Operations. As in other amputations where the amount of skin available varies considerably, several methods will be given. The first of these is the best.

Different methods. (1) Long palmar flap (Figs. 60 and 61). (2) Equal antero-posterior flaps. (3) Method of Dubreuil (Fig. 62). (4) Circular amputation.

(1) *Amputation by a Long Palmar flap* (Figs. 60 and 61). This has the advantage of preserving skin thick, well used to pressure, and

FIG. 60. Amputation through wrist by long palmar flap. Amputation through forearm by long anterior and short posterior flaps.

abundantly supplied with blood: the nerves are also cut square, and disarticulation is easy.

[1] *Artificial Limbs and Amputations*, p. 83.

[2] Disarticulation has these advantages over entire removal of the styloid processes (*vide infra*): (1) There is no risk of necrosis. (2) Rotation of the forearm is not interfered with, the inferior radio-ulnar joint being left. (3) The supinator longus is left to powerfully flex the forearm. (4) The stump is longer and more useful

The brachial artery being controlled by a tourniquet, the limb is brought to a right angle to the patient's side, and the hand, supinated,[1] is supported by an assistant, or rests on a sterilised towel on a small table. The wrist is now extended, the styloid processes defined, and the thumb abducted so as to make the palmar tissues tense. An incision is next made (on the left side) from the tip of the styloid process of the radius[2] straight down well on to the thenar eminence, and then curving across (about on a line with the level of the superficial palmar arch), and marking out a well-rounded flap by passing over the hypothenar eminence to the tip of the styloid process of the ulna. This flap is next dissected up, without scoring, to ensure its vitality, cleanly off the flexor tendons, as far as the level of the wrist-joint: it should contain on its under surface some of the fibres of the thenar and hypothenar muscles.

If this precaution be taken, the flap, if sound, will contain the superficial volæ and ulnar arteries, and thus run no risk of sloughing. In cases where the flap is damaged it will be wisest in making the flap to cut all the structures down to the bones. Cheyne and Burghard advise that it facilitates the operation to detach the pisiform bone and raise it with the palmar flap: it can easily be dissected out afterwards. The hand being now pronated and flexed at the wrist-joint, an incision, slightly convex, is made across the wrist from one styloid process to the other. The palmar flap being now retracted, the hand is strongly flexed and the joint opened on the other side first; the soft parts in front and behind are next severed with a circular sweep (the assistant pulling slightly on the hand), the remaining ligaments divided, and the hand removed. At this stage the extensor tendons must be cut boldly and cleanly, otherwise they will be ragged. If the articular cartilages of the radius are diseased, they must be dealt with either by gouging or, if necessary, by a clean section above the articular cartilage, a step which will interfere with free pronation and supination later on. The apices of the styloid processes should in any case be removed, but the base of that of the radius should always be left, if possible, to secure the action of the supinator longus. In amputating at the wrist-joint care should be taken, by keeping the point of the knife towards the carpus, not to open the radio-ulnar joint, so that there be no interference with pronation and supination. The radial, ulnar, the two interosseous, and the superficialis volæ arteries will probably need securing. Any

FIG. 61.

[1] If the operation is, thus, commenced from the front, the hand need only be turned over once. If the dorsum is attacked first, the hand must be turned twice, first to make the palmar flap, and secondly to disarticulate (Farabeuf).

[2] The tip of this is nearly on a level with the intercarpal joint, being half an inch below and somewhat in front of the styloid process of the ulna. On a level with the latter will be found the line of the wrist-joint. The two furrows in front of the wrists are both below the level of this joint. The lower one corresponds to the upper edge of the anterior annular ligament and the intercarpal joint. If the soft parts are much swollen, comparison with and measurements taken from the opposite wrist, will be helpful.

sinuses present are now scraped with sharp spoons, and the tendons trimmed. From the facility with which these last slip up into their sheaths, precautions should be carefully taken to avoid infection.

Another Method.—This consists in marking out the palmar flap (but not dissecting it up), opening the joint by a dorsal incision as given above, and then cutting the palmar flap by transfixion, the knife being passed behind the bones. As in this method it is difficult to avoid hitching the knife on the pisiform and uniform bones, and to obviate a jagged edge to the palmar flap, and as the flexor tendons, being relaxed, are pulled out by the knife instead of being cut cleanly, it is not recommended.

(2) *Amputation by Equal Antero-Posterior Flaps.* The surgeon may be obliged, where the soft parts are scanty, to make use of this method. The objections to it are that if the tissues are thin there is some risk that the cicatrix may be adherent to the bones, and that these will be but poorly covered.

(3) *Amputation at the Wrist by the Method of Dubreuil* (Fig. 62). In a very few rare cases, *e.g.* where the soft parts on the back and front of the wrist are much damaged, perforated by sinuses, &c., this ingenious method may be made use of. But the objection to it is obvious. Where the thumb is sufficiently healthy to afford [illegible] arts for a flap, it should be saved. [illegible] being pronated, the surgeon comm[illegible] point at the junction of the outer [illegible] middle third of the back of the forearm a little below the level of the wrist-joint, a convex incision, which reaches at its summit the middle of the dorsal surface of the thumb, and terminates in front, just below the palmar aspect of the wrist, at the junction of the outer with the middle thirds of the forearm. The flap, consisting of skin and fasciæ, having been raised, the two ends of its base are joined by an incision at a right angle to the long axis of the forearm. Finally, disarticulation is performed, beginning at the radial side. If needful, the flap may be taken from the hypothenar eminence, by reversing the incisions.

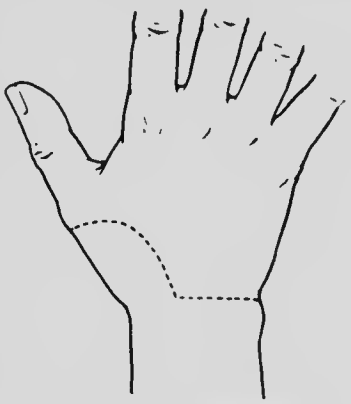


Fig. 62. Dubreuil's amputation.

(4) *Circular Amputation at the Wrist.* This method is only suitable to patients with thin, lax skin, and even to them it is often difficult to raise the skin quickly and neatly, for it is here adherent to some of the adjacent parts, as at the base of the hypothenar eminence. Moreover, cutting through such a thin, lax skin may be followed by sloughing, especially if its vitality is impaired by sinuses, &c.

The hand being supported by an assistant, the surgeon draws up the skin of the forearm, and makes his first circular incision through the skin on a level with the carpo-metacarpal joints of the little finger and thumb, encroaching thus upon the thenar and hypothenar eminences, two inches below the styloid process. The skin being retracted by freeing the soft parts with light touches of the knife, another circular sweep is made just above the level of the pisiform bone, so as to sever cleanly the numerous tendons, together with the vessels and nerves. The joint is then opened and the styloid process removed

LIGATURE OF THE RADIAL ARTERY ON THE BACK OF THE WRIST[1]

(Fig. 63).

Guide. A line drawn from a point just internal to the apex of the styloid process to the back of the interosseous space.

[1] The so-called "tabatière anatomique," a triangular space bounded externally by the extensor ossis metacarpi and extensor primi internodii, internally by the extensor secundi internodii; its apex is formed by the meeting of these tendons, and its base by the lower edge of the posterior annular ligament or base of the radius.

Relations.

Superficial

Skin, fasciæ; branches of superficial vein, and of radial and musculocutaneous nerves; fibro-fatty tissue beneath deep fascia.

Three extensor tendons of the thumb.

Outside	*Deep*	*Inside*
V. comes	Styloid process; scaphoid, trapezium; external lateral ligament of the wrist	V. comes

Indications. Few; usually wounds, *e.g.* by the slipping of a chisel, by breaking crockery, &c. In such cases both ends[1] would, of course, be secured, and the surgeon would examine as to injury of any of the extensor tendons.

Operation. The limb should rest upon its ulnar margin, steadied by an assistant, who with one hand holds the fingers, and with the other so moves the thumb as to make the tendons prominent. In the living subject these should be thrown into action, and their position and that of the radial vein defined before the operation. The incision, one and a half to two inches long, may be in the above line or parallel with the tendons. In either case it should be over the lower part of the vessel, just before it dips between the heads of the first dorsal interosseous into the palm. It should be made lightly, so as not to damage the radial vein or, deeper down, the tendons. The radial vein having been drawn aside with a blunt hook, and the deep fascia carefully opened, the tendons are drawn aside as needed and the artery separated from its veins. The ligature may be passed from either side. The artery lies deeper than would be expected, usually covered by fatty tissue. It will usually be tied between the bases of the first two metacarpals and to the radial side of the extensor secundi internodii. If the parts need relaxing, the hand should be hyperextended. All injury to the closely contiguous tendon-sheaths or joints must be avoided; and, for the same reason, union of the wound without suppuration is particularly indicated here.

In the following case aseptic surgery and the tying of diseased arteries with sterilised silk, and not too tightly, answered well:

M. A. S., æt. 60, was sent to Mr. Jacobson, November 1899, by Dr. Verrall, with an aneurysm of the right radial artery. Patient, old for her years, was operated on for cataract at 46. Superficial arteries tortuous and hard. No evidence of heart disease. An aneurysm the size of a large walnut on the outer and dorsal aspect of the right radius, just where the shaft and styloid process join, and extending into the "tabatière anatomique," had begun four years before. At first of the size of a nut, it gradually increased till a month before, when it became rapidly larger. The radial was tied just above the swelling, and again where the artery dips between the heads of the abductor indicis. Sterilised silk was used, and the veins were included in the first ligature. Specks of atheroma were seen in the radial artery when exposed above. The aneurysm was then incised and a good deal of pink laminated clot turned out. The wound ran an aseptic course; the aneurysm shrank and disappeared, the only trouble being some dermatitis caused by the iodoform gauze on a very aged skin.

[1] It may be difficult to find the distal end of the artery, owing to its tendency to retract.

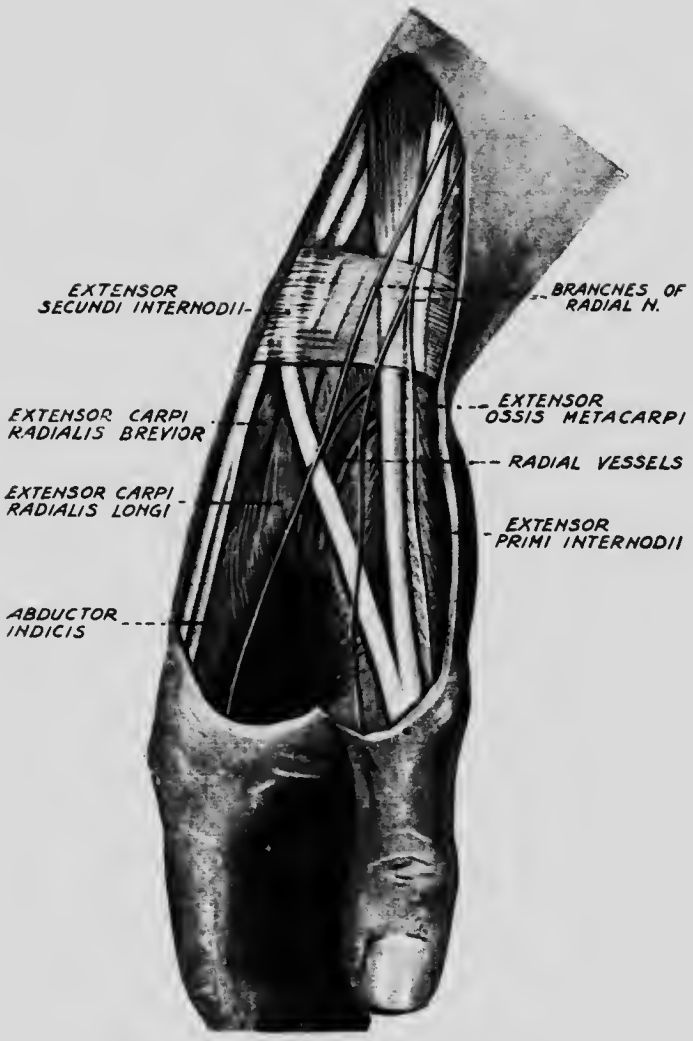

EXTENSOR SECUNDI INTERNODII
BRANCHES OF RADIAL N.
EXTENSOR OSSIS METACARPI
EXTENSOR CARPI RADIALIS BREVIOR
RADIAL VESSELS
EXTENSOR CARPI RADIALIS LONGI
EXTENSOR PRIMI INTERNODII
ABDUCTOR INDICIS

Fig. 63

CHAPTER VI

OPERATIONS ON THE FOREARM

LIGATURE OF THE RADIAL ARTERY IN THE FOREARM

(Figs. 64, 65, 66 and 67)

In the upper two-thirds the artery is sub-muscular; in the lower third it is sub-fascial.

Line. From the centre of the bend of the elbow (where the brachial artery divides, opposite the neck of the radius) to a point just internal to the styloid process of the radius.

Guide. The above line, and the intermuscular groove to the inner side of the supinator longus and its tendon. The pulsation of the vessel can usually be distinctly felt in the lower half of its course.

Relations.

In Front

Skin, fasciæ, viz., superficial, deep, and another layer, varying in distinctness, which ties the radial to the supinator longus and pronator radii teres.
Branches of the musculo-cutaneous nerve, especially below.
Superficialis volæ below.
Transverse branches of venæ comites.
Supinator longus overlapping for a varying amount and extent according to the development of the muscle.

Outside	*Inside*
Supinator longus	Pronator radii teres
Radial nerve (middle third)	Flexor carpi radialis
Vein	Vein

Radial artery in forearm.

Behind

Tendon of biceps.
Supinator brevis.
Pronator radii teres.
Radial head of flexor sublimis digitorum.
Flexor longus pollicis.
Pronator quadratus.
Radius.

Indications. (1) Wounds, stabs, cuts with glass, &c. (2) Traumatic aneurysm. In these cases, after the application of a tourniquet or an Esmarch's bandage, the surgeon opens the swelling, turns out the clot, and ligatures the artery above and below. If he prefers it he may snip out the swelling and twist or tie both ends of the artery. The first method is on the whole the most generally applicable. (3) Punctured

FIG. 64. A, Incision for ligature of the brachial at the bend of the elbow. B, Incision for ligature of the venæ at the middle of the forearm. C, Incision for ligature of the radial in the upper third of the forearm. D, Incision for ligature of the ulnar in the lower third of the forearm. E, Incision for ligature of the radial in the lower third of the forearm. F, Incision for exposure of the median nerve above the wrist.

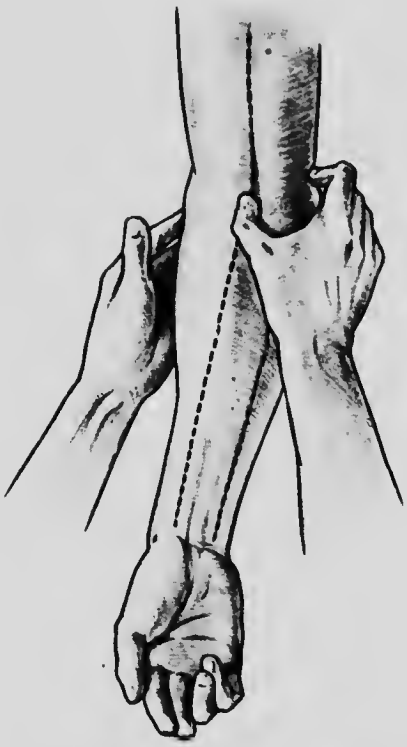


FIG. 65. Determination of the centre of the bend of the elbow. The left index is placed upon the epicondyle, the right upon the epitrochlea, while the right thumb occupies the centre of the fold of the elbow, to the inner side of the biceps tendon which projects beneath the soft parts. The line of the radial artery has been traced in its intermuscular furrow. (Farabeuf.)

wounds of the palmar arch. Ligature of both the radial and the ulnar is preferred by some, but reference should be made to the remarks at p. 89.

A. **Ligature in the lower third of the forearm** (Figs. 64 and 66). The forearm having been completely supinated and the wrist extended at first, the surgeon makes an incision, two inches long, midway between the tendons of the supinator longus and flexor carpi radialis, or (if this

be obscured by fat or by swelling) exactly in the line of the artery, going lightly [1] through the skin and subcutaneous tissue. A large branch of the radial vein, which is usually met with in the subcutaneous tissue just under the incision, is now drawn aside or divided between two ligatures. The deep fascia, here very thin, is carefully divided, and the wrist now flexed to relax the parts. The artery being separated from the venæ comites,[2] the needle may be passed in either direction. Damage to any of the tendon-sheaths should be most carefully avoided.

FIG. 66. Ligature of the radial in its lower third. Through the opening in the deep fascia the artery is seen with its venæ comites. Neither of the adjacent tendons has been exposed.

B. **Ligature in the middle third of the forearm.** *Guide.* Line of artery.

Relations. The nerve is now on the outer side of the artery, but not very close to it.

The steps are very much as above, but the artery is lying deeper. The radial vein, if present, must again be avoided. The incision over the middle third of the artery should be two and a half inches long, and the parts well relaxed when the deep fascia is opened; the inner aspect of the supinator longus is next defined, and this muscle drawn well outwards. The layer of fascia which unites the artery to the supinator and pronator must now be opened. The needle should be passed from without inwards.

Ligature in the upper third of the forearm (Figs. 64 and 67). *Guide.* The line of the artery and the inner border of the supinator longus.

[1] So as to avoid the radial vein, which always, and the superficialis volæ, which sometimes, lie superficial here, the one over and the other just under the deep fascia which is very thin.

[2] These, owing to the free collateral venous currents, may be included in the ligature if it is found very difficult to separate them from the artery.

Relations. The nerve is on the outer side, but well removed from the artery. The vessel itself lies somewhat obliquely as it passes from the middle of the ante-cubital space to the outer side of the forearm.

It is important to remember that the development of the supinator longus and the extent to which it overlaps the artery varies considerably. In a muscular arm it is very easy to get into difficulties by not hitting off the right intermuscular septum, and thus getting too near the middle line of the forearm, unless the line of the artery is remem-

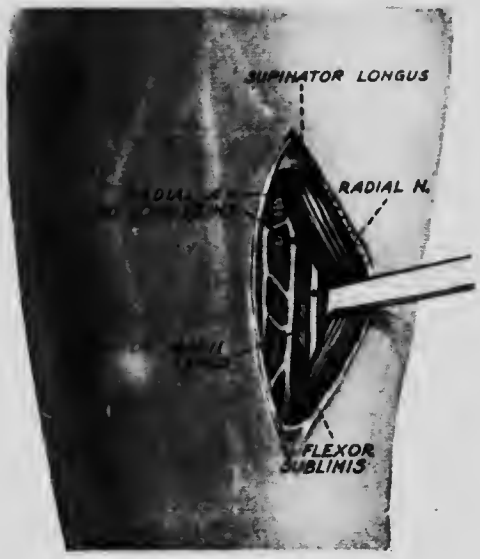


FIG. 67. Ligature of the radial just above the middle of the forearm. The supinator longus has been drawn aside. The vessels are resting on the pronator radii teres. The radial nerve is to the outer side of the vessels and rather on a deeper plane.

bered. An incision, at least two and a half inches long, is made over the upper third of the artery in the above line. Any branches of the radial vein are drawn out of the way, or secured with fine ligatures. The deep fascia is slit up to the full extent of the wound, along a white line which marks the interval between the supinator longus and the pronator radii teres. These muscles may be known by the direction of their respective fibres, the former going straight down along the radius, and the latter obliquely downwards and outwards to the centre of this bone. The muscles having been relaxed by bending the elbow and wrist-joints, and the cellular interval between them opened cleanly with a knife, they are drawn aside, and, if the vessel does not quickly come into view, its pulsation may be felt for. The venæ comites having been separated, if possible, the needle may be passed from without inwards.

LIGATURE OF THE ULNAR ARTERY IN THE FOREARM

(Figs. 64, 68, and 69)

Line. The surface-marking for the lower two-thirds of the vessel will be a line drawn from the tip of the internal condyle to the outer side of the pisiform bone. The upper third, which is deeply placed beneath the superficial group of flexors, may be marked out by a line curving slightly inwards from the bifurcation of the brachial to the junction of the upper and middle thirds of the above-mentioned line.

Guide. The above line and, in the lower third, the outer border of the flexor carpi ulnaris.

Relations in forearm.

In Front

Skin; superficial and deep fascia.
Branches of internal cutaneous, ulnar cutaneous nerve, and anterior ulnar vein.
Median nerve.
Pronator radii teres.
Flexor carpi radialis.
Palmaris longus.
Flexor digitorum sublimis.

Outside	*Inside*
Flexor digitorum sublimis (in lower two-thirds).	Flexor carpi ulnaris.
Vein.	Ulnar nerve.
	Vein.

Ulnar artery in forearm.

Behind

Brachialis anticus.
Flexor profundus digitorum.
Anterior annular ligament.

Indications. These are the same as for the radial.

Ligature in the lower third of the forearm (Fig. 68). Position of the hand supinated and not too strongly dorsiflexed, to begin with. An incision, commencing just above the pisiform bone, and two inches long is made, lightly at first, along the outer border of the flexor carpi ulnaris, the superficial veins avoided, and the deep fascia opened.

The wrist is then flexed, the flexor carpi ulnaris drawn gently inwards, the veins separated from the artery if possible, and the ligature passed from within outwards away from the nerve. Care is to be taken to avoid opening the sheaths of the tendons.

Ligature in the middle third[1] **of the forearm** (Fig. 69). The position of the limb being as before, an incision, quite three inches long in a muscular arm, is made in the above-given line of the artery over its middle third. Any superficial veins having been drawn aside or secured with double ligatures, and the wound wiped dry, a white line, which indicates the intermuscular septum between the flexor carpi ulnaris and the flexor sublimis, is looked for. If the incision is not directly

[1] The artery is only ligatured in its upper third for wounds; it is necessary to remember the course of the vessel—oblique from without inwards—and to divide sufficiently the superficial flexors which lie over it.

FIG. 68. Ligature of the ulnar artery just above the wrist. The process of deep fascia given off from the flexor carpi ulnaris has been opened and drawn aside, exposing the ulnar vessels, with the nerve lying internal to them.

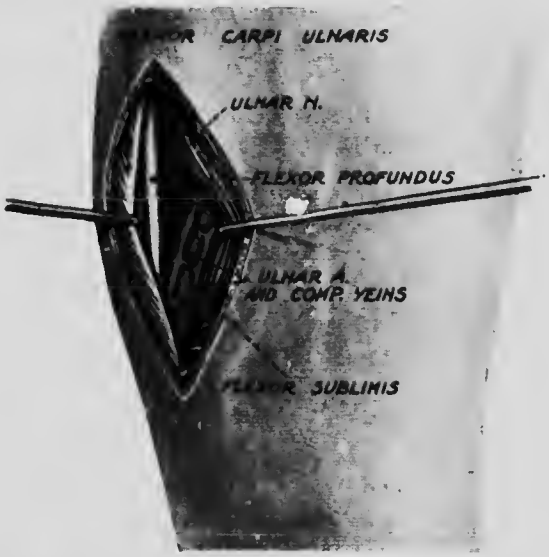


FIG. 69. Ligature of the ulnar artery in the middle of the forearm. The flexor carpi ulnaris internally, and the flexor sublimis externally, have been drawn aside. The ulnar vessels, nerve, and part of the flexor profundus are seen at the bottom of the wound.

over this, the edges of the superficial wound may be carefully cleared a little to one side or the other till the septum is found, or, with the finger-tip, the sulcus between the above muscles may be sought for. The deep fascia having been slit up to the full length of the wound, a muscular branch, which will serve as a guide to the artery, will often be found coming up in the intermuscular space. The cellular tissue here having been carefully torn through, the muscles are relaxed by bending the wrist and elbow; retractors are now introduced well into the wound, this wiped dry, and the artery looked for. The nerve, which lies to the inner side, and joins the artery at the junction of the middle and upper thirds of the forearm, may be seen first. The artery being cleaned, and the venæ comites separated from it if possible, the ligature is passed from within outwards.

This is the only ligature in the forearm which will give trouble in the dead subject, owing to the depth of the vessel, and sometimes the difficulty of hitting off the intermuscular septum. Being frequently set as an examination-test, the operation should be carefully studied by those at work on the dead body.

Difficulties and mistakes. (1) Depth of the vessel in a well-developed limb. (2) Making the incision too short, or too much to the inner or outer side, and thus finding a wrong septum, *e.g.* one between the flexor carpi ulnaris and the flexor profundus, or that between the flexor sublimis and the palmaris longus.

Aids. (1) Keeping carefully to the above-given line. (2) Hitting off the right intermuscular septum and corresponding sulcus. (3) Finding a muscular branch, and using it as a guide to the artery.

If a wrong space is much opened up in the living subject the contiguous muscles should be brought together with sterilised sutures cut short, due drainage being provided, if needful.

PARTIAL EXCISION OF THE RADIUS OR ULNA

Indications (1) New growths, especially myeloid sarcoma. (2) Tuberculous osteitis, *e.g.* of the lower end of the radius, caseating, and resisting erasion.

Operation for Removal of the Radius. This is the bone of the forearm in which myeloid sarcomata more commonly originate. The following is taken from a most successful case by Sir H. Morris,[1] in which he removed the radius and ulna extensively, for a myeloid growth originating in the former, becoming firmly attached to the ulna.

A long incision was made over the outer side of the radius, from the styloid process to the upper third. The radial nerve was used as a guide to the interval between the supinator longus and extensor carpi radialis longior. Sir H. Morris having found on the dead subject that he could most readily separate the soft structures from the front and back of the radius by going between those muscles, and keeping the supinator to the fore part of the incision. The supinator longus and pronator teres at their insertions having been detached from the radius, the bone, when freed of its muscles in front and behind, was sawn through at the lower edge of the supinator brevis. A second longitudinal incision of less extent than the first was made along the inner side of the ulna from the wrist-joint upwards, and through it the rest of the soft parts separated from the tumour and ulna. The bone was sawn between three and four inches above the wrist, and the lower ends of both bones disarticulated by opening the wrist-joint on the inner side. The entire tumour, with the ulna and pronator quadratus, was then removed *en masse*. Four

[1] *Clin. Soc. Trans.*, vol. x, p. 138.

years later Sir H. Morris brought the patient before the Clinical Society.[1] There was no recurrence. By the aid of a leather splint the patient was able to nurse, dress, carry, and wash and care for her children, and do all her household work. Latterly, since contraction had taken place, she could hold her hand out straight without any support.

The late Mr. Clutton reported three instructive cases of endosteal sarcoma of the radius.[2] Two of the cases affected the lower end of the bone. In one not only the lower end of the radius (the diseased bone), but that of the ulna also was removed,[3] "so that the hand might be left in a straight line with the forearm." The result of this step was that, while the limb was useful in the patient's occupation—that of a painter—as long as he wore a leather gauntlet, without this aid he could do nothing. Examination of the specimen showed that the ulna was quite free. In the second case, also of the lower end of the radius, amputation was performed, as the growth was thought to be parosteal or periosteal. Examination of the specimen showed that it was endosteal, and Mr. Clutton allowed that a free incision might have shown that resection and saving the hand were possible. The third was a myeloid growth of the upper end, head and neck of the radius.

This was successfully removed by an incision on the outer side over the most prominent part of the tumour, "the radius being divided an inch below the growth." This patient died, eighteen months later, of renal disease present before the operation. No recurrence took place in any of the three cases.

Slowness of growth and regularity of expansion of the bone are the most important guides in the diagnosis of endosteal from periosteal sarcomata. Crackling and pulsation are also very valuable, if present. Skiagraphy will also help. The first two were absent in all Mr. Clutton's cases, and it is noteworthy that, while the growth which involved the upper end of the radius appeared to be exceedingly hard and resistant, as if entirely bony, it turned out to be soft, almost diffluent. A free exploratory incision is the only reliable guide,[4] as it is certain that the malignancy of endosteal sarcomata varies within wide limits, some growing slowly and evenly inside the bone, others perforating it in one or more places. In such cases, after resection, the patient should be watched carefully and for several years.

Operation for Partial Removal of the Ulna. In the very much rarer cases of myeloid tumours springing from the ulna, the following may be the course adopted. The account is taken from a paper by Mr. Lucas.[5]

A longitudinal incision, about four inches long, exposed the tumour between the flexor and extensor carpi ulnaris. In making this the dorsal branch of the ulnar nerve was divided. The soft parts having been next retracted, the bone was exposed above the level of the tumour and sawn through. The piece connected with the tumour was next drawn out of the wound, while the interosseous membrane was divided, and the extensor indicis on the posterior, and the pronator quadratus

[1] *Trans.*, vol. xiii, p. 155, pl. vi.

[2] *Clin. Soc. Trans.*, vol. xxvii, p. 86.

[3] This step is not to be recommended. Only the bone affected should be removed. Lateral displacement of the hand will follow, but it will not be a flail, and, as contraction takes place, the hand will rapidly gain strength, and no apparatus, requiring frequent renewal, will be needed.

[4] Involvement of the soft parts, especially when these are complicated and difficult to deal with, as in the case of those around the head of the tibia as compared with those around the lower extremity of the radius, and the extensive implication of the muscles will be the chief indication for amputation.

[5] *Clin. Soc. Trans.*, vol. x, p. 1[illegible]

on the anterior, separated from the tumour. The removal was completed by dividing the ligaments of the lower radio-ulnar joint, the attachment of the triangular fibro-cartilage to the ulna, and the internal lateral ligament. The patient left the hospital in five weeks, the resulting usefulness being excellent.

Further remarks on the treatment of myeloid growths will be found in the Surgery of the Lower Extremity, when those affecting the head of the tibia are considered (*q.v.*).

Excision of the Radius and Ulna in Military Surgery. By this is meant deliberate removal of portions of these bones damaged by gunshot or other injuries, not the mere picking away of spicules and fragments. Experience gained in the South African War shows that this mode of treatment will be but rarely called for. Lieutenant-Colonel Hickson[1] collected sixty cases of gunshot fractures of the bones of the forearm, none of which terminated fatally, though six required amputation. The number is made up of injuries to both radius and ulna, fifteen; of the radius alone, twenty-seven; of the ulna alone, eighteen. Taking the regulation Mauser bullet as the standard, the varieties of wounds ranged within very wide limits, from extreme shattering and pulverisation to simple perforation without solution of continuity. The former, involving the shafts and often associated with extensive laceration of soft parts, were usually septic; the latter, usually involving the extremities which are largely composed of cancellous tissue, often escaped infection and healed readily. Colonel Hickson sums up the treatment of these injuries as follows:

"The most important measure in the treatment of all gunshot injuries of bones, whatever their nature and position, is the prevention of septic changes in the wounds. It is the occurrence of suppuration that threatens life and necessitates amputation in the vast majority of cases requiring that operation. Everything else sinks into insignificance beside it, and a fracture presenting the highest degree of comminution is, if aseptic, of less moment than a trivial one in which suppuration has occurred. Not only does suppuration cause delay in union and lead to necrosis, but it is only too often the precursor of septic osteomyelitis and general septicæmia. Unfortunately, owing to the conditions attendant on service in the field, suppuration occurs in a considerable number of comminuted fractures. . . . On the subject of the advisability of exploring comminuted fracture and removing loose fragments, differences of opinion seem to exist. Some surgeons are strongly opposed to this practice, and others as firmly convinced of its necessity. The truth seems to lie between the two extremes. If the fracture be septic and highly comminuted, the exit wound should be explored and all loose fragments removed. It is useless and dangerous to leave them *in situ*. Should the fracture be aseptic and badly comminuted, fragments of bone, separated from their attachments and lying loose in the surrounding tissues, should also, I think, be removed with the most careful aseptic precautions. If the fracture be aseptic, the comminution not very severe, and the fragments not much displaced, nothing is to be gained by interference, and harm may result."

The advantages of treatment on the above lines over the excision of portions of the injured bone, as practised in former days, are well seen by contrasting with the above the following remarks by Dr. Otis:[2]

"Of this large number of excisions in the continuity of the forearm there is little to remark save that, in the aggregate, the mortality of shot fractures appears to have been sensibly augmented by operative interference, and that I have sought in vain for a single instance in which a formal excision of a portion of the shaft of either radius or ulna had a really satisfactory result as regards the functional utility of the limb. . . . The cases are divided into three groups: (1) primary; (2) inter-

[1] *Rept. on Surg. Cases noted in the South African War*, edited by Surg.-Gen. Stephenson.
[2] *Med. and Surg. Hist. of the War of the Rebellion*, pt. ii, p. 935, *et seq.*

mediary (before the thirtieth day), and secondary (after the thirtieth day). Of the primary 10 per cent., and of the intermediary 19 per cent. ended fatally; the mortality of the secondary was nearly as high as that of the primary excisions.

Operative Treatment of Volkmann's Contraction (Ischæmic Paralysis). This deformity as a rule occurs in the forearm, though in rare cases it may affect the lower extremity. It usually occurs in children, and generally, though by no means always, follows the application of bandages or splints especially for such injuries as fractures of the bones of the forearm or the lower end of the humerus, or for separation of the lower epiphysis of the latter bone. In many cases there can be no doubt that the bandages have been too tightly applied, or that the splints have been allowed to remain too long unchanged. Though the severity of the contraction varies, the deformity in a typical case is characteristic. The forearm is firmly fixed in a position of full pronation, the wrist is flexed, the proximal phalanges are hyperextended, while the second and third are fully flexed. Though the pathology of the condition is not quite clear, it is certainly due to interference with the arterial supply of the affected muscles. The diminished supply of oxygen probably leads to a coagulation of the contractile substance, analogous to the change occurring in rigor mortis, and followed by fibroid change and contraction. The deformity develops in about four to six weeks after the injury. Jenks Thomas[1] discusses fully the pathology, causation, and treatment, in a paper based on 107 collected cases.[2]

When the deformity is but slight, gradual stretching of the contractions may be tried, combined with massage and electrical treatment. In severe cases these measures are useless: some form of operative treatment is required. The following methods may be employed: (1) tendon-lengthening; (2) resection of bones; (3) freeing nerves; (4) myotomy. In some cases a combination of two or more of these methods may be desirable.

(1) *Tendon-lengthening.* The methods of tendon-lengthening are described at p. 99. Owing to the number of tendons to be dealt with, the operation is long and tedious. Mr. Barnard[3] has fully reported two cases treated in this way.

In the first, the patient, æt. 13, had been treated for a fracture of both bones of the right forearm. When the splints were readjusted at the end of a week, a pressure-sore was found on the front of the forearm. A month later, the fingers began to be fixed, and, six weeks after the fracture, the hand was in the position of *main en griffe*. There was no definite anæsthesia, but voluntary movements were lost in the hand and wrist. Operative interference was delayed by the healing of the pressure-sore, and a whitlow on the tip of the right index finger. Six months after the injury an incision was made along the forearm, skin-flaps were reflected, and the tendons, no thicker than stout twine, split for one and a half inches and the halves severed above and below, on opposite sides. The fingers were then extended, and the two halves of the divided tendons allowed to slide upon each other as much as was necessary, and then united with one or two sutures of fine silk. The tendons of the flexor profundus digitorum were so blended and adherent in the depths of the wound that there seemed no end to the tiny strips which were separated from the mass and divided until all the terminal phalanges could be extended. Confusion was prevented by employing guide-sutures. The deepest tendons were sutured first. No form of tourniquet was employed; the whole operation, which lasted two hours, was strangely bloodless. The muscles, where exposed, were pale, firm, dry

[1] *Annals of Surgery*, vol. xlix. p. 330.

[2] See also a paper by Dr. E. G. Alexander on the Treatment of Volkmann's Contraction. *Annals of Surgery*, vol. lvii. 1913, p. 555.

[3] *Lancet*, vol. i. 1901, p. 1138.

and fibrous. The limb was put up on a back-splint with the fingers fully extended Healing took place by first intention. A fortnight after the operation, massage and passive movements were begun.

The second case was a boy æt. 4, whose forearm had been severely crushed with much effusion of blood, but without fracture. The limb was placed on an external angular splint, and light bandaging employed. Five weeks later the trouble began to appear. At the operation the flexor tendons were treated as described above, but the pronators were not interfered with. Improvement after four months was so marked that the mother wished something done for the loss of rotation of the forearm. The insertion of the pronator radii teres was exposed and the radial vessels and nerve separated from it. The muscle was then split and divided on opposite sides as the flexor tendons had been. As supination was still imperfect, an incision was made over the lowest part of the ulna, between the extensor and flexor carpi ulnaris. The pronator quadratus was separated with a periosteal elevator from the ulna. The pronator radii teres was then sutured in the upper part of the wound. The forearm could now be fully supinated on a splint.

Five to eight months after operation both children could grasp a stick or pick up a pin; neither could make a fist, but both cases were steadily improving.

(2) *Resection of bones.* In this method, portions of the radius and ulna are excised, the shortening of the forearm thus obtained allowing the wrist and fingers to be straightened without interfering with the tendons. Mr. R. P. Rowlands[1] describes a case in which he employed this method, giving interesting operative details.

The patient, a girl æt. 6, had six months before admission a fracture of the radius and ulna near the middle of their shafts. The arm was much bruised and swollen before splints were applied. The skin sloughed in three places. When seen the deformity was severe and quite typical. An incision was made along the middle third of the radial border of the forearm. The tendon of the extensor carpi radialis longior and the radial nerve were drawn forwards and the extensor carpi radialis longior was retracted in the opposite direction. This gave an excellent view of the insertion of the pronator radii teres and the outer surface of the radius as far as the extensor ossis metacarpi pollicis, where the latter passes obliquely forwards across the bone. At the lower end of the wound the upper fibres of the pronator quadratus were also displayed. The radius having been cleared of soft parts was drilled at two points one and a quarter inches apart, and then a portion of it one and a quarter inches long was removed by means of a fine saw. The piece removed extended from the insertion of the pronator radii teres to the pronator quadratus. A similar portion of the ulna was removed through an incision along its subcutaneous border, but one inch higher up. The bones were united by silver wire: the drill holes in the radius were so directed that when the wire was tightened the lower fragment of the radius was rotated into a position of semi-pronation. During the operation it was noticed that the deep flexors were firm and fibroid. At the end of the operation the wrist and fingers could be extended almost into a line with the forearm. Massage was commenced on the ninth day and passive movements as soon as union had occurred. When seen eighteen months later the muscles of the forearm had increased very considerably and the limb had lost its sunken appearance. The child could use the hand for most purposes and could pick up a pin or a penny with ease and rapidity. There was a good range of movement in the fingers, and a powerful grip. Supination and pronation were well performed.

The advantages of this method are (1) that the operation is easier and shorter than tendon-lengthening. (2) The radius can be drilled in such a manner as to correct the crippling limitation of supination. (3) The tendons are not interfered with. The chief disadvantage is that there is a possibility of non-union.

(3) *Freeing the nerves.* Though a lesion of the nerves is not the cause of the deformity, yet secondary affection of the nerve-trunks from involvement in connective-tissue overgrowth is frequent. Jenks Thomas[2] says: "Disturbance of sensation in the hand can only be

[1] *Lancet*, 1905, vol. ii, p. 1168.

[2] *Loc. supra cit.*

produced in this way, especially when it is limited to the area of skin corresponding to the distribution of one of the nerves of the arm. The same thing is true of atrophy of the small muscles of the hand, and the presence of the reaction of degeneration in these muscles is positive evidence of involvement of the nerve-trunks. Paralysis of these hand muscles can only be due to nerve involvement, and this point is one frequently overlooked." In such cases considerable benefit may be obtained by freeing the affected nerve or nerves. Jenks Thomas[1] mentions one case in which the ulnar nerve was freed, dissected clear of the internal condylar groove, and followed downwards through the flexor carpi ulnaris. It was then transferred to a point anterior to the internal condyle, the fascia being sutured beneath it, leaving the nerve between the deep fascia and the subcutaneous fat. Though this was the only operative treatment, a marked improvement followed, and six months later there was good functional use of the hand in every way in spite of slight shortening of the flexors. It is only fair to point out that that some surgeons have found freeing of the nerves a matter of great difficulty or even an impossibility.

AMPUTATION OF THE FOREARM

(Figs. 60, 70, 71 and 72)

This operation is frequently performed, usually for extensive injuries, but occasionally for malignant growths or severe and intractable tuberculous or septic trouble in the wrist or hand.

Practical Anatomical Points. (*a*) The two bones are not fixed, like [illegible] in the leg, but movable. This mobility may prevent their being divided when the knife is sent across in transfixion, and thus lead to laceration of the interosseous membrane; it must also be remembered in sawing off the bones. Lastly, on this mobility in pronation and supination depends the usefulness of the stump, which must therefore be left as long as possible, the bones being always, when practicable, sawn well below the insertion of the pronator radii teres into the middle of the outer surface of the radius. If the bones be divided above the insertion of the pronator teres, the radius will become supinated and further rotation movements will be lost. (*b*) In the upper part of the forearm, both in front and behind, are fleshy bellies; below, the soft parts are increasingly tendinous. Furthermore, the anterior border of the radius and the posterior of the ulna, especially the latter, are largely subcutaneous.

These facts render the forearm an unsuitable locality for amputation by the circular method.

Different methods. (1) Skin flaps, antero-posterior or lateral, with circular division of muscles, &c. (2) Modified circular method with equal anterior and posterior flaps. (3) Transfixion flaps.

(1) *Amputation of the Forearm by Skin Flaps, with Circular Division of Muscles, &c.* (Figs. 70 and 71). While in an amputation so often called for it is well to practise several methods, none, on the whole, answers so well as this, for the following reasons: (*a*) By cutting one flap a little longer than the other, sufficient skin can always be obtained to give a good stump. (*b*) Transfixion, while quite unsuited to the

[1] See also a paper by Jenks Thomas on "Nerve Involvement in the Ischæmic Paralysis of Volkmann," *Annals of Surgery*, vol. xlix, 1909, p. 330.

lower third, owing to the numerous tendons, can only be performed in the upper third in moderately muscular forearms with ultimate satisfaction. For in a bulky, fleshy limb (as in a case of accident in a male adult) it is not easy always to cut the skin longer than the muscles in bringing out the knife, and so to prevent the tendency of the fleshy bellies to protrude while the flaps are being united; and a little later, these muscles, with large surfaces cut obliquely, give rise to a good deal of blood-stained oozing, which is very likely to cause tension. The brachial having been controlled by a tourniquet, the arm extended from the side, with the forearm pronated and the hand steadied by an assistant, the surgeon, standing outside the limb on the right, and

FIG. 70.

inside it in the case of the left side, places his left index and thumb on the borders of the radius and ulna, at the spot where he intends to saw the bones. The point of a narrow-bladed knife (about four inches long) is then inserted just below the index, carried along the bone for three inches, then curved suddenly across, so as to mark out a broadly arched, not a pointed, flap (Fig. 70), and finally carried up along the bone nearest to the surgeon to a point just below the thumb.

This flap is then dissected up, consisting of skin and fascia, and of even thickness throughout.[1] The forearm is next raised by the assistant holding the hand, so that its palmar aspect faces the surgeon,[2] who marks out, by a curved cut joining the two horns of the other incision, a similar flap on the anterior surface, but one only about two inches in length. This flap having been raised and both retracted, the soft parts are divided with a circular sweep close to the base of the flaps, this being repeated once or twice till the bones are quite exposed. The knife is then passed, with due care of the severed arteries, between the bones, so as to divide the interosseous membrane, and the periosteum next cut circularly where the saw is to pass. The bones are sawn

[1] The under surface of a so-called skin flap should always, when possible, show a few muscular fibres; this shows that the deep fascia is present, in which the vessels run from which branches pass to the skin.

[2] Care must be taken to keep the bones parallel, now, and throughout the operation.

through, with the following precautions: The heel of the saw having been placed on the bones, it is drawn lightly, but firmly, towards the operator two or three times, so as to make a groove. With a series of light sweeps, in which the whole length of the saw is used, the two bones are then cut through together, the limb being kept supinated during the use of the saw, so as to keep the bones as parallel as possible.

The assistant in charge of the lower part of the limb must be most careful to hold it steady; if he depress at all, the bones will certainly splinter when half sawn through; if, on the other hand, he raise the parts the saw will be locked. Any tendons requiring it are then trimmed, nerves cut short and square, and the vessels ligatured or twisted. There are usually four, viz. the radial, under cover of the supinator longus, close to its bone; the ulnar, covered by the flexor carpi ulnaris, on the front of the ulna.

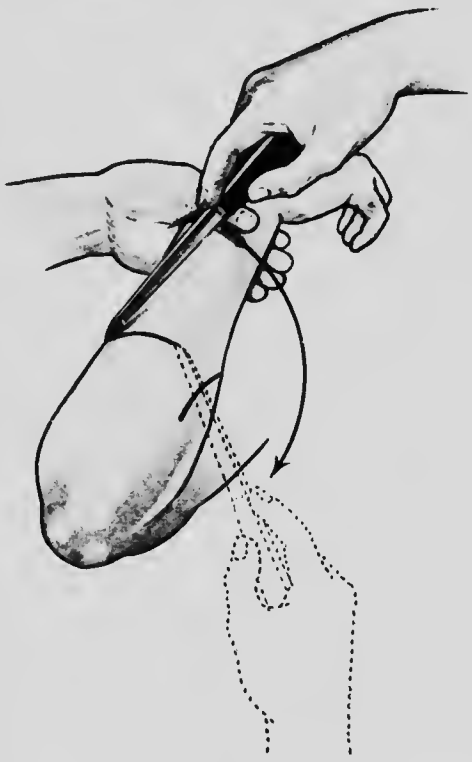


Fig. 71.

Their respective nerves are good guides to the arteries, save quite low down, when the radial has gone to the back of the limb. The anterior interosseous is found on the front of the interosseous membrane, and the posterior interosseous between the deep and superficial extensors.

If the surgeon prefer it, instead of having the forearm raised so as to face him (Fig. 71) while he shapes the flap from the anterior or flexor surface, he will tell the assistant to completely supinate the forearm, and proceed to make the flap with the limb in this position.

If, owing to the condition of the soft parts, **lateral flaps** are preferred, the limb having been pronated, the surgeon marks the site of bone-section with his left forefinger and thumb placed on the centre of the extensor and flexor aspects of the limb at this level. Then, looking over the forearm, he enters his knife in the middle of the flexor surface, and carries it, cutting a broadly arched flap, about two and a half inches long, to a corresponding point on the centre of the back of the limb, and then from this point down again over the side nearest to him, to the spot where the knife was first entered. The flaps are next dissected up with the precautions already given, and the operation completed as before.

(2) *Modified Circular Method with equal Anterior and Posterior Flaps.* In this method the anterior-posterior flaps being of equal length seldom have to be more than one and a half inches long, the bones can be divided at a lower level than any other, and thus the largest possible stump is given.

While the scar lies directly over the ends of the bones, this will, under most circumstances, be the point where there is least friction, because the pressure of an artificial limb must fall either upon its anterior or posterior aspect, and not upon the end of it, as is the case in the lower extremity. Should, however, the occupation of the patient

Fig. 72.

involve pushing, it is difficult to see how the face of the stump and the scar will escape pressure.

The limb being abducted and fully supinated, the surgeon standing to the right of the limb places his left forefinger and thumb on either side of the limb at the point proposed for division of the bones. The knife is then entered about half an inch below one of these points, and is made to trace a short anterior flap terminating at a corresponding point on the opposite side. When this is done a similar posterior flap is marked out. In a forearm of ordinary size the lower limit of the flaps will be about one and a half inches below the seat of circular division of the muscles, and this again about one and a half inches from the point of section of the bones. The periosteum is divided cleanly right round the bones and stripped up with a rugine, together with the muscles. This provides a cap of periosteum for the cut ends of the bones and a nicely rounded end for them, and in the forearm guards against a fusion of the cut ends, which would cause a loss of pronation and supination.

The muscles should never be first stripped off the periosteum, and the latter then separated from the bones.

(3) *Amputation of the Forearm by Transfixion Flaps* (Fig. 72). In the case of a moderately muscular forearm the surgeon may make use of this method in amputating through the middle of the forearm. For reasons already given (*see* p. 48), this method is not recommended, but the rapidity with which it can be done commends it to the notice of those who may have to treat wounded in war on a large scale, or in railway accidents where more than limb requires amputation. The limb being abducted, and the forearm supported and pronated, with the bones as parallel as possible, the surgeon, standing outside the right and inside the left limb, lifts up the soft parts at the spot where he intends to saw the bones, and sends a narrow-bladed knife (four to five inches long) across the limb, entering it and bringing it out just above the bones. He then, by cutting downwards and forwards, shapes as broad a flap as possible with a steady sawing movement, taking care, before bringing out the knife to cut the skin longer than the muscles by continuing the use of the knife after the latter are felt to be cut through. The flap should be three to four inches long, according to the condition of the tissues on the other side, each flap being made as broad as possible and bluntly rounded as it is finished.

The tissues on the front are then lifted from the bones and transfixed by passing the knife across immediately above the bones at the base of the first-made flap, the limb being now supinated. As in this second transfixion the skin on the farther side of the limb may be punctured, it is well for the surgeon to hold down its cut edge with a finger.

The second flap is then cut, broad, well-rounded, and two and a half to three inches long, according to the length of the anterior.

In making either flap, while the muscles are being severed, the wrist should be kept flexed. The flaps are then retracted, the soft parts severed with a circular sweep, the interosseous membrane divided, and the rest of the operation completed as in the method first described. If this method is used, the nerves should always be cut short and square; otherwise painful, bulbous ends may follow.

A very rapid and effective modification of the above is the following: As, owing to the inequality of the soft parts on the back as compared with those on the front of the forearm, and also from the proximity of the ulna to the surface here, transfixion of a dorsal flap is not always easy, a quicker method is as follows: A skin flap, three and a half inches long, broad, and well rounded, being marked out on the posterior aspect of the limb, the knife is immediately, without being taken off, pushed across in front of the bones and made to cut a flap, by transfixion, two and a half inches long, the skin being cut longer than the muscles (*vide supra*). The dorsal skin flap is then dissected up, the flaps retracted, and the bones cleared as before.

CHAPTER VII

OPERATIONS IN THE NEIGHBOURHOOD OF THE ELBOW-JOINT

AMPUTATION AT THE ELBOW-JOINT (Figs. 73, 74, and 75)

This operation gives excellent results, good flaps being obtainable from the thick soft parts in front and from the skin behind, which is well used to pressure. It has not been performed so often as it might have been, owing perhaps to the fact that disarticulation, however simple, is considered by some to be inferior to an amputation; and because, owing to the expanded end of the humerus, the flaps required are somewhat larger than in amputation through the lower third of the humerus. New growths of the bones of the forearm and, occasionally, severe crushes are the chief indications.

Practical points. (*a*) The internal condyle is nearly half an inch below the level of the external. (*b*) The joint is opened most easily on the outer side, where the head of the radius is the best guide. (*c*) There are thick masses of muscles on the front and sides; of the latter those on the outer side (owing to the presence of the supinator longus) retract more powerfully than those on the inner. (*d*) The skin at the back of the joint is well used to pressure, and is connected by fibrous bands to the back of the ulna.

Methods. Owing to the vascularity of the parts many methods may be employed. The first three are especially recommended. (1) A large antero-internal flap and a short postero external one. (2) Long anterior and short posterior flaps. (3) By a single lateral flap.

The condition of the soft parts may render it desirable to employ one of the following: (4) Circular method. (5) Long posterior flap. (6) Long anterior flap.

(1) *Amputation by a large Antero-Internal and a short Postero-External Flap.* The elbow is slightly flexed, and the antero-internal flap is first cut. The incision begins at the centre of the bend of the elbow and is continued down parallel with the long axis of the humerus for about three inches; with the arm flexed to an angle of 135 degrees the incision will meet the inner border of the forearm at about this point. The incision is then carved backwards and upwards to the olecranon to mark out a rectangular flap with rounded angles. A somewhat similar flap is next cut from the external surface, but this should only be about one inch long. The soft parts are taken up with the flaps right down to the bone. Any remaining structures in front are severed, the joint is opened preferably on the outer side between the head of the radius and the capitellum, and the forearm is then removed by dividing the lateral ligaments and the triceps.

(2) *Long Anterior and short Posterior Flaps* (Figs. 73 and 74). This method gives an excellent covering to the front of the humerus, allows of easy drainage, and preserves skin which is well used to pressure.

FIG. 73. Amputation through the elbow-joint by anterior and posterior flaps, at the moment of disarticulation.

The brachial being controlled above its centre, the forearm being held somewhat flexed and completely supinated, the surgeon standing on the inner side in the case of the left, and outside the right limb, raises

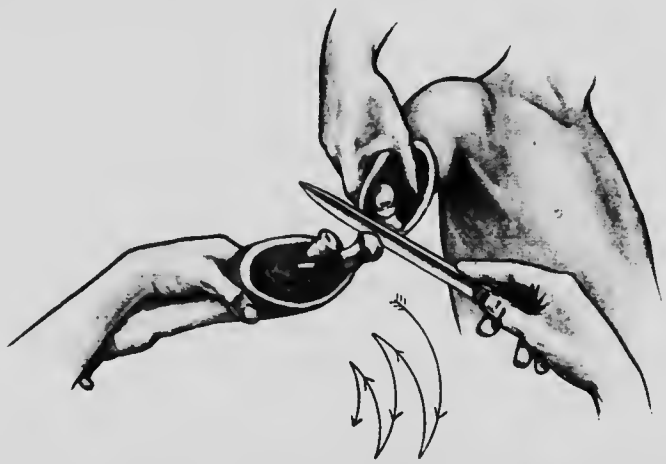


FIG. 74. Completion of amputation through the elbow-joint by anterior and posterior flaps. The arrows indicate the saw-like action with which the knife should be used. (Farabeuf.)

the soft parts in front of the elbow triangle, and sends his knife, held horizontally, across, just in front of the joint. Thus entering it one inch below the internal condyle, and bringing it out one and a half inches below the external one, or *vice versa*, he cuts a well-rounded flap, three

inches long, taking care, as the knife emerges, that the skin is cut longer than the muscles. Then, passing his knife behind the limb, and looking over, the surgeon joins the two ends of the base of his first incision by a convex cut through the skin over the back of the olecranon, so as to mark out a flap an inch and a half in length. This is raised without scoring, care being taken to keep the knife towards the ulna for fear of "button-holes." The joint is then opened and the forearm removed as described above. During this stage the assistant in charge of the forearm pulls this away from the arm.

The brachial artery is then secured, together with any other vessels which continue to bleed on removal of the tourniquet. Any nerves which require it are cut short, drainage is provided, and the flaps carefully united.

Should the surgeon prefer to do so, the anterior flap may be cut from the surface instead of by transfixion. This course should be adopted in the case of a bulky, muscular limb.

(3) *Amputation by one Lateral Flap or by Lateral Skin Flaps.* The advantages of these methods are that they are very easily done, and that, if more skin is available on one side than on the other, flaps unequal in length can readily be made. If the surgeon amputate by lateral flaps—standing as before, and having his left index finger o[illegible] the centre of the elbow-triangle and left thumb at the corresponding point behind, he looks over, and entering the knife close to his thumb, marks out, on the side furthest from him, a flap well rounded and about two and a half or three inches long, reaching to the finger in front. He then marks out a corresponding flap from this point, on the side nearest to him, to that where he began. These flaps are then dissected up of skin and fascia as thick as possible, the soft parts severed with a circular sweep, and disarticulation performed, beginning at the outer side.

(4) *Circular Method.* The surgeon, standing as before, makes a circular incision round the forearm two and a half or three inches below the joint, going through skin and fascia. A cuff of skin is then turned back as far up as the joint, the muscles severed with one or two firm sweeps, the lateral ligaments divided, and disarticulation performed as before. The edges of the wound may be united either horizontally or vertically from above downwards.

Mr. A. G. Miller, of Edinburgh,[1] suggests the following modification:[2]

> The limb being held out quite straight, a circular incision is made one and a half inches below the condyles down to the deep fascia. The skin on the anterior or flexor aspect at once retracts considerably, making the line of incision oblique.
>
> The extensor flap is now dissected up as far as above the olecranon, care being taken to cut on the deep fascia, and so to reflect the subcutaneous deep fascia, and its contained blood-vessels along with the skin. The flap is loose and ample, being taken from a part where the skin is naturally redundant in order to accommodate itself to the normal action of flexion. After reflexion of this flap—practically the only one—disarticulation should be performed from the front. It will then be found that there is a long flap on the extensor and posterior aspect, with practically no flap upon the flexor aspect. After the blood-vessels are secured and the nerves cut short, this single flap folds nicely over the condyles, and is easily secured by sutures. Later, the appearance of the stump is very satisfactory. Much tissue

[1] *The Scottish Medical and Surgical Journal*, Sept. 1904, p. 193.

[2] See a paper by Dr. A. C. Wood, of Philadelphia (*Ann. of Surg.*, vol. xlix, p. 101) in which he records a case of sarcoma of the forearm treated in this way.

is not required. The operation is, therefore, suitable for both primary and secondary amputations.

Amputation by (5) by a long posterior flap and (6) a long anterior flap require no special description.

EXCISION OF THE ELBOW-JOINT (Figs. 75–81)

Practical points. These bear upon the success of this operation. (1) It is a comparatively simple joint, with small articular surfaces readily got at. (2) Its synovial membrane is simple. (3) Its vascular supply is abundant. (4) The surrounding muscles are powerful, ensuring, if they regain firm attachment, excellent mobility. From the above and from the untoward effects of ankylosis, a natural cure in the elbow is often not so useful as that given by excision. This operation should be performed oftener, especially in the first six of the following conditions.

Indications. (1) *Tuberculous disease.*[1] Where this has resisted treatment in a patient who shows no sign of general tuberculosis, lardaceous disease, &c., where it is the only large joint affected, and where the powers of repair are sufficient. If other treatment fails to promise a sound and useful joint, there is no good losing more time; the muscles will only be more wasted, sinuses will only form more extensively, and the patient's health be more impaired. If caseation has occurred and, still more, if sinuses and mixed infection are present, it will be impossible to remove the disease entirely by excision; subsequent troublesome curettings will be needed, and the risk of a stiff joint is enormously increased. The rule should be, especially in adults, for excision to antedate the above complications.

Fig. 75. The hook in this illustration shows the continuity of the outer head of the triceps with the fascia over the anconeus (Maunder). Too much of the posterior aspect of the ulna has been cleared.

(2) *Recent injury and its results.* A. Primary excision. When the joint is much opened, the cartilages much damaged, when the shaft is intact and the tissues in front are sound, an excision may be preferable to expectant treatment. If aseptic from the first the operation excludes the risk of acute arthritis, and its certain sequela, a stiff joint. But here, as in excision for disease, the determination and pluck of the patient will be most important factors. And the age of the patient's tissues and organs will have much more weight than the age given, in the decision between excision and amputation.

B. Secondary excision. When acute arthritis, not yielding to incision and drainage of the joint, has followed on an injury, and ankylosis

[1] See an interesting paper by J. Wingate Todd. *Annals of Surgery*, 1913, vol. lvii, p. 430.

is the best result which can be hoped for without operation. In such cases, as the inflamed condition of the bones and soft parts may produce infective cellulitis and osteomyelitis after an operation, it will be wiser, before excising, to wait till the inflammation has somewhat subsided. It must be remembered that in excision after injury, reaction will probably be greater, suppuration more certain, and a tendency to bony ankylosis more marked, especially if the periosteum is preserved. Sufficient drainage is absolutely needful.

(3) *Old injuries to the Elbow-Joint*, resulting in stiffness, ankylosis, or, more rarely, pressure on the main vessel or nerve-trunks. Operative interference is justified in such cases, where the patient is otherwise healthy, and where his future will be seriously crippled. The following mode of treatment may be employed.

A. *Forcible Movement under an Anæsthetic.* This, often resulting in the "infraction" of some American surgeons, is not to be recommended. The results are rarely good, may be nil, and may be followed by serious damage. Where the needful forcible movement is painful and followed constantly by swelling and no permanent increase in the mobility of the joint, the patient must decide between a complete excision, performed on liberal lines and having the limb put up in a fixed position, at an angle as acute as possible.

B. *Arthrotomy.* Opening the joint, with division of adhesions, and attempted reduction of the displaced bones, will be found a step of very limited usefulness and is not to be recommended.

C. *Complete or partial excision.* The former is usually indicated in these cases. The question of partial excision for injury is discussed at p. 159.

The following is, very briefly given, an interesting case of excision of the elbow for an old dislocation and fracture:

M. E. W., aged 28, was sent to Mr. Jacobson in February 1894, by Dr. E. Davies, Swansea. The injury, received the previous November while he was riding over a sheep-farm in Tierra del Fuego, had never been treated. A dislocation backwards of both bones of the right elbow-joint was typically evident, and, in addition, there was distinct shortening of the limb, marked coldness and lividity of the hand, and deficient radial pulse. The forearm was fixed at a very obtuse angle, active and passive movements being almost completely abolished. During the excision it was found that a fracture ran obliquely from without inwards through the lower third of the humerus. When the limb was placed in the extended position after the operation, there was still a full one and a quarter inches between the bone ends. Healing was uneventful. At the end of four months the patient could use the arm to play lawn-tennis, shoot rabbits with a rifle, and ride. Five months after the operation, extension and pronation were practically complete, flexion was full enough to allow of his touching his right ear and buttoning his collar-stud with the right hand, but not sufficiently perfect for him to touch his right shoulder. Only about half the range of supination was present. In 1898 the patient wrote, saying: "My right arm is as useful to me as it was before the accident. I can shear sheep, ride, and shoot with any man."

(4) *Some rare cases of injury to the Lower Epiphysis of the Humerus.* In the great majority of these cases, judicious treatment, especially early examination and reduction of the displacement under an anæsthetic, and putting up the elbow fully flexed with the hand on the shoulder will suffice. Should this not be successful, an open operation for fixation of the separated epiphysis in good position by a wire screw may be expected to yield good results. There will however usually,

be cases where, some weeks or months after the injury, the joint remains stiff at a useless angle. In some of these cases the ankylosis is clearly intra-articular and not muscular, and breaking down of adhesions is constantly followed by recurrent inflammation, pain, swelling, and by no permanent improvement. The ankylosis may be due to osteoid deposit by stripped up periosteum or to a portion of detached epiphysis, *e.g.* the epicondyle, having been wedged between the trochlea and the sigmoid cavity, thus rendering improvement of the position impossible from the first. In these cases excision may give the best prospect of a freely movable and useful joint, but needless to say in such cases careful and thorough radiographic examination is of the greatest help in enabling the surgeon to decide upon the best mode of treatment. The following remarks by Mr Keetley[1] on the diagnosis of the common injuries about the elbow joint in young subjects will be useful to many: "For comparison of the two elbows, the patient should place the two hands, one on the other, upon the top of the head, and then bring the elbows as near each other as possible in front of the face. There are now two triangles to be compared. The base of each is formed by a line uniting the tips of the two condyles; the apex is at the olecranon. Effusion into the joint will cause a fulness between the condyles and the olecranon. If there be a fracture between the condyles, the joint there will be an increase of the distance between the condyles, best measured by a pair of calipers. Fracture of either condyle will disturb the relations of the external or internal condyle to one of these two points. If the head of the radius is dislocated outwards, backwards, its head will become more prominent than on the other side. A supracondylar fracture or separation of the epiphysis will result from the large amount of swelling and the pain in the region of the elbow. The elbows should next be flexed to a right angle and viewed from behind. A radiographic examination should invariably be made both from the side and in front. The elbows should be examined."

(5) *Ankylosis in a faulty position.* The following are the chief points which will present themselves for consideration. How far the angle is an obtuse one, and the position of the limb such as to render it useless; the age and vitality of the patient, and his interest in possessing a mobile joint; the condition of the muscles (for if the ankylosis be of long standing these may be so utterly atrophied that the usefulness of the limb will be but little increased by operation); the coexistence of any cicatricial bands, especially in front, which will interfere with the after-result.

A bilateral ankylosis, especially at useless angles and in young subjects, calls urgently for resection, the operations being performed at an interval of about four weeks, and the limb in which the muscles are least wasted being taken first, so that a good result may encourage the patient. The more complete the ankylosis the more the articular surfaces are fixed throughout (*i.e.* not at one spot only, *e.g.* olecranon tip to olecranon fossa), the greater the thickening of the periosteum, the more are osteoid nodules or spicules found scattered about in the ligaments, the more freely must the bones be removed. Further, in all cases of bony ankylosis, the surgeon should examine into the state of the superior radio-ulnar joint, for an ankylosis here may be overlooked

[1] *Clin. Journ.*, Feb. 1, 1903, p. 247

after the main disease has been treated. Mention may be made of the method of *résection économique* which the ingenuity of French surgeons has led them to try in cases of ankylosis after injury. Here, after a removal of the bones less free than that which is advised below, a flap of muscle—*e.g.* the triceps—is brought between the resected ends and attached to the capsule in front, to prevent fresh ankylosis occurring.[1] Perusal of some of the recorded cases conveys the impression that the result, especially in children, is not superior to that of the older method of a free resection.

(6) *Disorganising arthritis of elbow* after one of the exanthemata, pyæmia, or rheumatic fever.

(7) *Osteo-arthritis.* If the patient is healthy, not advanced in years (*i.e.* not much over forty) and not broken down, if the muscles are likely to recover their tone, and if this is the only joint attacked. The surgeon must be prepared for sawing very dense bones here. Dr. F. W. Collinson reports a most instructive case of excision of both elbow-joints for osteo-arthritis.[2] The patient, æt. 22, was admitted into the Preston Royal Infirmary, June 30, 1890.

The disease had begun when she was eleven. All the joints were more or less affected. The right elbow was absolutely fixed. When attempts were made to move it under an anæsthetic the humerus gave way at its lower epiphysial junction. The left elbow-joint could only be flexed through an angle from 8 to 10 degrees. The right joint was excised September 6, the left in December 1890. Both healed quickly. In August 1891 there was on the right side almost perfect flexion and extension with practically no lateral movement. Pronation and supination were absent owing to the absolute ankylosis of the wrist and inferior radio-ulnar joints. On the left side extension was not quite so good, a certain amount of lateral movement persisting. Both hands were now most useful. As an instance of how crippled the patient had been before the operations, when eating she was compelled to place her plate on her knees, she then lowered her head and raised her knees, and thus managed to get her food into her mouth.

The following points call for consideration in any case where excision of the elbow is being discussed:

(1) *Age.* This must always have much influence. In very young children due attention must be paid to the naturally great power of repair. After thirty-five or forty the surgeon should weigh very carefully all the points of the case, and only excise where all else is favourable. From puberty to thirty-five may be regarded as the best age. Those who see much of the surgery of childhood will, of course, be called upon to decide upon the operative treatment of tuberculous disease of the elbow-joint at a much earlier date. During the first three or four years of life resection is certainly not to be recommended. This is partly due to the fact that, owing to the greater tendency to repair, less severe steps—*e.g.* curetting, removal of tuberculous foci of osteitis and caries—will often be sufficient, but partly because the surgeon will be driven to hold his hand on account of the feeble, miserable condition of those patients with tuberculous disease of a large joint so early in life. Owing to the difficulties, inevitable during the after-treatment, in carrying out active and passive movements, the surgeon must be careful to keep the limb, from the first, at a useful, *i.e.* an acute, angle. After the age of four the patients, owing to their increasing vitality and resisting power, are better fitted for resection,

[1] *Quénu, Bull. et Mém. de la Soc. de Chir.*, Juin 27, 1905, p. 622.
[2] *Lancet*, 1899, Nov. 4, p. 1233.

but the activity of the periosteum, together with the fact that it is impossible to rely upon the patients for any help in active mobilisation of the joint, calls for free removal of bone.

(2) *Complications.* These are most likely to present themselves in the shape of disease of other bones and joints, for such a complication as phthisis will probably call for amputation. Caries of the metacarpal or metatarsal bones is not of itself a contra-indication. If a diseased spine is present, the question of excision will depend on whether the vertebral caries is old, or recent, or active. If old, is the elbow a source of much irritation? Two large joints are rarely diseased at the same time. Mr. Holmes[1] has recorded a case of a boy, aged 5, where he excised, with excellent results, both elbow-joints only a few weeks intervening between the two operations. Mr. Clement Lucas[2] relates a case in which disease of the left elbow came on about two years after excision of the right joint, and was also successfully operated on. Since 1886 Mr. Jacobson has excised the elbow-joint with good results in four children, in whom some years before he had successfully excised a knee-joint. And in one of the four he had, later on, to remove a tuberculous tarsus by a Symes amputation. When this child was seen a year later all three operations were sound. The new elbow-joint was a very useful one.

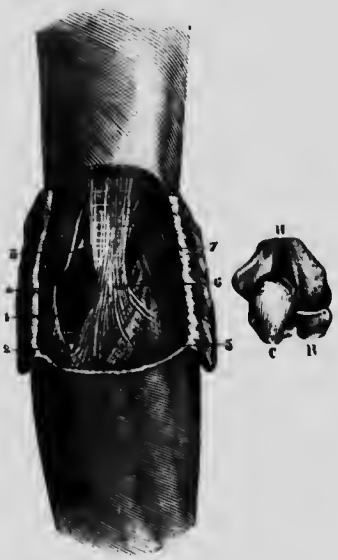


Fig. 76. Right elbow after excision of the joint by the usual posterior incision. (Farabeuf.) 1 and 4, Cut edges of the outer expansion of the triceps tendon. 2, Ulna. 3, Humerus. 5, Anconeus, covered by 6. Outer expansion of triceps. 7, Supinator longus and radial extensors of the carpus. To the right the bones removed during the operation are seen. The humerus has been sawn through at a point somewhat higher than usual. It will also be noticed that care has been taken not to unduly expose the shaft of the ulna.

(3) *Question of the Value of Preserving the Periosteum.* While the periosteum may be easily preserved in cases where it is swollen and loose, its preservation is in others a matter of very great difficulty, rendering the operation much more laborious and prolonged, and it is extremely doubtful if it is of any advantage in this joint, where the ordinary operation gives such excellent results.[3]

Some cases—*e.g.* primary excision for injury—are unsuited to this method, as the unaltered periosteum is most difficult to remove from the irregular bone ends. In tuberculous disease it is often undesirable on account of the risk of leaving mischief behind.

Subperiosteal resection is said to lead to less hæmorrhage, less disturbance of the capsule and attachments of muscles, with greater lateral steadiness and completeness of the new joint. While the last two are

[1] *Clin. Soc. Trans.*, vol. i. p. 143.

[2] *Brit. Med. Journ.*, 1881, vol. ii. p. 897.

[3] In the case of excision of the shoulder-joint (p. 222) the conditions are very different.

undoubted, this step may bring about impaired movement,[1] and the surgeon should only trouble to preserve the periosteum, while clearing the lower end of the humerus of its important muscular attachments, especially in cases where an unusually large amount of bone has to be removed. If the periosteum is kept, the removal of the bone will be additionally needed.

Operation. The single vertical incision at the back gives such excellent results that this operation will alone be fully described; the method by two lateral and a single bayonet-shaped incisions which have the preference by high authorities will be given later. As in all difficult and not very common operations, the surgeon will act most wisely by practising one operation. An Esmarch's bandage having been applied as high as possible over the upper arm, which is first well elevated, or the whole limb being rendered evascular as far as the above point by the use of two bandages, the limb is flexed and carried over the front of the trunk, so as to present it fairly to the surgeon, who usually stands on the opposite side of the body.

FIG. 77. To show the level to which the bones are to be cleared, and the way in which the thumb-nail is kept between the knife and the soft parts.

The surgeon, then, noting the relative position of the condyles and the course of the ulnar nerve, makes a straight incision of sufficient length (about four inches in the adult) with its centre at the tip of the olecranon, a little internal to the centre of the back of the joint, and parallel with the ulnar nerve. This incision should begin above or below as is most convenient, and go down to the bone throughout its whole extent, splitting the triceps muscle and tendon and incising the capsule. Partly with the point of the knife, partly with a rugine or elevator[2] (Fig. 80), the surgeon then raises, as far as possible in one piece and without tearing or jagging, the outer half of the triceps, which, with its expansion into the deep fascia of the forearm over the anconeus (Figs. 75 and 76)—this latter muscle being drawn up at the same time—is peeled up as thickly as possibly from its insertion into the ulna. It is on the preservation of this expansion that the regaining of active extension will depend. Resection-knives and elevators of the French pattern (Fig. 80) are the best.

[1] A case is given (*Langenbeck, Arch.*, vol. viii, p. 136) in which, after subperiosteal resection, the condyles had been very perfectly reproduced, and the olecranon had been reformed to even an inconvenient extent, for it was so long and curved as somewhat to limit extension. This method should usually be rejected in children, and also in cases of ankylosis, for fear of a recurrence. The candid Prof. Ollier, with all his experience wrote (*loc. supra cit.*, p. 218), "Aussi, après une résection sous-periostée, est-ce la roideur qui est plus à craindre que la trop grande laxité."

[2] Unless the tissues are softened by inflammation any "blunt dissectors" are useless. Any periosteal elevator, *e.g.* the one shown in Fig. 80, should have a distinct but not sharp edge. If the knife be used each cut should be short, and, as it is made, the edge must ever be kept turned towards the bone.

The deeper parts on the outer[1] side of the joint are then separated from the bones with the elevator until the external condyle and the head of the radius are completely exposed. The left thumb, all the time sunk deeply into the wound, pushes the flap of soft parts, as it is detached towards and over the external condyle. It is, finally, displaced over this, as the joint is flexed strongly. Next, the parts on the inner side should be detached from the inner condyle and inner border of the olecranon, great care being taken, by the following precautions, to keep intact the ulnar nerve: (*a*) By keeping the knife or engine parallel with the nerve and close to the bone; here and on the outer side alike the instrument should follow closely the different bony irregularities around the joint. (*b*) By the use of the thumb which displaces the soft parts as they are separated by the knife. By these means the soft parts will be satisfactorily cleared from the bones; retractors well applied will be found most useful, as the process of peeling off the soft parts is somewhat fatiguing to the thumb. This is especially the case in excision for accidents or on the dead body, and it is in these only that the nerve may be seen, though indistinctly. Where the parts have been long inflamed, they peel off much more readily, and the nerve is buried in the swelling. It is well to remember that the nerve may be injured at three places: (1) Above, in the inner head of the triceps; (2) behind the internal condyle; (3) below, under the extensor carpi ulnaris.

The clearing of the soft parts off the bony prominences will be much facilitated by keeping the joint extended as much as possible, and the soft parts thus relaxed.

Each lateral ligament, if this has not been already done, is raised, together with the periosteum and the group of flexors or extensors respectively, freed from their bony attachments and pushed over them, and there retained with retractors. The joint is now strongly flexed, and the capsule opened just above the olecranon. The bone ends are then turned out and prepared for the saw by passing the knife down to the bone along the lines of intended section, the soft parts being well retracted beyond these lines. In turning out the bone ends it is easy, in patients where the parts are delicate or softened by inflammation, to strip off a needless amount of periosteum, *e.g.* on the anterior aspect of the shaft of the humerus.

Site of bone section.[2] The ulna should be sawn (from behind forwards with a small Butcher's saw set firmly), so as to remove the greater and lesser sigmoid cavities with the olecranon. The radius is removed at the same time just below its head, above the biceps. Before this is done, the assistant, who is holding the forearm, should thrust the ends of the bones prominently but carefully (*vide supra*) into the wound. The section of the humerus requires careful attention. An insufficient amount is usually removed here, and limitation of subsequent movement thereby invited. It is generally considered sufficient to remove all the articular cartilage, the section being made to pass through the lower part of the coronoid and olecranon fossæ, and below the level of the epitrochlea on the inner, and through the epicondyle on the outer side. This is not

[1] For the sake of practice, it is well to take the outer side first, before clearing the inner with the ulnar nerve in proximity to it.

[2] Refer also on this point to Fig. 76.

enough.[1] The saw should pass at a higher level, *i.e.* above the level of the epicondyle, and through the highest part of the epitrochlea, removing quite the lower two-thirds of this process. This is the very lowest level at which the surgeon should hold his hand if he desires to obtain good movement.[2] And before he is satisfied on this point he should place the fingers of the affected limb not only on the opposite shoulder and the mouth (as is often done), but on the shoulder of the same side, and behind the back to the angle of the opposite scapula.

FIG. 78. To show the application of the saw. The dotted line across the humerus passes above the articular cartilage, but is not high enough (*vide infra*).

Unless these movements are perfectly free, he should take another thin slice off the humerus, removing the whole of the epitrochlea. This step may seem a needless shortening of the limb, and likely to lead to a flail-joint. Such, however, is not the case. As long as the elbow-joint is freely movable, shortening of the bones matters very little. If attention has been paid to the advice given at p. 151, and the soft parts separated very carefully and, as far as possible, subperiosteally from the epicondyle and the epitrochlea, the joint will become sufficiently steady laterally as well as freely movable although these bony prominences have been widely removed. Another test which the surgeon should always apply before considering the section of the bones completed is the interval between the sawn ends.

Professor Annandale considers that an inch and a half should intervene between them when the bones are extended. This will be none too much in adults, especially in cases where, owing to the condition of the parts, recurrent inflammation is certain. Here two or even two and a half inches separation is desirable.[3] In all cases (and this is especially so in those of ankylosis[4] where a recurrence of the trouble is to be dreaded) more bone must be removed from the humerus than

[1] If only half an inch of humerus be removed, together with the head of the radius and the olecranon process—the latter perhaps obliquely—ankylosis is certain.

[2] M. Ollier (*Traité des Résections*, t. ii. p. 203) usually makes the section at a much higher point than most surgeons. He first states that the section of the humerus may be made at different levels: (1) That which removes the articular surface only, the subepitrochlear; (2) That which passes just above through the substance of the epitrochlea, the intratrochlear; (3) That which passes just above the epitrochlea, the supraepitrochlear; (4) That passing through the shaft. He then goes on to say: "The section most frequently made—that which is indicated in the majority of cases of chronic joint-disease, whether in young or old subjects—is the section above the epitrochlea," *i.e.* number (3).

[3] Mr. Whitehead (*Brit. Med. Journ.*, 1872, vol. ii. p. 554) records the case of an adult in which two and a half inches of the shaft of the humerus had to be removed after sawing off the condyles. The patient was the subject of tertiary syphilis, and the operation was performed three years after an injury to the elbow. The joint is stated to have been completely disorganised. Nine months she was able to follow her occupation as charwoman with full use of the joint.

[4] In cases of bony ankylosis, it is well, before attempting to make sections of the bones, either to break down the union forcibly (care being taken not to fracture the possibly atrophied bones above and below, or to separate any of the epiphyses); or, better, to divide the ankylosis, with a saw, chisel, or osteotome.

from those of the forearm, where the section is limited by the attachment of important muscles. The extent of bone to be removed having been detailed, it is well to remember the advice of Professor Kocher[1] to make the sawn section curved. It is especially important to do so with the olecranon, as this step goes a long way towards preventing partial dislocation of the forearm forwards and also gives good leverage for the triceps. Mr. Holmes has pointed out, long ago, that if, after removing as much bone as is wise, disease is still felt upon the anterior surface, it is not necessary to make further sections so as to get beyond it; thorough curetting will be sufficient, and will save any further interference with the attachment of muscles.

Cheyne and Burghard[2] give the following advice here, which is one recommendation of the method of two lateral incisions: "The finger can be made to pass from one incision to the other between the capsule and the superficial structures, amongst which will be the brachial artery.

"By passing the finger across from one incision to the other and shifting the soft parts upwards and downwards, the entire front part of the capsule can be separated, and may be cut across at its attachments to the bones and removed whole." While the bones are sawn, the olecranon and trochlea of the humerus may be steadied in the grip of a lion-forceps, the soft parts being well retracted.[3] Any soft, caseous patches in the bone ends are now gauged, any possible sequestra removed. In bad cases the bones are liable to be fatty, with little natural marrow; such, however, are not necessarily irrecoverable. If the bone above the levels of section appear roughened, and the site of periostitis, this need not be touched; all will probably subside when the cause of irritation is removed. Any sinuses or suppurating pockets should next be laid open, with due regard to the ulnar nerve, and their contents scraped out with sharp spoons. The extensive wound should then be thoroughly irrigated with sterilised saline solution (temp. 120° Fahr.). A drainage tube should always be inserted, as considerable oozing is certain to take place. If infected pockets or sinuses have been opened and scraped a few sutures may be used and additional drainage secured by packing these with sterilised gauze soaked in iodoform emulsion.[4] Very varied forms of splint have been advised.[5] Some surgeons, to keep the bones apart, from the first put the limb upon some form of right-angled splint; others, fearing a flail-like condition of the joint, prefer to begin with the arm and forearm on a straight splint, or on one with an obtuse angle (about 135 degrees) some form of hinged angular splint, allowing the degree of flexion of the elbow to be altered at each dressing, should be used. Cases may be put up from the first on a metal angular splint, using some such cheap form as that

[1] *Text-book of Operative Surgery*, Stiles's translation, third English Edition, p. 317.

[2] *Manual of Surgical Treatment*, vol. iii. p. 248.

[3] Mr. Heath thinks (*loc. supra cit.*) that "the ulnar nerve is in more danger of being cut with the saw when the ulna is divided than when the section of the humerus is made, it being more difficult to clear the former bone."

[4] Farabeuf (*Man. Oper.*, p. 710) points out that if, owing to long-existing disease of the elbow, the shoulder, wrist, or fingers are stiff, opportunity should now be taken to break down adhesions.

[5] By some surgeons a splint is here dispensed with. The use of one which is light and simple is strongly advised (*vide supra*), especially in children, as during the first two weeks, where a splint has been dispensed with, the bone ends have been known to project from the wound.

described in the *Brit. Med. Journ.*, 1877, vol. i. p. 774, in which the anterior metal bar supports the limb, while it leaves the wound and its vicinity well exposed and is easily kept clean, both parts being readily boiled in a steriliser; moreover, the movable handpiece readily admits of some early passive pronation and supination. The only

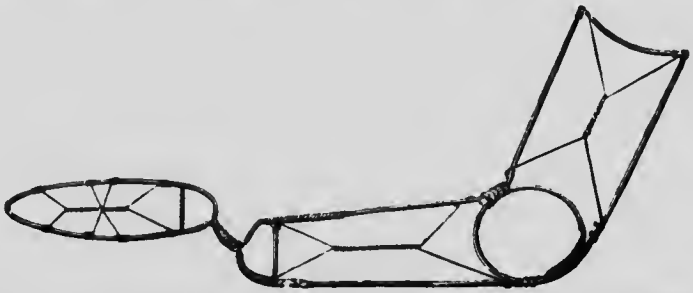


Fig. 79. Esmarch's wire splint for excision of left elbow. The supine position of the hand, which it is important to preserve, is well maintained in this splint. Plaster of Paris bandages may be used. The splint should be bent to an acute angle. (MacCormac.)

objection to this splint is that it does not give quite enough support to the limb. Volkmann's (based on that of Nathan Smith for the lower extremity), Esmarch's (Fig. 79), and Ollier's, all of wire and easily bent, are better in this respect, and all admit of the limb being slung—a great relief to many patients during the first week or so, this position also readily showing whether any discharge has made its way through the dressing. Plaster of Paris bandages should not be employed to fix the splint owing to their cramping effect upon the muscles.

Passive movement of the fingers and wrist should be begun on the second or third day. The joint itself should be moved as soon (but very gently and slightly) as all irritation has subsided—about seventh

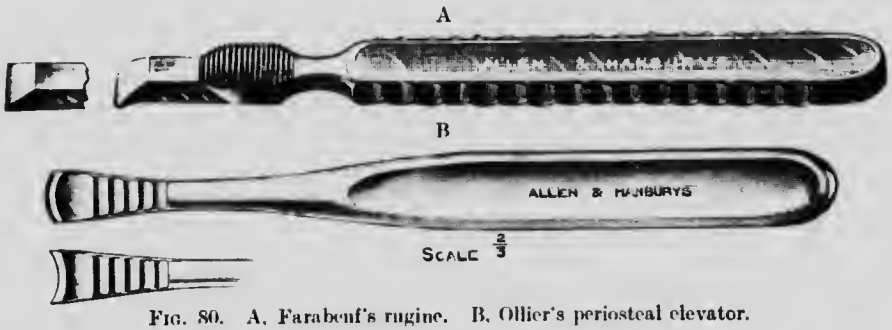


Fig. 80. A, Farabeuf's rugine. B, Ollier's periosteal elevator.

to tenth day—this date varying according to the size of the gap left between the sawn bones, the probable condition of the tissues as to inflammatory exudation, &c. In children an anæsthetic may have to be given several times. The angle of the splint should be altered or the limb put up straight for a few days, and then again flexed. Later on weight-extension should be used, by securing a bag of shot, which

is added to from day to day. A better method, especially with children, because it is gradual and gentle, and one that can be made interesting to them, is the old-fashioned one of weight and pulley. The patient is seated with the elbow resting near the edge of a table. To a pulley overhead a rope carrying a weight is attached. The patient grasps the free end of the rope with the hand on the sound side, while with the other he holds the rope a little above the weight. The rope is now pulled upon with the hand on the sound side; this flexes the joint, and when the pull is relaxed the limb is extended. This should be practised assiduously until half an hour a time two or three times a day is attained. To be of use this method must be begun early. The elbow must be kept firmly on the table, or the movements will be made at the shoulder-joint. Later, the sound limb may be fastened up, so that the child must use the excised joint. But when these aids have to be resorted to, the result will often be imperfect. The surgeon should put himself on the safe side by ensuring, originally, a sufficient gap between the bone ends when he uses the saw. The best test of the future usefulness of the limb is that the first passive movements are free and almost painless. The getting of children to use the joint is often most difficult, as friends are usually too foolish to see that the surgeon's directions are carried out daily, because they cause a little brief, but most necessary, suffering. Parents are far too ready to think that because an operation has been performed, and the wound nearly, if not quite, healed, no more is necessary.[1] In commencing pronation and supination early the ulna should be steadied while the hand and radius are very carefully moved. The first attempts at passive movement should be exceedingly gentle, and too much should not be attempted at first. When the parts are sufficiently firm, usually at the end of two weeks, the splint may be left off and a sling substituted.

Falls must be carefully avoided, and no liberties taken with the new union, *i.e.* by a patient attempting to do too much with the limb, as in lifting. Later on, when an increasing range of movements may be allowed, resort to a gymnasium will be very beneficial.[2] Finally, it is always to be remembered that a twelvemonth must elapse before the full benefits of the operation—viz. a complete combination of mobility and stability—are gained.[3]

If, at the end of four weeks, movement is so free that a flail-joint seems likely, the limb should be again immobilised for another month, either on the splint or by plaster of Paris bandages. Should flail-like union still threaten the patient should wear moulded leather supports for the arm and the forearm, the two portions being connected by two jointed metal bars which permit of flexion and extension at the elbow, but prevent all lateral mobility.

Tests of success. In about four months from the operation the patient should be able to move the new joint freely and efficiently, to dress and feed himself easily, and to lift fairly heavy weights. But it

[1] Pronation and supination in a child are often only apparent, the forearm and arm being rotated together from the shoulder.

[2] In some cases the regaining of only a limited amount of movement is unavoidable, *e.g.* where an injury to the elbow-joint requiring excision co-exists with a fracture of the humerus necessitating absolute rest of the limb. Here the bone ends must be removed very freely.

[3] See a paper by Mr. T. Wingate Todd (*Ann. Surg.*, 1913, vol. lvii, p. 430) on "The End Results of Excision of the Elbow for Tuberculosis."

will be nine months or a year before the joint is thoroughly firm and strong.

Repeated excision. Mr. Jacobson has tried this in three cases, two of them instances of obstinate tuberculous disease; in each a very useful, but much shortened, limb resulted. In the third, partial excision had been performed at a provincial hospital for an injury to the lower epiphysis of the humerus in a boy of fourteen. Great pains had been taken, but the limb was almost completely stiff and at an obtuse angle. After re-excising the joint completely, a useful angle was secured admitting of the hand being brought to the mouth, placed behind the back, &c., so that the boy could feed and dress himself. The movements of the joint ultimately remained much restricted owing to the absolute apathy and indifference of the patient. While opening up the old wound and again separating the bone ends gives excellent access to the remaining disease, this step will be but seldom required if the rule is followed, after excision of such joints, to give ether repeatedly as soon as there is evidence of persistent disease, and slit up any sinuses or undermined tissues, thoroughly use sharp spoons, and, if needful, pack in, for a few hours, strips of iodoform gauze wrung out of an emulsion of glycerine and iodoform or sulphur. (*See* the remarks made on this subject under "Excision of the Wrist and Knee.") Where, in cases of failed excision, the tubercular mischief has burrowed out amongst the muscles, where osteitis and osteo-myelitis are also present, amputation is to be preferred, especially if the general condition of the patient is not satisfactory.

Other methods. Excision by a single posterior incision has been described in detail because this method gives the best results in the largest number of cases, and is best suited to the majority of operators who will not perform this operation very frequently, and who should, therefore, strive to perfect themselves in one method. The above method is very simple; it affords, if freely made and efficiently aided by retractors, ample exposure of the joint; its limited interference with the triceps does not prevent the regain of complete extension. Therefore other methods will be very briefly given.

M. Ollier, while admitting that the single posterior incision allows of the fulfilment of the essential conditions of the subperiosteal method, considered it inferior to his method because it affords less facility for the different steps of the operation, gives less room, and is, besides, inferior as regards the after-treatment. A final and especial objection given is that this incision cannot serve as an exploratory one when the surgeon is uncertain whether he will perform a complete or partial resection. These objections are, however, not serious ones, and, with regard to the last, partial excisions are not to be recommended.

Ollier's Method by a Bayonet-shaped Incision. This method, though generally preferred by the well-known Lyons surgeon, was introduced by him especially for cases in which ankylosis, which could not be broken down, was present in an extended position. An incision, vertical at first, made above, over the external supra-condyloid ridge, sinking between the triceps and supinator longus from a point two and a half inches above the level of the joint to the top of the external condyle, and passing vertically down over this; the incision then passes obliquely across the olecranon between the outer head of the triceps and anconeus, and below descends, vertically again, upon the posterior border of the ulna for two inches. Through this, the main incision, the external condyle, head of radius, and olecranon are dealt with. To expose the inner condyle, make sure of the ulnar nerve, and to detach the

soft parts and lateral ligament, a second small incision, about two inches long, is made internal to the ulnar nerve and parallel with the inner border of the humerus. The incision is at first a superficial one. As it is carefully deepened, the above-mentioned intermuscular planes are identified, and along these planes the bones and joint are reached, by division of the periosteum and capsule. The operation is completed on the lines already given. The following are objections to the above method. In the first place, ankylosis in the extended position is a rare condition. Further, the central or oblique part of the incision must surely divide the very important outer expansion of the triceps. Finally, while the main incision exposes fully the parts above the external condyle, the small internal one, while introducing a complication, would be inadequate, with most operators, for the separation of parts on the inner side of the wound.

Kocher's Modification of Ollier's Incision.[1] With the elbow flexed to about 150 degrees, an angular incision is begun at the external supra-condylar ridge one and a half to two inches above the line of the joint, and is carried downwards, practically parallel to the axis of the humerus, i.e. vertically downwards to the head of the radius, and from thence along the outer border of the anconeus to the posterior border of the ulna, three inches below the tip of the olecranon; finally, the incision terminates by curving inwards over the inner surface of the ulna. This incision falls in the interval between those muscles supplied by the musculo-spiral and those supplied by the posterior interosseous. Subsequent muscular atrophy is thus avoided. The external lateral ligament with the attachments of the extensor tendons and the capsule attached to the external condyle, are separated by a raspatory. The forearm can now be completely dislocated inwards. If complete resection is desired, the internal lateral ligament is separated along with the muscles from the border of the ulna and the internal condyle, and the ends of the bones are removed.

FIG. 81. Kocher's incision for excision of the elbow.

Method by Two Lateral Incisions. Both Ollier and Henter have employed this method largely, especially advocating it in cases of ankylosis. It is also strongly recommended by Cheyne and Burghard[2] both for excision and erasion of the elbow-joint. It is described in the account of the latter operation on p. 181.

Treatment of Gunshot Wounds of the Elbow-joint. The structure of the joint renders it impossible for the capsule to be injured without injury to bone. As in the case of gunshot wounds of other bones and joints, the experiences of the South African War differ considerably from those of previous campaigns, both as regards the nature of the injury, the treatment, and the prognosis. With modern high velocity projectiles a simple perforation of the joint may occur, or there may be extensive comminution involving the articular surfaces with severe laceration of adjacent soft parts. The latter are by far the more serious injuries, especially as, in the majority of instances, they are septic.

[1] *Operative Surgery*, third Eng. Ed. by Stiles and Paul, p. 314.
[2] *Man. of Surg. Treat.*, pt. iv, vol. iii, p. 246.

Lt.-Col. Hickson [1] collected forty-nine cases of gunshot injury of the elbow-joint, thirteen of which were of the nature of pure perforations, the remaining thirty-six being either comminutions or fissured fractures extending into the articulation. Of the first group nine were aseptic, and of the latter only three. Only one case terminated fatally, and there amputation was performed for gangrene, which appears to have been caused, or at any rate contributed to, by the application of a plaster of Paris casing.

Treatment. "In the aseptic and in the less serious septic cases the treatment was directed to keeping the wound as free from infection as possible and placing the limb on suitable splints. The total number of comminuted fractures which recovered without recourse to operative measures was only eight. The remainder were subjected to operative interference of some sort; thus, in seventeen, fragments of the various bones were removed, of which number fifteen were septic, one aseptic, and one doubtful. Incision for the evacuation of pus, without further measures being required, was performed, and was followed by recovery in one case. Excision of the elbow-joint has been reported in seven cases, but in two of these amputation was subsequently carried out on account of necrosis and suppuration. Amputation of the arm was required in seven cases, in two of which an unsuccessful excision had previously been performed, and one died."

Mr. G. H. Makins[2] does not mention any cases in which excision of the elbow-joint was performed. He writes: "Injuries to this joint [3] came second in frequency in my experience to those of the knee. They were, in fact, comparatively common especially in conjunction with fractures of the various bony prominences surrounding the articulation. Fractures of the lower end of the humerus were of worse prognostic significance than those of the ulna, on account of the greater tendency to splintering of the bone. I saw several cases of pure perforation of the olecranon without any signs of implication of the elbow-joint. Several cases of suppuration which came under my notice did well. I saw one of them, six months after the injury, with perfect movement."

Partial Excision. The value of this operation has been disputed. In cases of disease it should not be employed as, in addition to the probability of ankylosis, it is likely that the parts affected will be imperfectly removed. It should also be rejected for the treatment of ankylosis at an unsatisfactory angle, for excision of the lower end of the humerus alone will not permit of pronation or supination afterwards, as the radius and ulna are firmly united at their upper ends.

In excision for injury it might be permissible to leave the bones of the forearm untouched when it had been needful to remove the ends of the humerus very freely. The importance of securing free mobility must always be borne in mind. The same conditions, which, after an injury to the elbow-joint, may interfere with a good result from forcible movement, will also interfere with success after partial excision. Thus osteoid masses may be formed by stripped-up periosteum, a torn part of the capsule may be displaced between the joint surfaces, the articular surfaces or the radial, olecranon or coronoid fossæ may become filled with fibrous tissue, or ankylosis develop at the superior radio-ulnar joint. Some of the above *e.g.* the formation of osteoid deposits—will be especially marked in young patients. Partial excision thus risks a result of incomplete value, *i.e.* a joint of limited mobility, though one, perhaps, with a useful angle.

The only cases in which partial excision of the elbow-joint for injury is to be recommended are: (1) Cases where it is necessary to excise a large amount of bone from the humerus. (2) Excision of a fractured epicondyle or epitrochlea, or fracture of the head of the radius. Removal

[1] *Rept. on Surgical Cases in the South African War.*
[2] *Surg. Experiences in South Africa*, 1899–1900, p. 236.
[3] Apparently all the injuries were from bullet and not shell.

of this process will be specially indicated when it is made out, at once or later on, to be the cause of limited movement in the joint, or when it is the cause of pressure upon the ulnar nerve. (3) Some gunshot injuries (*vide supra*).

Excision of the Superior Radio-ulnar Joint. *Indications.* This operation may be, very occasionally, made use of, with every precaution, in old cases of dislocation of the head of the radius, where reduction has not been effected owing to the amount of swelling, &c., and where the movements of the forearm are much hampered, especially in a young and healthy adult.

Operation. An incision about two inches long is made over the projecting head of the bone behind or through the posterior part of the supinator longus.

The soft parts having been separated with a blunt dissector and held aside with retractors, the neck of the radius is carefully divided with a fine saw or cutting bone-forceps. Sufficient bone must be removed here or from the external condyle to leave a gap that will avoid the risk of fresh ankylosis. The musculo-spiral nerve lies to the inner side, and great care must be taken not to interfere with this or the biceps tendon. The forearm should be put through its movements (*see* p. 152) freely but carefully, while the patient is under the anæsthetic, so as to break down adhesions. Any needful drainage should be provided, and every care taken, by not interfering with the soft parts more than is absolutely needful, and by keeping the wound aseptic, to secure primary union, and thus avoid the risk of stiffness again occurring. After a few days a sling may be substituted for a splint, and, ten to fourteen days later (*see* p. 155), passive movements made use of daily, with the aid of an anæsthetic if needful. In October 1894 Mr. Jacobson excised the head of the radius in the following obscure and instructive case:

In the previous August the lad, aged 12, had fallen from a ladder on to his feet, partly on his right elbow, not on the hand. Much swelling of the joint had followed, with subsequent stiffness, rendering the limb very useless. The forearm was fixed in a position midway between pronation and supination, and flexed at a right angle. No flexion was possible beyond this. Passive extension possible to about 120 degrees. Pronation and supination, passive and active, quite abolished. A prominence—? the head of the radius—to be felt below the external condyle, but not admitting of rotation: there was no crepitus. A diagnosis of dislocation of the head of the radius was made, though against it were the history of direct violence and the absence of any rotation in the swelling. On exploration of the injury by a free lateral incision, it turned out to be one of those rare cases of fracture through the neck of the radius. Just below the external condyle the head of the radius was found separated from the shaft by a fracture through the upper part of the neck, and lying with its articular surface turned directly outwards. On removal of this there was distinct improvement in pronation, but little in supination. Flexion was now possible to 40 degrees, and extension to almost the complete range, but only on forcible movement. As the movements were still incomplete, and certainly would not be retained, I removed the capitellum of the humerus from the same incision with a narrow osteotome. The forearm could now be put through its full range of movements. The wound healed under an aseptic clot, and the patient, on leaving the hospital five weeks later, had recovered almost complete active movements of the joint, though the whole limb was still weak. Three months later he could "do everything nearly as before the accident, and he could also carry considerable weights."

Unfavourable Results and Sequelæ of Elbow-joint Excision. (1) *Persistence of tuberculous disease.* This is especially likely when, previous

to the operation, the capsule has been perforated and disease has burrowed out amongst the origins of the flexors or extensors.

(2) *Caries and chronic osteo-myelitis.* These are not unlikely to supervene when the reparative power is poor and the wound becomes infected.

(3) *Ankylosis.* This is not uncommon in children, owing to the great tendency of inflammatory products to organise quickly in early life. Furthermore, there is the difficulty of getting them to use the joint or submit to passive movement; all they will do is to move their arm and forearm from the shoulder-joint. But thorough persevering treatment will secure a sound, though stiff, joint, with a very useful hand.

(4) *A flail-like joint.* A limb may remain weak for some time, owing to the muscles not taking on firm attachments. Friction and galvanism should be used perseveringly. If there is too much separation between the ends, the patient should wear a well-moulded support; the use of the hand and fingers will thus be retained and, if the patient is young, gradual and great improvement will very likely take place in the elbow. Re-excision and wiring may be tried in some cases with healthy patients. Most of the flail-joints follow the extensive removal of the lower end of the humerus, especially in cases of injury. In such cases the periosteum of the condyles and the muscular attachments should be as little interfered with as possible. Flail-joints are of two kinds: (1) Active flail-joints, in which the muscles are strong and exercise control. These may be very useful, especially when aided by a support to the elbow. (2) Passive flail-joints, where the muscles are wasted, and the hand only can be used by the employment of a supporting splint.

(5) *Infection of the wound.*

(6) *A useless limb*, owing to the muscles being utterly wasted from long disease and disuse.

(7) *Injury to the ulnar nerve*, with its resulting interference with motion, sensation, and nutrition. A few days after the excision the nerve should be found by a second incision below and in front, traced upwards and the divided ends united.

(8) *An adherent scar.*

ERASION OF THE ELBOW-JOINT

This operation has not been extensively practised, partly on account of the good results given by a carefully performed excision and partly because this joint does not lend itself to free exposure by so simple an incision as in the case of the knee-joint. Erasion is especially indicated in children, but in the elbow, as in other joints, it can only be perfectly satisfactory if performed in suitable, *i.e.* early, cases. Where the bones themselves are not diseased, erasion will give better results than excision, but tuberculous disease of the joints, and among them the elbow, does not always come before the surgeon in its early stage.

Mr. Clutton, at a meeting of the Medico-Chirurgical Society[1] advocated early erasion of the elbow-joint in place of late excision. He exposed the joint by dividing the olecranon. Nine cases were thus treated. Of these the first two had ankylosed joints, but very serviceable limbs. Six cases resulted in more or less movement in the joint,

[1] *Brit. Med. Journ.*, Dec. 16, 1893.

with cessation of the disease. The ninth and last case was subsequently excised. After excision there is always a tendency to fibrous ankylosis between the ends of the bones which are left. Now this is not a matter of much importance in the lower extremity where a firm support, as little shortened as possible, is the chief point to be attained. In the case of the elbow-joint, on the other hand, complete removal of the disease and free mobility should be our aim. The latter certainly — and the former also with the majority of operators will be best attained by excision with free removal of the ends of the bones. Next to thorough exposure and complete removal of the disease, a freely movable joint is what we require here and, if this be attained, it matters very little if the limb is shortened.

Operation. The following account is taken from the "Manual of Surgical Treatment," vol. iii, p. 246, by Cheyne and Burghard. It will be noticed that these writers speak guardedly of the amount of movement which may be expected afterwards. "Arthrectomy in children is an extremely satisfactory operation, which generally leaves a certain amount of movement, although the restoration of function is not complete. The operation is best performed through two long lateral incisions, one on either side of the joint. On the outer side the incision should reach from just below the point at which the ulnar nerve pierces the internal intermuscular septum downwards to about two or three inches below the level of the joint. On the outer side the incision may extend slightly higher up the arm, but must not reach as low down on the forearm for fear of injuring the posterior interosseous nerve just opposite the neck of the radius. It is as well to make the incisions as free as possible because plenty of room is required to enable the surgeon to see clearly what he is doing. The incisions are carried down to the condyles of the humerus, and the removal of the synovial membrane from the back of the joint is proceeded with. The capsule can usually be readily defined especially upon the outer side, and the skin and subcutaneous tissues are raised from it by a blunt dissector. The whole of the capsule over the radio-ulnar and radio-humeral articulations is thus gradually separated as far as the edge of the olecranon. The triceps is also raised from the capsule as far as the middle line of the joint, when a similar procedure is adopted on the inner side, care being taken to raise the ulnar nerve from its groove behind the internal condyle along with the soft parts and not to injure it. The fingers can then be made to meet across between the triceps and the capsule, and thus the whole of the upper part of the synovial membrane is easily separated and can be divided by a knife just at its reflection on to the bone, and peeled carefully downwards; it is also divided on each side in the line of the incisions, and is cut away below at its attachments to the olecranon, and to the radius and ulna. The entire posterior portion of the synovial membrane is thus removed, and the next step is to deal with the anterior portion. In order to do this satisfactorily it is generally advisable partially to detach the tendinous origins of the muscles from the condyles of the humerus, beginning over the outer one. The periosteum is incised and stripped forwards together with the muscles; these structures are pulled forcibly forwards, an assistant holds the limb flexed to a right angle, and the anterior surface of the capsule is defined and separated by a blunt dissector and the fingers. Special care must be taken not to damage the posterior interosseous nerve

in the lower part of the incision. The structures on the inner side are then dealt with in a similar manner, the periosteum and the tendinous origins of the muscles being separated from the internal epicondyle and the capsule defined and separated from them. The finger can soon be made to pass across from one incision to the other between the capsule and the superficial structures, amongst which will be the brachial artery. The entire front portion of the capsule can now be separated and may be cut across at its attachment to the bones and can be removed whole. The lateral ligaments are divided in doing this, and the ends of the bones can then be easily protruded through the wound; the olecranon is first pushed through whichever incision it can be made to project from more easily—generally the outer—and the synovial membrane of the radio-ulnar articulation is completely removed. The orbicular ligament will also require careful inspection, for it is often diseased. After all the synovial membrane has been removed from its attachment to the bone, and after any portions of cartilage or bone that are affected have been shaved off with a knife or freely gouged out, the humerus is protruded through one of the wounds—generally the inner—and examined. Special attention must be paid to the olecranon and coronoid fossæ, and the articular surface must be treated in a manner similar to that adopted for the bones of the forearm. After the disease has been thoroughly removed, the bones are replaced, the wounds stitched up without a drainage tube, the usual antiseptic dressings applied, and the limb placed upon an internal angular splint."

"**After-treatment.** The splints should be retained for three or four weeks, after which the arm should be kept in a sling for another two or three weeks, and the patient encouraged to move it freely. There is no particular advantage in performing passive movement. The only form of passive movement that is really desirable is rotation of the hand, and this may be practised diligently, both actively and passively."

OPERATION FOR FRACTURE OF THE OLECRANON

A. *Simple fractures.* Operation should be the rule, a few days after the injury, unless contra-indicated by the want of any separation between the fragments, by some constitutional condition or by the age of the patient. In the first case the diagnosis may be only possible after a radiographic examination. Otherwise firm bony union is very improbable owing to (*a*) the wide separation of the fragments brought about by the triceps; (*b*) the interposition of torn portions of the aponeurosis of this muscle between the fragments; and (*c*) tilting to the upper fragment. The subsequent fibrous union leads to considerable deficiency in the power of extension of the joint and consequently of serious disability. It is especially indicated when both olecranon processes have been fractured, or when a patient, in addition to a fracture of one olecranon has a fracture anywhere in the other upper extremity, thus rendering him very helpless.

B. *Compound fractures.* Here the operation is distinctly indicated. The free incision required will relieve the tension of the ecchymosed soft parts, it will aid the needed asepsis, it will admit of the removal of any detached fragments, it will enable the surgeon to empty the joint of clot, which, even if it do not suppurate, will persist tediously and impair future movements.

C. *In some old-standing fractures*, originally treated by splints, where treatment is sought on account of the resulting weakness.

It may here be mentioned that, when for any reason, operation is not performed, no time should be wasted by attempts, usually futile, to draw down the upper fragment with strapping. The case should be assiduously treated from the first with well-applied massage. If this be intelligently carried out, the wasting of the triceps and other muscles does not take place, the effused products are quickly absorbed, and the adhesions in and about the joint are prevented. The splint is left off after a few days, the patient then carries his arm in a sling and begins to use it cautiously. The result is excellent with far less irksomeness to the patient, and trouble on the part of the surgeon.

Operation. The parts having been most carefully cleaned, the surgeon raises a convex flap, including the skin, subcutaneous tissue and the olecranon bursa. The incision begins a little above the level of the fracture, about one inch to one side of it, and is then carried downwards and curved across the back of the elbow about one inch below the lower extent of the olecranon, and then finally carried up upon the opposite side to a point opposite to where it began. The convexity of the flap is thus directed downwards; care must be taken that it is of even thickness throughout.

The line of fracture is then made out,[1] any torn edges of fascia which may lie between the fragments are turned aside and trimmed clean, but not removed; the joint is fully flexed, and any clots picked out or washed away with sterile saline solution. To carry out the wiring, a small incision is made vertically down to the ulna, a full half-inch below the line of fracture. The cut edges of the periosteum are at once seized with small clip forceps, to mark the spot and to obviate one difficulty in passing the wire. The bone is then drilled obliquely with a drill of suitable size, the point emerging on the articular surface just behind the articular cartilage. A second small vertical incision is then made with the same precautions through the periosteum of the upper fragment, and its edges seized with forceps. The drill is then again introduced obliquely so as to make a passage for the wire exactly opposite to the first. The greatest care must be taken in drilling these holes that they exactly correspond on the fractured surfaces, otherwise exact apposition will not be secured. Sterilised silver wire is then insinuated through the openings in the fragments, and the forceps which act as guides are not removed until this is done. Full flexion of the joint facilitates the passage of the wire. The joint is now finally washed out with hot sterilised saline solution, the forearm is extended, and an assistant brings the fragments accurately together by pressure with a piece of sterilised gauze in each hand. The surgeon, grasping the ends of the wire in strong forceps, straightens them, and keeping his hands low makes a small, neat twist of about four half turns. The ends, cut short, are then hammered down into the periosteum and bone. The ends should be completely buried by suturing over them with catgut any fascia or periosteum that is to hand. Any lateral gaps in the capsule are closed in the same way. The skin is then sutured and, as a rule, no drainage is required. An ample dressing should be applied, but no

[1] This may be in one of three places: (*a*) The tip of the olecranon may be broken off; (*b*) fracture may occur at the narrowest part of the sigmoid cavity; (*c*) the process may be detached at its junction with the shaft of the ulna.

splint is necessary. Passive movements should be commenced in about a week, and massage as soon as the stitches have been removed. The patient may be allowed to move the joint himself at the end of a fortnight, but free use should not be permitted for five or six weeks.

In old-standing cases the operation will be upon similar lines, but owing to adhesions having formed between the upper fragment and the olecranon fossa of the humerus, and owing to the great separation brought about by the action of the triceps, great difficulty may be experienced in drawing the fragments together. This may be overcome by lengthening the triceps. The method of effecting this is indicated in Fig. 82.

Fig. 82. Method of lengthening the triceps in the operation for wiring long standing cases of fracture of the olecranon. The larger figure shows the long flap required for exposure of the triceps, and the serrated division of the muscle described in the text. The smaller figure shows the method of approximating the serrations above and below, and how the muscle is elongated. The apices of the serrations are made blunt in order to secure a larger surface for union. (Cheyne and Burghard.)

Mr. Walton[1] suggests as an improvement a method similar to that advocated by Lord Lister for old-standing fractures of the patella.[2]

Fractures of the Condyles of the Humerus. These injuries, which always involve the articular surface, are, unless the fragments are accurately replaced, very likely to be followed by serious disability. Either condyle may be fractured, or there may be a T-shaped fracture, in which the lower extremity of the humerus is separated while a vertical line of fracture extends from the transverse line to the articular surface. The tip of the epicondyle may also alone be fractured, in which case the joint is not opened. A thorough and careful radiographic examination is essential for the diagnosis of these injuries, and also to guide the surgeon in the treatment to be adopted.

An attempt may at first be made to manipulate the fragments into position, the patient being anæsthetised.

The arm should then be put up in the fully flexed position. A second radiographic examination should always be made and if the position is not satisfactory, open operation, if not contra-indicated by age, or by some constitutional condition, should certainly be advised. It must be remembered that in an important joint, such as the elbow, a very trifling irregularity of the articular surface may cause much limitation of movement, and also that callus

[1] *Fractures and Separated Epiphyses*, 1910, p. 155.
[2] See *Operations for Fracture of the Patella*.

or osteoid masses formed by stripped-up periosteum may subsequently seriously interfere with the mobility of the joint.

Operation. The fracture must be freely exposed either by a long vertical median incision over the back of the joint, or by a lateral incision along the supra-condylar ridges of the humerus. The former incision is best for dealing with a T-shaped fracture, while in separation of one condyle a lateral incision may be employed. Two lateral incisions may be made if necessary, when the soft parts may be separated from the capsule in front and behind (as described for Erasion, *see* p. 161). Care must be taken to avoid injury to the ulnar or musculo-spiral nerves. In this way a free exposure of the fracture and of the joint may be obtained. With either incision, after the soft parts have been reflected, the joint is opened and all blood clot washed away with sterile saline solution. The fragments are now manipulated into good position and secured by a screw or by a small Lane's plate. In the case of a T-shaped fracture the two small fragments should first be accurately fitted together, while the lower extremity should be fixed to the shaft by means of a small plate. One of Lane's three-limbed plates may be employed for this purpose.

The rent in the capsule is then closed by a few catgut sutures and the wound closed. An internal angular splint should be applied, care being taken that the vessels in front of the elbow are not constricted by too tight bandaging.

Cautious passive movements may be started in a week, while gentle massage should be commenced as soon as the stitches have been removed.

Separation of the Lower Epiphysis of the Humerus. In certain cases, where reduction of the deformity is impossible or in some old-standing cases where the mobility of the joint is seriously affected, operation may be called for. It is carried out on the lines described above. The epiphysis is exposed through one of the above-described incisions, manipulated into position, and secured by a plate, wire, or staple.

The after-treatment is also similar. Sir A. Lane advises removal of the plate as soon as union has occurred in all cases of mechanical fixation of epiphyses, otherwise interference with growth, leading to subsequent deformity, is likely to occur.

Dr. G. E. Davies, of Philadelphia, advises osteotomy of the humerus for **cubitus varus**, the deformity which may follow a fracture of the internal condyle not corrected at the time of the accident. He looks upon this as the most common of fractures about the elbow-joint.

Technique. An incision is made over the internal condyle and prolonged upwards, and the bone exposed by careful dissection. The brachial artery and the median nerve lie to the outer side and in front of the ulnar nerve to the inner side and behind this incision. The edges of the wound having been well retracted, a narrow osteotome is introduced and the bone divided, but not completely. The remainder is then fractured or bent until the desired position is attained. The limb is kept extended in plaster of Paris for six weeks after the removal of this, massage and movement restore the mobility of the joint in two weeks. Three cases are given with successful results.[1]

Arthrotomy. Opening the elbow joint may be called for in the following conditions: (1) For drainage in cases of acute suppurative arthritis. This may be the result of a punctured wound or be pyæmic in origin. (2) For the removal of loose bodies. These are usually small pieces chipped from the articular surface, the result of injury. In the

[1] *Ann. of Surg.*, January, 1899.

former case drainage may be effected by two incisions, one on each side of the olecranon. The proximity of the ulnar nerve must be remembered when making the inner incision. Frequent free irrigation with sterile saline solution should be carried out, or immersion of the elbow in an arm-bath containing hot boracic lotion or saline solution may be tri-

The elbow should be flexed to a right angle and the forearm kept midway between full pronation and supination. Passive movements should be commenced early, as ankylosis is very likely to follow. Not infrequently however in pyæmic cases, especially in children, surprisingly good movement is obtained. For the removal of loose bodies an incision on the outer side, over the head of the radius, is recommended. A fragment detached from the articular surface of this bone is one of the commonest loose bodies in the elbow-joint.

VENESECTION

Indications. Though not very frequently performed, there are a number of conditions in which this operation is strongly indicated. Generally speaking, these are characterised by a rapid, weak, often irregular pulse of low tension, a labouring and dilated right ventricle, and backward pressure along the systemic veins. Dr. Beddard says: "In extreme cases of cardiac dilatation venesection may be an almost necessary preliminary to enable the overstretched muscle to respond to digitalis, strychnine, and other cardiac stimulants."

The following are the chief indications: (1) In some cases of chronic bronchitis, especially when an acute attack exaggerates the chronic trouble leading to rapidly increasing cyanosis and cardiac failure from over-distension of the right side of the heart.[1]

(2) In some cases of injury to the lung and pleura and of traumatic pneumonia. Captain F. J. Porter, R.A.M.C., relates a case[2] which illustrates the truth of the above remarks:

"A lieutenant was shot through the chest in a Boer ambush. He was picked up four hours later in a critical condition, owing to dyspnœa from a large effusion of blood into the right pleura. Twenty-four hours later, while the patient was being taken across country to Heilbron, the lividity became so great and the pulse failed so much that ten ounces of very dark blood were taken from the median basilic vein. The patient immediately turned on his wounded side and went to sleep. Next morning he was quite rational. Fifty miles were trekked in twenty-eight and a half hours. The recovery was uninterrupted."

In cases of acute lobar pneumonia, owing to the tendency to cardiac failure, venesection will be very seldom indicated and should only be done after consultation with a physician.

(3) In severe cases of cardiac valvular disease, when the heart is so dilated and engorged that the right ventricle can with difficulty contract upon its contents.

(4) In some severe epileptic attacks, especially the status epilepticus, a moderate venesection is of service. In severe uræmic convulsions the fits may be arrested in this way, though care must be taken not to draw off too much blood. It has also been employed with advantage in the treatment of puerperal eclampsia.[3]

[1] Very interesting papers (with cases) will be found by Dr. Pye Smith (*Med. Chir. Trans.*, vol. lxxiv, p. 14), Dr. Ogle and Sir S. Wilks (*Lancet*, vol. i, 1891, pp. 1029, 1139).

[2] *Brit. Med. Journ.*, vol. i, 1901, p. 954.

[3] Dr. Thomas (*Brit. Med. Journ.*, 1898, vol. i, p. 400).

(5) In aneurysms, especially thoracic. Only a small amount of blood should be withdrawn, though the treatment may, if necessary, be repeated. Venesection here undoubtedly relieves certain very troublesome symptoms, viz. dyspnœa and pain.

Operation. The skin having been cleansed, the patient being usually in a sitting position, and a bandage tied round the middle of the arm with sufficient tightness to retard the venous circulation without arresting that in the arteries,[1] the surgeon selects the median cephalic or the median basilic, whichever is more prominent.[2] Steadying this vein by placing his left thumb upon it just below the point of intended puncture and with his right hand resting steadily upon its ulnar margin, he opens the vein with a small, sharp scalpel, scrupulously clean, making with, a gentle sweep of his wrist a small incision, and not a mere puncture, into the vein. The anterior wall of this being divided, the joint, without penetrating any deeper, is thrust onwards, first increasing the slit in the vein, and then being cut vertically, care being taken to make the skin wound larger than that in the vein. The thumb is now raised and the stream directed into the measuring vessel.[3] While the blood is escaping the limb should be kept in the same position, lest, by the skin slipping over the wound in the vein, the blood should be prevented from escaping freely and thus make its way into the cellular tissue.

The required amount of blood having been withdrawn, a sterilised thumb is placed on the wound while the bandage is removed. A small pad of aseptic gauze is then placed on the puncture, and secured with a bandage applied in the figure of 8. This pad may be removed in about forty-eight hours, and for a day or two the patient should use a sling.

Difficulties during and complications after Venesection. (1) Difficulty in finding a vein. This may be due to their small size, the feebleness of the circulation, or the abundance of fat. If a vein cannot be made sufficiently distinct by hanging down the limb, putting it in warm water, flexing and extending the wrist and fingers, and chafing the limb, one should be opened on the back of the hand, or blood withdrawn from the external jugular or internal saphena at the ankle. (2) In other cases, where the patient is much emaciated, owing to the absence of steadying fat the mobility of a vein may enable it to avoid puncture, unless a very sharp instrument be used and the vein well steadied. (3) When the vein has been opened, sufficient blood may not escape owing to: (*a*) The opening may be a mere puncture. (*b*) The skin opening may be insufficient in size, or not parallel in position to that in the vein. These impediments are removed by a freer use of the knife, carefully made or by bringing the wound in the vein parallel with that in the skin. (*c*) A pellet of fat may block the opening in the vein. This should be snipped away. (*d*) The patient may faint. (*e*) A thrombus may form. This will disappear when the venous current becomes more active. (*f*) The bandage may be tied too tightly round the arm. (4) Wound of the brachial or some other artery, *e.g.* an abnormal

[1] The surgeon makes use of the pulsation in the arteries to tell the relation of the brachial or one of its branches given off abnormally high up and running superficially to the vein at the bend of the elbow.

[2] If the patient is nervous, or if the veins are small, he should be told to hold a walking stick or book. This fatigues his arm, distracts his thoughts, and, by producing muscular contraction, supports and fills the veins.

[3] Not a drop of blood should be allowed to fall on the bed or the patient's linen.

ulnar. This can always be avoided by a careful use of the scalpel, and by noting beforehand the existence of any pulsation. The force of the jet and the mixture of bright with dark blood will tell of this accident. Pressure should be carefully applied and maintained, and blood taken from the opposite arm if required. (5) Escape of blood into the cellular tissue. This will lead to ecchymosis, and perhaps formation of a thrombus, which may be absorbed, but which also may suppurate. (6) Phlebitis or inflammation of the lymphatics. These may be caused by the use of infected instruments. Every precaution must be taken to secure asepsis, as any failure is likely to lead to the following two most grave results. (7) Cellulitis and septicæmia. (8) Intense pain in the limb, with gradual flexion of the elbow-joint. This is due to puncture of the external or internal cutaneous nerves, which are connected through the brachial plexus with the motor nerves to the brachialis anticus and biceps, which flex the elbow-joint. The injured nerve should be divided, subcutaneously if possible, or the scar excised.

LIGATURE OF THE BRACHIAL ARTERY AT THE BEND OF THE ELBOW (Figs. 64 and 83)

This operation, common enough fifty years ago owing to the frequency of venesection and the facility with which the brachial artery was wounded, will be briefly described here.

Indications. (1) Wound of the artery, especially after venesection or tenotomy of the biceps tendon (here a ligature above and below the wound will be required), or a punctured wound from any other cause. (2) Traumatic aneurysm, whether arterio-venous or not, occurring after accidents such as the above.

The late campaign in South Africa saw a great increase in the occurrence of arterio-venous aneurysms from the passage of high velocity bullets of a small calibre through adjacent arteries and veins. This subject will be referred to at p. 190 in the account of ligature of the axillary artery, the vessel of the upper extremity in which, according to Mr. G. H. Makins, operative interference is most likely to be useful.

Guide. The inner side of the biceps tendon.

Relations.

In Front

Skin; fasciæ; bicipital fascia; median basilic vein. Branches of internal and external cutaneous nerve.

Outside		*Inside*
Biceps tendon.	Brachial artery at bend of elbow	Median nerve
Vena comes.		Vena comes

Behind

Brachialis anticus.

Operation (Figs. 64 and 83). The limb being steadied, with the elbow slightly flexed, the site of the biceps tendon should be defined, and also that of any large veins, by making pressure a little above the proposed site of the ligature. An incision about two and a half inches long is then made, a little to the inner side of the biceps tendon, through the superficial fascia, carefully, so as to avoid the median basilic vein and its companion, the internal cutaneous nerve. If these are seen, they must be drawn inwards. The deep fascia is then divided, but this

and the semi-lunar fascia of the biceps, which strengthens it, should be interfered with as little as possible. The artery, with its venæ comites, lies directly underneath. The needle should be passed, after the veins are separated and the artery cleaned, from within outwards, so as to avoid the median nerve, which lies more deeply and to the inner side.[1] In the case of traumatic aneurysm, arterio-venous or not, resisting other treatment, a proximal ligature placed as near as possible above the sac, or the old operation of placing double ligatures,[2] will be preferable to the Hunterian one, which runs the risk of overlooking the possibility of a rather higher division than usual of the brachial into radial and

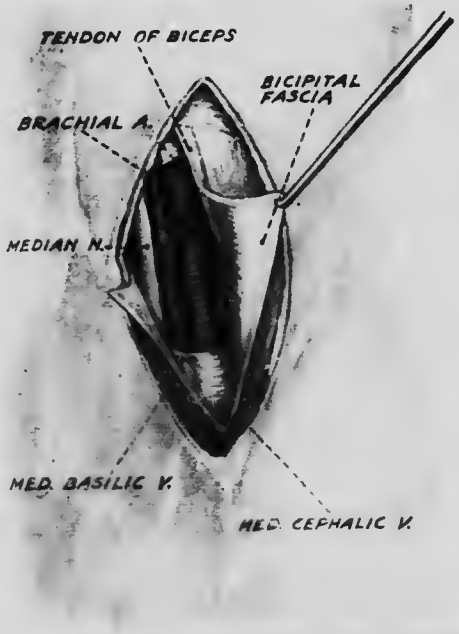


FIG. 83 Ligature of the brachial artery at the bend of the elbow.

ulnar. If much hæmorrhage is expected, the brachial should be compressed about the middle of the arm with an Esmarch's bandage or a tourniquet.

The median basilic vein will, in many cases of arterio-venous

[1] If it be needful to prolong the incision downwards so as to secure the upper end of the radial or ulnar, the bicipital fascia must be divided more freely, and the median basilic vein secured if it cannot be drawn to one side.

[2] On this and all other arterio-venous aneurysms the advice of Mr. Makins, p. 981, should be studied. It will be seen that he prefers trial of a proximal ligature first. If a local operation is found to be needful, ligatures will be required above and below the communication with the vein in the case of aneurysmal varix, and above and below the sac if the surgeon is dealing with a varicose aneurysm. It may be better (the artery being commanded above) to open the sac, and thus find the apertures into the artery by the aid of a small bougie. As Mr. Holmes (*Syst. of Surg.*, vol. iii. p. 92) points out, the other plan of attempting to find and tie the artery without opening the sac presents these difficulties, viz. that the artery is surrounded by dilated and closely packed veins, and that below the sac it is of small size. Every precaution should be taken to spare the main vein. If hæmorrhage from it, uncontrollable by pressure, be present, a lateral ligature should be attempted. Only, if it be absolutely unavoidable, should the vein be tied above and below.

aneurysm, be found much dilated by the entrance of arterial blood. Occasionally it has been obliterated. In ordinary traumatic aneurysm the sac should be cut away with scissors after the artery above and below has been secured.

This operation at the bend of the elbow should always be performed with the utmost carefulness at the time, and pains taken with the after-treatment, so as to ensure the minimum of disturbance and the smallest amount of cicatrix, and thus to interfere as little as possible with the movements of the elbow-joint.

CHAPTER VIII

OPERATIONS ON THE ARM

LIGATURE OF BRACHIAL ARTERY (Figs. 84, 85 and 86)

THIS is performed (*a*) in the middle of the arm and, much more rarely, (*b*) at the bend of the elbow, the operation last described.

(*a*) **In the middle of the Arm** (Fig. 85). *Indications.* (1) Chiefly wounds of the palmar arch, resisting pressure (*see* p. 89)

(2) Wound of the artery itself by a penknife, bayonet, bullet, &c.

(3) Gunshot wound of the elbow, leading to secondary hæmorrhage resisting other treatment.

(4) Angeioma of hand.

In March 1891 Mr. Jacobson tied first the brachial, and, five months later, the radial and ulnar arteries for a congenital angeioma with much erectile tissue affecting all the fingers and the palm of the hand in a girl aged 18. By the first

FIG. 84 Incision for ligature of the brachial artery.

operation the vascular [illegible] quickly reduced; the second, aided by catgut setons, was followed by very [illegible]ked skrinking, and, ultimately, a complete cure. A full account of the case with the result ten years after the operation, is given in the *Guy's Hospital Reports*, vol. lvi.

(5) Wound of one of the arteries of the forearm, followed by severe hæmorrhage, a sloughy condition of the parts preventing ligature of the vessel above and below the wound.

In the year 1882 a patient came under the care of Mr. Jacobson for secondary hæmorrhage from a wound of the forearm, inflicted by the bursting of a gun in rook-shooting. The parts were much swollen and sloughy: the ulnar artery in its middle third, from which the hæmorrhage was coming, was greenish in colour, and apparently not in a condition to hold a ligature. A good recovery, with no further hæmorrhage, took place after ligature of the brachial in the middle of the arm. In 1885 it was found necessary again to tie this artery, for hæmorrhage occurring repeatedly a few days after a suppurating palmar bursa had been opened in the usual way, above and below the anterior annular ligament. The patient recovered with a weakened limb.

(6) Traumatic and spontaneous aneurysm. In traumatic aneurysm,

whether of the brachial or the arteries of the forearm, the old operation is preferable to the Hunterian, as the sac is often imperfect (*see also* remarks on p. 173 on "Abnormalities of the Brachial Artery").

Dr. H. Bousquet records[1] a case of traumatic aneurysm[2] of the forearm, dating to a gunshot injury, cured by excision of the sac.

A labourer, while poaching, received a charge of No. 6 shot, which, entering in the lower third of the forearm, passed obliquely upwards almost as high as the elbow. The wound healed up in about six weeks. Evidence of an aneurysm became manifest thirteen days after the injury, but operative treatment was refused. Six months after the accident, an Esmarch's bandage having been applied, an incision was made over the swelling, which was now of a pyriform shape, and reached from the middle of the arm to the lower third of the forearm. The brachial artery having been tied as low down as possible, the aneurysm was separated from the

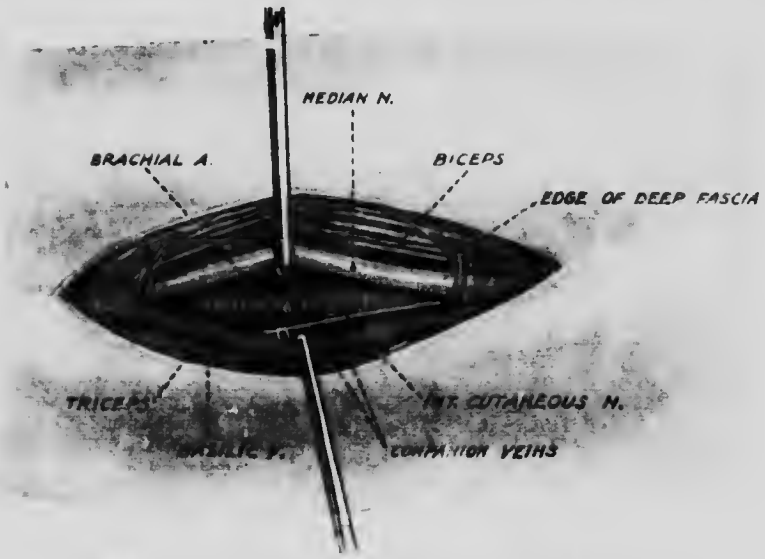


FIG. 85. Ligature of the brachial artery in the middle of the arm.

adjacent structures. In spite of much care, its walls, which were very thin, gave way at several spots. Its interior was filled with passive clot. Its lower extremity was embedded in the cicatrix of the wound. The aneurysm probably sprang from the arteries of the forearm near their origin, perhaps also from the brachial. The removal of the aneurysm left a large cavity, of which the floor was formed by the interosseous membrane, and the sides by muscles of the forearm. Several vessels were tied before and after the removal of the Esmarch's bandage. As it was impossible to bring so large a wound together, it was plugged with iodoform gauze. The patient recovered with a useful limb.

With regard to spontaneous aneurysms, it is well known that these are very rare in the upper extremity, and usually associated with cardiac disease. When this complication is present, ligature will only be thought of when the aneurysm is rapidly increasing, or causing painful pressure upon a nerve.

Local anæsthesia may be useful here.

[1] *Congrès Franç. de Chir.*, 1895 p. 741.

[2] The aneurysm is also described as arterio-venous, but no evidence of this is given. The account of the vessels affected is practically nil.

Line. From the junction of the middle and anterior thirds of the axilla, along the inner edge of the coraco-brachialis and biceps, to the middle of the elbow-triangle. This line is of especial importance, when, owing to the swelling, &c., the edge of the biceps is difficult to make out.

Guide. The above line and the inner edge of the biceps.

Relations in arm.

In Front

Skin; fasciæ; branches of internal and external cutaneous nerves.
Median nerve[1] (about the centre of the arm).

Outside		*Inside*
Coraco-brachialis (above).	Brachial artery in arm.	Ulnar nerve.
Biceps.		Internal cutaneous nerve.
Vena comes.		Vena comes.
		Basilic vein superficial to deep fascia in lower half, beneath it above, usually

Behind

Triceps (middle and inner heads); coraco-brachialis; brachialis anticus.
Musculo-spiral nerve and superior profunda artery (above).

Collateral circulation. (*a*) If the ligature be placed above origin of the superior profunda, the vessels chiefly concerned will be:

Above		*Below*
The subscapular The circumflex	with	The superior profunda.

(*b*) If the ligature be placed below origin of the superior profunda:

Above		*Below*
		The radial recurrent.
		The posterior ulnar recurrent.
The superior profunda	with	The interosseous recurrent.
		The anastomotica magna.

(*c*) If the ligature be placed below the inferior profunda:

Above		*Below*
		The radial recurrent.
		The anterior and posterior ulnar recurrents.
The superior profunda The inferior profunda	with	The interosseous recurrent.
		The anastomotica magna.

Abnormalities. These are so far from infrequent that the surgeon must be prepared for the following:

(1) The artery being in front of the nerve.

(2) A high division of the artery. According to Quain, in one out of every five cases there were two arteries instead of one in some part, or in the whole, of the arm. The point of bifurcation is thus described by Gray: "It is most frequent in the upper part, less so in the lower part, and least so in the middle, the most usual point for the application of a ligature; under any of these circumstances, two large

[1] The median nerve is to the outer side of the artery at its commencement, crosses it superficially about the middle of the arm and is to the inner side in the lower third.

arteries would be found in the arm instead of one. The most frequent (in three out of four) of these peculiarities is the high origin of the radial. That artery often arises from the inner side of the brachial, and runs parallel with the main trunk to the elbow, where it crosses it, lying beneath the fascia; or it may perforate the fascia, and pass over the artery immediately beneath the integument."[1]

(3) The artery may be partially covered by a muscular slip given off from the pectoralis major, biceps, coraco-brachialis, or brachialis anticus.

(4) Instead of following its usual course along the brachial anticus, the brachial artery may accompany the median nerve, behind an epicondylic process or ligament, as in many carnivera.

(5) It may also give off a vas aberrans or a median artery, and any of its ordinary branches may be absent. The vas aberrans usually ends in the radial, sometimes in the radial recurrent and rarely in the ulnar artery (Cunningham).

Operation (Fig. 85). The arm being extended and abducted from the side, with the elbow-joint flexed and supported[2] by an assistant, the surgeon, sitting between the limb and the trunk,[3] makes an incision three inches in length along the inner border of the biceps, beginning from below or above as is most convenient, going through the skin and fasciæ, and exposing just the innermost fibres of the muscle.[4] This is then drawn outwards with a retractor, the median nerve next found and drawn inwards or outwards with an aneurysm-needle, and the artery defined and sufficiently cleaned, when the ligature is passed from the nerve. In doing this the basilic vein and the venæ comites, which increase in size as they ascend, must be carefully avoided.

It may be here pointed out that the brachial artery is by no means so easy a vessel to tie as might be supposed from its superficial position. This is especially the case when the artery is concealed by the median nerve at the point where it is sought, and when its beat is feeble and the vessel itself small and but little distended after repeated hæmorrhage lower down.[5]

AMPUTATIONS OF THE ARM (Figs. 87–90)

Indications. Amongst these are:

(1) Accidents, *e.g.* compound fractures, machinery accidents, &c., which do not admit of any part of the forearm being saved or of amputation at the elbow.

(2) New growths involving the forearm and not admitting of extirpation.

(3) Disease of the elbow-joint not admitting of excision, or in which this operation has failed (*see* pp. 156, 160).

(4) Gunshot injuries of the upper part of the forearm, elbow, and arm not admitting of conservative treatment or excision.

[1] The possibility of this superficial position of the radial or ulnar should always be remembered when venesection, or ligature of the brachial, at the elbow is about to be performed.

[2] Mr. Heath has pointed out (*Oper. Surg.*, p. 18) that if the arm, when at right angles to the body, be allowed to rest upon the table the triceps is pushed up, and displacing the parts, may bring into view the inferior profunda and the ulnar nerve instead of the brachial and the median nerve.

[3] This is a much more comfortable position than standing on the outer side and looking over.

[4] Authorities differ as to this step. The operator is strongly advised to avail himself of this guide. If it can be done carefully, and the wound kept aseptic afterwards, it can do no harm. The fibres of the muscle are a distinct help, and (as stated above) ligature of this artery is not so easy a one as it would appear.

[5] This was so marked in the latter of the two cases mentioned at p. 171, that, when the vessel was exposed, several bystanders felt certain that it was not the brachial, but one of its branches.

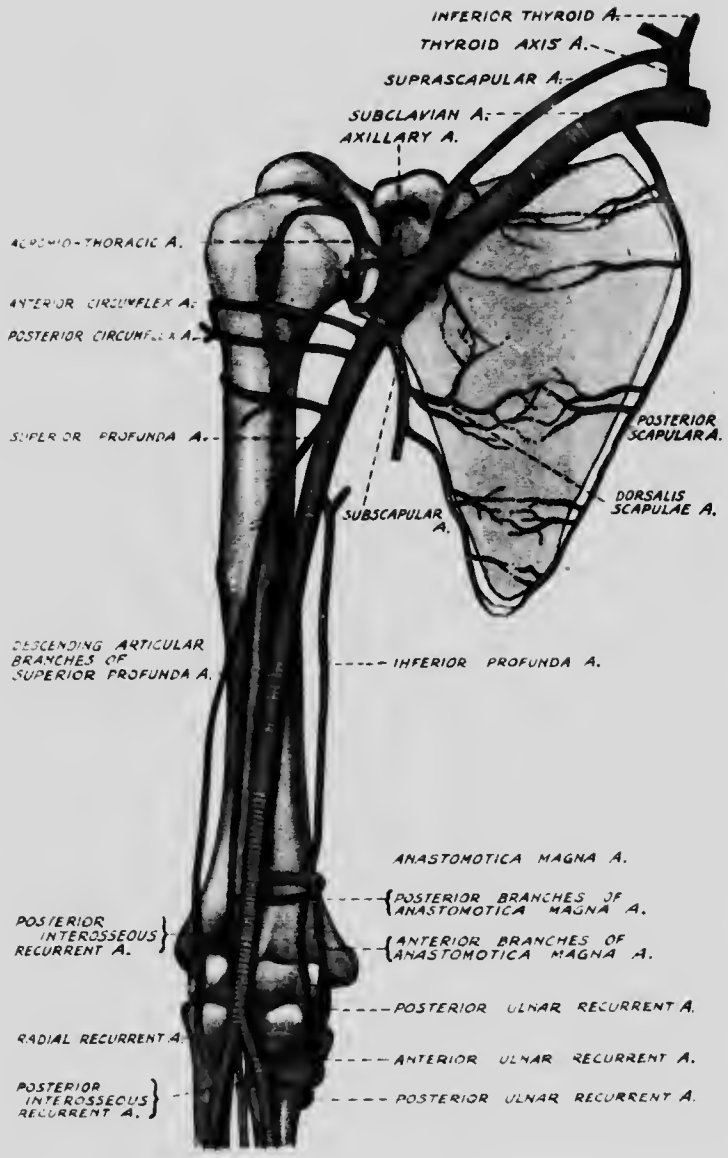


Fig. 86. Anastomosing branches of subclavian, axillary and brachial arteries.

Amongst the special conditions which will have to be considered here are the size and character of the projectile, the gravity of the laceration of the soft parts, the amount of longitudinal splintering of the bones, the extent of lesions to the vessels and nerves and the degree to which conservative measures can be adopted in the absence of hospital facilities or of easy transportation.

If the surroundings of the surgeon and patient admit of it, attempts will, nowadays, be made to suture the nerve ends, especially when only one or two of the chief trunks are involved. Reference has already been made to the infrequency of severe gunshot injuries to the elbow-joint in the South African War.

It is noteworthy here that Mr. Makins writes :[1]

"I am unable to say what was the proportional number of shell wounds among the men hit, but I can say with some confidence that it was not as great as 10 per cent. I should be inclined to place it as low as 5 per cent. Again, I cannot fix the proportionate occurrence of wounds from bullets of large calibre, such as the Martini Henry, but this was certainly not large. I think if 10 per cent. is deducted to represent the number of hits from either of these forms of projectiles, that we may fairly assume the remaining 90 per cent. of the wounds to have been produced by bullets of small calibre." With regard to treatment of wounded joints Mr. Makins states (p. 235) that this was generally simple. "The old difficulties of deciding on partial as against complete excision or amputation was never met with by us. We had merely to do our first dressing with care, fix the joint for a short period, and be careful to commence passive movement as soon as the joints were properly healed, to obtain in the great majority of cases perfect results. If suppuration occurred, the choice between incision and amputation had to be considered. In the early stages this choice depended entirely on the nature of the injury to the bones. If this were slight incision was the best course to adopt. I saw several cases so treated which did well, although convalescence was often prolonged, and only a small amount of movement was regained. Amputation was sometimes indicated in cases of severe bone-splintering when the shafts were implicated, but as a rule only performed after an ineffectual trial to cut short general infection of the septicæmic type by incision. I should add that, on the whole, suppuration of the joints was uncommon, except in the case of injuries far exceeding the average in primary severity."[2]

(5) In some cases of acute septic infection of the forearm, when septicæmia or toxic absorption threatens the patient's life.

So inestimable is the value, even when only partial, of the hand, and so good are the results of conservative treatment and secondary amputation, that the tissues must be almost disorganised for the surgeon to think of primary amputation here.

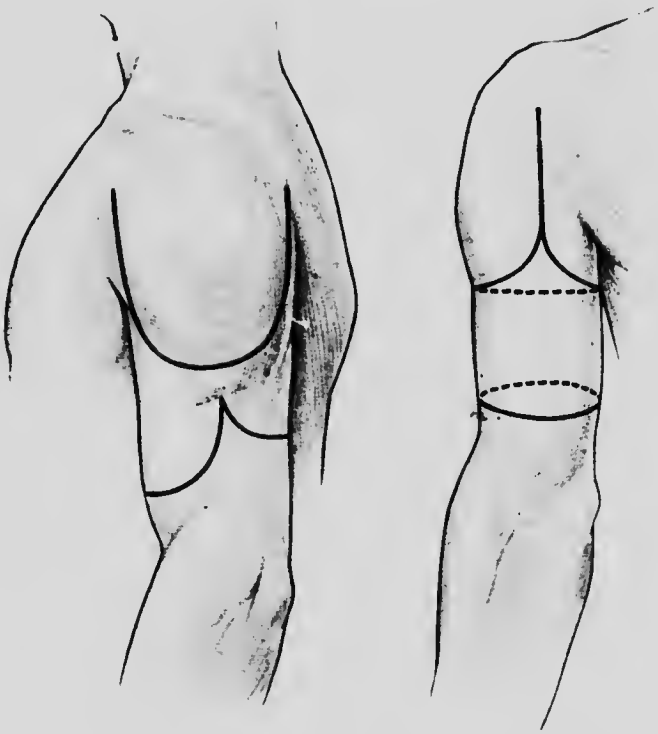
The following case illustrates the power of recovery after very extensive injury to soft parts :

A man, æt. 22, was admitted into Guy's Hospital in November 1911 with a large transverse gash just below the right elbow-joint, caused by a fall through a glass window. The severe hæmorrhage was checked by a tourniquet applied at once by a policeman, but on arrival at the hospital he was almost pulseless. The whole of the soft structures were divided down to the bones, the elbow-joint being opened and the head of the radius exposed on the outer side. All the superficial flexors of the forearm were divided just below the internal condyle, and also the supinator longus and the tendon of the biceps. The radial and ulnar arteries were divided at their commencement and also the common interosseous. The median, radial, and posterior interosseous nerves were severed, the latter, just at its passage through the supinator brevis. The tendon of the biceps and the muscles were sutured, though it was impossible to identify the various muscular bellies. The

[1] *Surgical Experiences in South Africa*, 1899-1900, p. 11.

[2] In the present war the proportion of shell wounds is certainly much greater than in the South African War. Owing to the conditions of trench warfare, too, infection and suppuration are almost certain to occur.

median and radial nerves were also identified and sutured, but considerable difficulty was experienced in identifying the posterior interosseous as it was here giving off a number of muscular branches. The injured arteries were ligatured. Except for the sloughing of a large lacerated area of skin on the forearm below the elbow, the wound healed well. The function of the median and radial nerves was recovered and there was good movement, and sensation in the fingers, but owing to the scarring in front of the forearm, though this was minimised as far as possible by skin-grafting, full extension of the elbow was impossible. Owing to the persistence of paralysis of the extensors the posterior interosseous nerve was subsequently exposed, dissected free from the scar tissue and sutured.



A. B.

FIG. 87. A. Amputation through shoulder joint by deltoid flap. Amputation through arm by long anterior and short posterior flaps. B. Amputation through arm by the circular method. Spence's method of amputating at the shoulder.

A compound fracture, especially when comminuted and associated with severe laceration of the soft parts and division of the main vessels or nerves will probably require a primary amputation, though even in some of these cases conservative treatment may be tried.

Methods. (1) Circular. (2) Skin flaps with circular division of muscles —(*a*) antero-posterior; (*b*) lateral flaps. (3) Antero-posterior flaps, usually cut by transfixion. (4) Skin and transfixion flaps combined. (5) Single flap.

(1) **Circular method** (Fig. 88). Owing to the moderate size of the limb, its cylindrical shape, and its single centrally situated bone, this is the place, above all others, where this method can be employed, especially

in limbs which are not very bulky. Whether he make use of it in after life or not, the student should always practise circular amputation here on the dead subject.

Standing on the outer side of either limb, the brachial artery having been controlled by a tourniquet placed as high as possible, the surgeon with his left hand draws the skin up strongly and passes his knife under the arm, then above, and so around it, till, by dropping the point vertically, the back of the knife looks towards him, and the heel rests on the part of the arm nearest to him. A circular sweep is then made round the limb, the completion of this being aided by the assistant in charge of the limb, who should rotate it so as to make the tissues meet the knife. A cuff-like flap of skin and fasciæ is then raised, for about three inches, with light touches of the knife, these being especially needed along the lines of the intermuscular septa. In a very muscular arm it may be difficult to raise the skin as directed, and it will be sufficient here for an assistant to retract it evenly all round as

Fig. 88.

it is freed by the knife. When the skin has been sufficiently folded back and retracted the muscles are cut through close to the reflected skin, the biceps being cut rather longer than the rest, as, owing to its having no attachment to the humerus, it retracts more. The cut muscles are next retracted by the operator's left hand, and the remaining soft parts, with the main vessels and nerves, are severed clean and square.[1] The bone is then cleared for three-quarters of an inch and, the periosteum having been divided, is sawn through as high as possible.

The modified circular method (Fig. 89), as described for the forearm on p. 140, may also be employed.

The vessels to be secured will be the brachial upon the inner side, the superior profunda in the musculo-spiral groove and the inferior profunda to the inner side of the brachial close to the ulnar nerve. The wound should be sutured so that the resulting scar is in the antero-posterior plane.

(2) **Skin Flaps with Circular Division of Muscles.** This method should be made use of for bulky muscular arms.

(*a*) *Antero-posterior Flaps.* The brachial having been controlled,[2] and the arm supported, at a right angle to the body, the surgeon stands

[1] In an amputation which passes through the musculo-spiral groove, great care must be taken to divide completely the nerve lying in this before the bone is sawn. The depth of this groove varies much. When it is considerable, the nerve may easily escape division and be frayed by the saw, giving rise, if overlooked, to a most painful bulbous end.

[2] In amputation high up the application of a tourniquet may be impossible. The axillary must then be controlled by elastic tubing as described on p. 201, or the subclavian

outside the right and inside the left limb, with the forefinger and thumb of his left hand marking the site of the intended bone-section (Fig. 90). He then enters the knife on the side of the limb farthest from him, carries it first down three, three and a half, or four inches, according as he is going to make this flap longer than the other or not,[1] next across

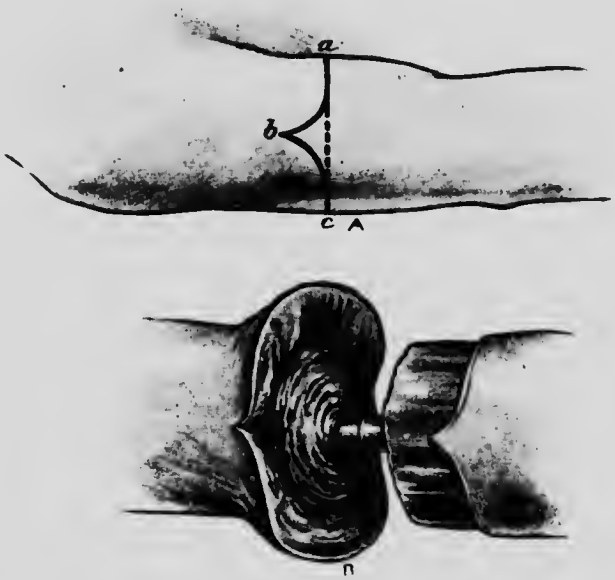


FIG. 89. Amputation of the arm by the modified circular method. The dotted line *a c* in A is the ordinary incision in the circular method, while the thick line *a b c* shows the modified circular incision. The skin flaps are shown in B as well as the circular division of the muscles.

Two equal flaps of skin and subcutaneous tissue are cut, their lower limit being, in the case of an ordinary forearm, about 1½ inches below the seat of the circular division of the muscles, and then again about 1½ inches below the point of section of the bones. In the arm each of these measurements will be increased to 2½ inches or more. After the flaps are raised, the muscles are divided by a series of circular sweeps of the knife. After each cut they are firmly retracted until the bone is exposed at the proposed point of division. The periosteum having been divided circularly, it is stripped up with a rugine along with the muscles. Thus, when the bone has been sawn, a cap of periosteum falls over the cut end. The muscles and periosteum must be stripped off the bone together, not separately. (Cheyne and Burghard.)

the limb, with square edges, and up the side nearest to him, to the point opposite to that from which the incision started. Then passing the knife under the limb, he marks out a posterior flap, usually somewhat shorter than the anterior. These flaps, consisting of skin and fasciæ, are now dissected up, the muscles cut through at the flap-base with a

must be controlled by a reliable assistant, or the vessels secured by Spence's method. The latter which is described on p. 206, is, owing to its simplicity and reliability, strongly recommended.

[1] Long anterior and short posterior flaps are preferable; if equal, the cicatrix will be opposite, and perhaps adherent to, the bone. This is undesirable, though of less importance than in the lower extremity.

circular sweep, and the bone sawn through as high as possible. The biceps should be cut rather longer than the other muscles, and especial care should be taken here to divide the nerve-trunks cleanly and as high as possible. In tying the arteries each must be thoroughly separated from its accompanying nerve.

(*b*) *Lateral Flaps.* This method may be employed, one flap being cut longer than the other, when the skin is more damaged on one side.

The surgeon, standing as before, marks the site of bone-section by placing his left forefinger and thumb, not now on the two borders of the arm, both on the middle of the anterior and posterior surfaces of the limb. Looking over, he enters his knife at the latter spot, and cuts a well-rounded flap, ending on the middle of the anterior aspect, and then from this point, without removing the knife, another flap is marked out by a similar incision ending at the middle of the back of the arm. The flaps are then dissected up, and the operation completed as before.

(3) **Transfixion Flaps,** usually antero-posterior. In an arm of moderate size, or where rapidity is required, as in warfare or in cases of double amputation, this method may be made use of. The objection to it is that it involves the removal of an undue amount of bone and, where the amputation is high up, interferes with the preliminary securing of the brachial artery by Spence's method. The surgeon, standing as before, and with his left hand marking the flap-base, and lifting up the soft parts anterior to the humerus so as to get in front of the brachial vessels, and thus avoid splitting them, sends his knife across the bone and in front of the above vessels, and makes it emerge at a point exactly opposite; he then cuts a well-rounded flap, about three inches long, with a quick sawing movement, taking care, after he feels the muscular resistance cease, to carry his knife on a little, so as to cut the skin longer than the muscles, the knife being finally brought out quickly and perpendicularly to the skin. The flap being lightly raised, without forcible retraction, the knife is passed behind the bone at the base of the wound already made, and a posterior flap cut similar to the anterior, but somewhat shorter. Both flaps are then retracted, any remaining muscular fibres divided with circular sweeps of the knife, and the bone exposed a little above the junction of the flaps. The saw is then applied after careful division of the periosteum. The brachial artery will either be found in the posterior flap, or if, as both flaps are made, the soft parts are drawn a little from the humerus, the main artery and nerves will be left, and must be cut square with the circular sweeps of the knife.

If it be preferred, lateral flaps can be made by transfixion, one, of course, being cut longer than the other if this is rendered desirable by the condition of the soft parts.

(4) **Combined Skin and Transfixion Flaps** (Fig. 90). This, a speedy and efficient method, may be made use of here. An anterior flap of skin and fasciæ, about three inches long, having been marked out and dissected up, the bulk of the soft parts behind the bone are drawn a little away from it, the knife passed behind the humerus, and a posterior flap, somewhat shorter, cut by transfixion. The operation is completed as described above.

(5) **Single Flap.** The condition of the soft parts may render this method advisable. If possible an anterior flap is cut by transfixion and so arranged as not to include the large nerves.

In all cases of amputation high up in the arm some part of the insertion of the pectoralis major should be preserved in order to counteract the tendency to abduction of the stump.

EXCISION IN CONTINUITY OF THE SHAFT OF THE HUMERUS

By the term "excision in continuity," deliberate removal of portions of the shaft of the humerus—*e.g.* two to six inches—the periosteum being preserved as far as possible, is meant. If such operations as incision and removal of splinters, for necrosis, and for pseudo-arthrosis be excluded the indications are very few. It has been performed for gunshot injuries and possibly might be required for a localised growth such as a chondroma and in some cases of necrosis. In the latter the surgeon will, in the great majority of cases, wait for the sequestrum

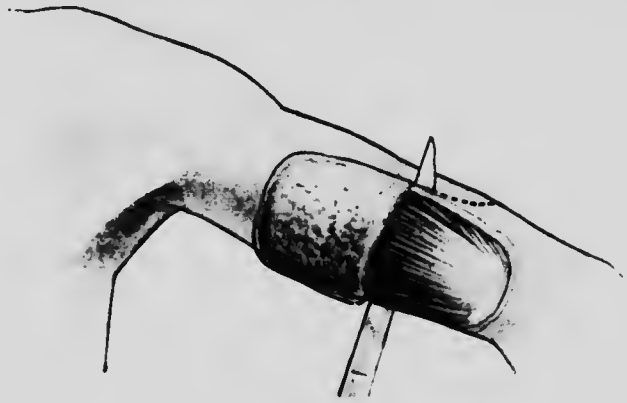


Fig. 90.

to separate and then remove the necrosed portion of the shaft by sequestrotomy (*q.v.*).

With regard to its employment for gunshot wounds.[1] Dr. Otis thus wrote in 1883:

> "I cannot discern that the experience of the war lends any support to the doctrine of the justifiability of operations of this nature except in very exceptional cases. The numerical returns, and the necessarily abbreviated summaries, may appear, at first glance, to represent the results in a favourable light, but a more precise analysis reveals most lamentable conclusions. . . . The mortality rate is nearly double that observed in the cases treated by expectant measures, and more than 12 per cent. higher than the fatality in a larger series of primary amputations in the upper third of the arm."

Free exposure of the shaft of the humerus is not easy, owing to the important vessels and nerves in more or less close relationship with it. It is best exposed by an incision commencing in the interval between the deltoid and the pectoralis major and continued downwards along the groove to the outer side of the biceps as low, if necessary, as the level of the external condyle. The bone is reached to the outer side of the coraco-brachialis and the brachialis anticus. Care must be taken to avoid injury to the circumflex vessels in the upper part of the incision,

[1] See also the remarks on gunshot wounds of the radius and ulna, p. 134.

while towards its lower end the musculo-spiral nerve should be identified and be drawn, together with the superior profunda artery, the supinator longus, and triceps, to the outer side. The periosteum should be carefully peeled off the bone with the help of a sharp periosteal elevator. The requisite quantity of bone is then removed, the shaft of the bone being divided by a fine saw.

Another incision sometimes employed commences, as described above, in the interval between the deltoid and the pectoralis major. Below the insertion of the deltoid it is carried more superficially (so as not to injure the musculo-spiral nerve) till it gets into the interval between the triceps behind and the brachialis anticus and supinator longus in front, whence it is carried down to a point just above the external condyle. The nerve is made sure of by opening the intermuscular septum and drawing the triceps backwards and the brachialis anticus forwards, and then held carefully aside with an aneurysm-needle. The shaft is exposed and the necessary amount of bone removed, as described above.

Causes of Failure after Excision of the Humerus in Continuity. Amongst these are: (1) Osteo-myelitis and pyæmia. (2) Secondary hæmorrhage. (3) Secondary necrosis. (4) Non-union, leading to a limb which dangles or is flail-like, and is more or less useless in spite of a support.

Operative Treatment of Acute Infective Periostitis. This disease may commence either at the upper or the lower epiphyseal line. The pus collects beneath, and strips up, the periosteum from the shaft. Acute osteo-myelitis always occurs at the same time. Necrosis of a part of the shaft is an inevitable sequela. In the acute stage one or more incisions, according to the extent of the abscess, must be made, care being taken to avoid the important vessels and nerves. The medullary cavity should be freely gouged open in all cases. No attempt should be made to remove the necrosed portion of the bone until the sequestrum is separated. This will occur in from ten to twelve weeks. The operation of sequestrotomy is then required. A free incision is made, if possible, on the outer aspect of the limb, but this will depend upon the situation of the sinuses. The bone is exposed, the soft involucrum, consisting of newly formed soft periosteal bone, is freely gouged away until the sequestrum is thoroughly exposed. This is removed, and the cavity, often of considerable extent, is washed out with lot. hydrogen peroxide. A few stitches are inserted, but free drainage must be provided and the wound allowed to heal by granulation—a long and tedious process. Methods for filling up the cavity and thus hastening the healing of the wound will be given below. Occasionally the periosteum of the entire shaft may be separated, which then is certain to necrose. Should this condition be found the diaphysis should be removed, but, unless separation has occurred, a small piece of the shaft adjoining the epiphysis should be left, to avoid injuring the cartilage at the epiphyseal line.

Operative Treatment of Fracture of the Humerus. This will be required in some cases when it is impossible to get the fragments into apposition by manipulation, and in those cases where non-union occurs or where there is injury to the musculo-spiral or other nerves. The fracture is best exposed by a long vertical incision between the triceps and the brachialis anticus on the outer aspect of the arm.

Any intervening portions of muscle or fascia are removed, the fragments are brought into position by extension and are secured by a plate. An internal angle splint is applied; massage is started as soon as the wound is healed and the stitches are removed.

Operation for Pseudo-arthrosis. A false joint is not an uncommon sequela to a fracture near the centre of the shaft of the humerus. It probably depends upon imperfect immobilisation. Operative treatment is always required. The fracture is exposed freely through the long external incision described above. A portion of each fragment must be removed by a fine saw so that the section passes through healthy bone. The refreshed surfaces are then brought together and secured by a plate. Where there is much separation this may be impossible. An attempt may then be made to fill up this space by bone-grafting (*vide infra*).

In any of the above operations, the treatment of the periosteum will be of very great importance. Professor Ollier warns those who would expect that periosteum methodically detached from the bone will always and completely reproduce the bone that it normally covered, that they are under a dangerous illusion. It can only be relied upon to do so in early life in young subjects, and when there has been no infective suppuration destructive to the bone-producing cells and when some longitudinal splinters have been left attached within the periosteal sheath. If detached with a blunt elevator, the outer elastic tissue of the periosteum is alone detached. When separated with a knife or a sharp periosteal elevator or rugine, however, the inner bone-forming layer and attached spicules of bone are preserved. When it is desired that new bone should be developed this method of separation should always be adopted.

In these, and in similar operations on the other long bones, a considerable gap in the continuity of the shaft resulting in non-union and a useless limb, or a large cavity in the bone which will only slowly heal by granulation, may have to be treated. The following methods have been employed.

(1) *Bone grafting.* The bone required to fill up the gap may be obtained from the patient himself by chiselling away portions of the same or another bone (auto-plastic method), or by taking portions of bone from a freshly amputated limb, or by making use of a bone taken from one of the lower animals (hetero-plastic method). The former is naturally of very limited use.

Sir W. McEwen[1] records a successful case in which a boy who had necrosis of the entire shaft of the humerus after acute infective periostitis with a useless dangling limb, in which he grafted portions of bone derived from cases of cuneiform osteotomy of the tibia between the widely separated extremities. These filled up the gap to the extent of four and a quarter inches, the arm then measuring six inches in length. Seven years afterwards the shaft of the humerus was found to have increased to seven and three-quarter inches. The patient could use his arm for a great many purposes—taking his food, adjusting his clothes, and in many games.

Sir A. Lane has recorded two cases in which he restored the shaft of the ulna by grafting bone from a rabbit.

One case was that of a child with congenital maldevelopment of the bone. The ulna consisted of two separate portions, whose pointed extremities overlapped, and whose axes varied considerably in direction. Both were freely exposed and separated from the adjacent parts. Extension was then made on the lower one until the hand was in normal position. The femur of a rabbit was then split longitudinally, and its halves wired to the fragments of the ulna so as to bring their

[1] *Ann. of Surg.*, vol. vi, p. 301.

axes into the normal line and to retain the lower one on a level with the radius. The result was most satisfactory, not only as to the deformity, but also because of the marked and progressive improvement in the usefulness of the limb.

The second case was that of a man, æt. 19, who had lost the shaft of one ulna two years before. Radiographic examination showed the existence of a fine spiculum between the two extremities. An incision exposed the two ends of the ulna and the spicule, and freed them from the adjacent parts. The femur of a very large rabbit was then securely wired to the ends of the ulna. The resulting limb was much stronger than it was before the operation. It is pointed out that in such a case the presence of new bone thrown out at the upper extremity of the ulna, as a result of the original inflammation, and some ankylosis of joints may interfere with a perfect result.

In the latter of the two cases, however, a sarcoma subsequently developed about the grafted bone.

As regards the technique of the operation the greatest care must be taken to secure the most rigid asepsis. The grafts in the auto-plastic method, and, unless there is a very large gap to be filled, in the hetero-plastic also, must be broken up into small pieces and placed accurately in the axis of the bone. Any periosteum must be carefully preserved. Where no connecting periosteum is present, as was the case in Sir W. McEwen's patient, a groove must be made between the muscles for the reception of the grafts. An interesting case, quoted from the German Surgical Congress Transactions, 1906,[1] shows that a large graft may be employed and that living bone is not essential.

Rausch, of Schoneberg, filled a gap 9 cm. long in the shaft of the tibia, the result of the excision of a portion of the bone for a myeloid growth, by grafting a portion of tibia of sufficient length taken from an amputated limb. Before this was secured in its new position by ivory pegs, it was boiled to ensure sterilisation. Nine months later the leg was amputated for recurrence of the growth, and examination then showed that the grafted portion had firmly united at each end and that it was covered by new periosteum.

(2) *The use of Decalcified Bone.* This is sometimes employed for filling cavities in bone, such as are left after removal of a sequestrum. Though occasionally successful the results are usually disappointing. This is owing to the septic condition of the cavities, the foreign substance being usually disintegrated and discharged.

(3) *The Iodoform Bone-filling of Moestig and Moorhof.* This also may be used for filling cavities in bone. The material consists of: Finely powdered iodoform 60 parts, spermaceti oil 40 parts, oil of sesame 40 parts. The cavity must be aseptic and should be thoroughly dried preferably by means of a hot-air blast. The iodoform wax is melted, shaken up, and then poured into the cavity which it completely fills to the normal surface of the bone. The soft parts are then brought together without drainage and the wound completely closed. The chief objection to this method is that mentioned for decalcified bone, viz. the difficulty in ensuring the asepsis of the cavity. It is stated that the best results are obtained when tuberculous cavities are treated in this way.

[1] *Ann. of Surg.*, vol. xliv, p. 792.

OPERATIONS ON THE MUSCULO-SPIRAL NERVE

(Figs. 91 and 92)

Owing to its proximity to the humerus as it lies in the musculo-spiral groove, this nerve is liable to injury in fractures about the middle of the shaft,[1] either by laceration by the fractured ends of the bone or by subsequently becoming involved in the callus. In either case operation

FIG. 91. A, Deltoid. B, Outer head of triceps. C, Long head. D, Inner head. E, Supinator longus and extensor. C', Radialis longior. F, Latissimus dorsi. *a*, Superficial branch of posterior circumflex. *b*, Anastomotica. 1, 1, Cutaneous branches of circumflex. 2, Intercosto-humeral. 3, Internal cutaneous of musculo-spiral. 4, Nerve of Wrisberg. 5, Posterior branch of internal cutaneous. 6, External cutaneous branches of musculo-spiral. * Acromion. † Internal condyle. (Godlee.)

will be required. Occasionally the nerve is divided by a stab. Mr. Lucas [2] has recorded two such cases.

In one case, a lad æt. 16, the axillary vein and superior profunda artery were wounded, as well as the musculo-spiral nerve, which was divided, and its lower part torn and notched. The damaged part was cut away and the ends united by catgut sutures. Complete recovery followed, about three months after the injury. The other case was seen two months after the injury. The scar was five inches from the acromion, opposite the insertion of the deltoid, behind and to the outer side of the humerus. On laying bare the nerve it was found that there was a high division into radial and posterior interosseous, the latter being severed just after its origin. The musculo-spiral just before its division, and the radial at its commencement, were involved in dense scar tissue. They were freed from this, and the ends of the posterior interosseous, after resection, were united by fine catgut. The arm gradually improved with three months' galvanism and a complete cure followed.

[1] Much interesting information on this subject is contained in a paper by Dr. Charles Scudder and Dr. Walter Paul on "Muscular Spiral Paralysis Complicating Fracture of the Humerus." (*Ann. of Surg.*, 1909, vol. l, p. 1118.)

[2] *Guy's Hospital Reports*, vol. xlvi, p. 1.

Relations (Fig. 92). In the upper third of the arm the nerve runs vertically downwards, behind the brachial artery, to the inner side of the humerus, resting upon the long head of the triceps. In the middle third it passes obliquely downwards and outwards, with the superior profunda artery, close to the bone in the musculo-spiral groove, at first between the long and outer, and then between the outer and inner heads of the triceps. In the lower third it pierces the external intermuscular septum and passes to the bend of the elbow in front of the external condyle, between the brachialis anticus and the supinator longus.

Operation. It will most frequently have to be exposed in its middle third, as it here lies close to the bone in the groove and is especially

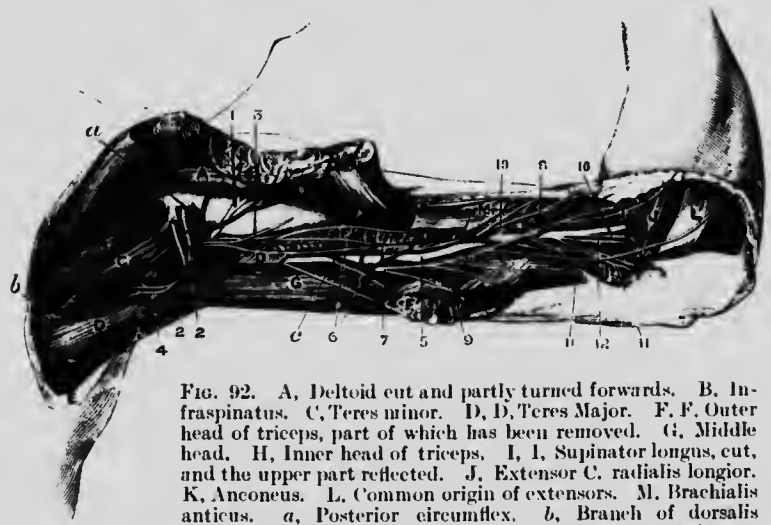


FIG. 92. A, Deltoid cut and partly turned forwards. B, Infraspinatus. C, Teres minor. D, D, Teres Major. F, F, Outer head of triceps, part of which has been removed. G, Middle head. H, Inner head of triceps. I, I, Supinator longus, cut, and the upper part reflected. J, Extensor C. radialis longior. K, Anconeus. L, Common origin of extensors. M, Brachialis anticus. *a*, Posterior circumflex. *b*, Branch of dorsalis scapulæ. *c*, Superior profunda. 1, 2, 2, Branches of circumflex to deltoid. 3, Cutaneous branches of circumflex. 4, Branch to T. minor. 5, Musculo-spiral. 6, 6, Branches to outer head of triceps. 7 and 8, External cutaneous branches of musculo-spiral, the former supplying outer head of triceps. 9, Branch to long head of triceps. 10, 10, Branches of musculo-spiral to brachialis anticus. 11, 11, Branches to supinator longus. 12, Branch of extensor carpi radialis longior. (Godlee.)

liable to injury by fractures in this situation. An incision, four inches in length, should be made in the axis of the humerus on the posterior aspect of the arm. The centre of the incision is opposite the insertion of the deltoid. The posterior border of the latter muscle is identified, and then on separation of the long and inner heads of the triceps the nerve comes into view. For free exposure it is however necessary to incise and separate the fibres of the inner head in the vertical direction.

If required, the nerve may be exposed in its upper third by an incision along the internal bicipital ridge opposite the lower extent of the posterior fold of the axilla. It will here be found resting on the latissimus dorsi behind the brachial artery close to the inner aspect of the humerus. In the lower third it may be readily exposed by an oblique incision in the interval between the supinator longus and the brachialis anticus. The median cephalic vein should be drawn aside and, on separation of the above-mentioned muscles, the nerve comes into view.

CHAPTER IX

OPERATIONS ON THE AXILLA AND THE SHOULDER

LIGATURE OF THE AXILLARY ARTERY (Figs. 93–96)

Indications. (1) Wound of the artery.[1]

(2) Aneurysm of the brachial high up. The following instructive case[2] will repay perusal. It (1) enforces the importance of exploring at once a wound near a large artery that has bled "profusely"; (2) it proves, if this step be not taken and a traumatic aneurysm arise, how much the old operation of tying the vessel above and below the aneurysm and emptying the latter of clot is to be preferred to the Hunterian method;[3] and (3) it is an interesting instance that gangrene, which is by no means unknown in the lower limb after ligature of the external iliac (*q.v.*), may also occur in the upper extremity with its better collateral supply.

FIG. 93. Incisions for ligature of the first part of the axillary artery and the third part of the subclavian.

A man, æt. 30, accidentally stabbed himself in the outer aspect of the right arm, in its middle third. Profuse hæmorrhage followed. The wound was cleansed and dressed antiseptically, and the arm was bandaged from the hand upwards. The patient was sent home, but at night severe bleeding again set in. This was arrested by "plugging." The following night hæmorrhage recurred, and was again arrested by plugging. The wound gradually healed, and, three weeks later, a circumscribed traumatic aneurysm of the brachial artery developed at "the seat of the original wound, but on a higher level." The aneurysm increased rapidly, soon occupying the whole of the inner and anterior aspect of the upper arm, causing œdema and loss of sensation of the hand and fingers. About fourteen days later, pressure having failed, it was decided to tie the axillary artery in its third part. This cured the aneurysm, but gangrene[4] of the thumb, together with

[1] In some wounds of the artery, the surrounding parts, *e.g.* veins and nerves, may be so injured, that the vitality of the limb is impaired beyond what ligature and nerve suture can do, and the advisability of amputating at the shoulder-joint must be considered.

[2] *Lancet*, 1895, vol. i, p. 92.

[3] It is always invidious to criticise cases, especially those which the writer has not seen, and it is only fair to the surgeon who publishes this to quote his words. "The only alternative would have been to open the aneurysm, turn out the contents, and attempt to tie both ends of the artery, an operation fraught with great danger to the limb and to the patient in his then weakened condition."

[4] In this case the repeated bleeding had reduced the size of the main vessel (as in the case mentioned at p. 152) and its anastomoses. Ligature of the axillary artery, very

sloughing of the tendons of the forefinger, commenced thirty hours afterwards. Amputation of the thumb at the metacarpo-phalangeal joint was required later on, and the index finger remained stiff.

More rarely still: (3) As a distal operation for aneurysm of the subclavian.

(4) In some cases of axillary aneurysm.

(5) For hæmorrhage from malignant disease in the axilla. This last is extremely rare, but a good instance, and one showing the difficulties which may be present, was published by Sir W. Savory.[1] Injury to

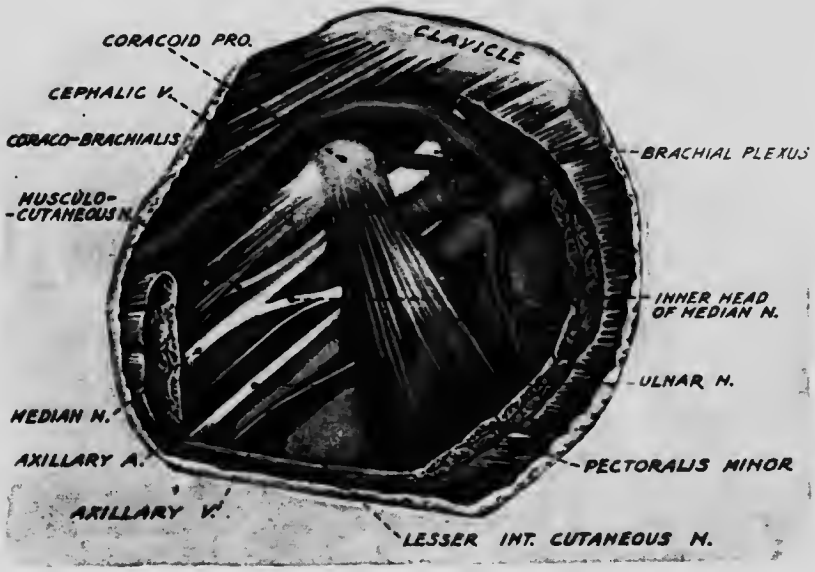


FIG. 94. Anatomy of the parts concerned in ligature of the axillary artery.

the axillary vessels during removal of the breast is dealt with under this heading.

Results of injuries from modern bullets to the axillary artery,[2] traumatic aneurysm, varicose aneurysm, and aneurysmal varix.

These are given by Mr. G. H. Makins: [3]

External primary hæmorrhage from the great vessels of the limbs or even of the neck proved responsible for a remarkably small proportion of the deaths on the battlefield. Only one case of rapid death due to bleeding from a limb artery was recounted to Mr. Makins. In this a wound of the first part of the axillary artery proved fatal in the twenty minutes occupied by the removal of the patient to the dressing station. With regard to the treatment of primary hæmorrhage

probably, further cut off the blood-supply through one of the most important collaterals, viz. the superior profunda (p. 150).

[1] *Med. Chir. Trans.*, vol. lxix. p. 157.

[2] Reference may be made to an interesting cure of a wound of the axillary artery by a pistol bullet recorded by Dr. F. W. Murray (*Ann. of Surg.*, 1909, vol. l, p. 448). The first part of the artery was ligatured and the patient made an excellent recovery.

[3] *Surgical Experiences in South Africa*, 1899-1900.

while the readiness with which spontaneous cessation of hæmorrhage from small calibre wounds was secured was very marked, the frequency with which traumatic aneurysms of every variety followed shows that the ultimate result is in many such cases by no means satisfactory. "Under the circumstances it may be said that the classical rule of ligation at the point of injury should never be disregarded. Against this, however, certain objections may be at once raised; thus in many cases both artery and vein need ligature, a consideration of much importance in the case of such vessels as the carotid and femoral arteries. . . . On the whole it seems clear that the military surgeon must be guided by circumstances, since it may be far better to risk the chances of recurrent hæmorrhage or the development of an aneurysm or a varix, than those of gangrene of a limb, or softening of the brain. As a general rule, therefore, on the field or in a field-hospital, primary ligature of the great vessel is best reserved for those cases only in which hæmorrhage persists, while in those in which spontaneous cessation has occurred, or in which bleeding is readily controlled by pressure, rest and an expectant attitude are to be preferred."

Secondary hæmorrhage in simple wounds by small calibre bullets was decidedly rare: in compound fractures, especially of the "explosive" kind, it was not uncommon. Lesions of vessels short of perforation, but causing devitalization of the walls, perforation by a sharp spicule of bone, and, in the large majority, sepsis and suppuration were the chief causes. The treatment to be adopted depends on the nature of the case. When the wound is aseptic and bleeding, the result of separation of sloughs (this was found to be very tardy in aseptic wounds), local ligature is the proper treatment. In septic cases, on the other hand, it is usually far better to amputate, unless the general state of the patient and the local conditions are especially favourable. When neither amputation nor local ligature is practicable, proximal ligature may be of use. Thus one case is given in which ligature of the common carotid was successful for hæmorrhage from an arterial hæmatoma in connection with the internal maxillary artery.

Traumatic aneurysms. The experience of the campaign fully bears out that of the past as to the steady increase of the number of aneurysms from gunshot wounds in direct ratio to diminution in the size of the projectiles employed. Every variety was met with, and most frequently of all, perhaps, aneurysmal varices and varicose aneurysms. The following are instances of traumatic aneurysms of this region.

False traumatic aneurysms or aneurysmal hæmatoma of the axillary artery. Entrance wound in posterior fold of axilla, exit one and a half inches below the junction of the anterior fold with the arm. The man rode four miles after being hit, but the horse then fell and rolled over him twice. The wound healed, but the whole upper arm was swollen and discoloured, while an indurated mass extended along the vessels into the axilla. This was not obviously distensile, and pulsation was very slight. The pulses below were absent. A fluctuating swelling was present along the anterior border of the deltoid. Tactile anæsthesia existed in the area of the median nerve. On the thirty-first day considerable enlargement was noticed This, together with continued rise of temperature, aroused suspicion of suppuration, and an exploratory puncture was made by Major Longhead, R.A.M.C., after consultation with Prof. Chiene. Clot escaped, followed by profuse hæmorrhage. The incision was enlarged, while compression of the third part of the subclavian was maintained, and an oval wound half an inch long was found in the axillary artery. Ligatures were applied above and below the opening between the converging heads of the median nerve. All the swelling disappeared with the healing of the wound, but the diminished median tactile sensation persisted. A somewhat similar case, but one of true traumatic aneurysm, treated by double ligature of third part of the axillary artery, came under Mr. Jacobson's care in the spring of 1902, at Guy's Hospital. The patient had been shot through the inner and upper part of the pectoral region, the wound of exit being in the posterior fold. He received the wound in one of the night attacks on our camps, and his assailant was so close that he killed him by a snapshot with his rifle resting on his thigh. Both wounds healed by first intention, and he was admitted for diminished tactile sensation over the area of the musculo-spiral.

The radial pulse was normal, and there was nothing to call attention to the existence of an aneurysm. A bruit was not, however, listened for. The musculo-spiral nerve, which alone appeared damaged, was explored by an incision along the axillary vessels, with partial division of the great pectoral. No damage could be found in the course of the nerve, but, as it was traced upwards, a small ovoid sac of a traumatic aneurysm was found between the two heads of the median nerve. Ligatures were placed above and below, the aneurysm opened, and some

old clot turned out. Owing to the intimate association of the nerve it seemed wiser not to try and remove the aneurysm. It was hoped that any pressure which the aneurysm might be making on the nerve would gradually diminish with the shrinking of the opened sac. This, however, was not realized. When the patient left the hospital there was no evidence of recovery of the diminished tactile sensation over the musculo-spiral area. A very similar case is given by Mr. Makins.[1] The Mauser bullet entered two and a half inches below the acromial end of the right clavicle, and emerged over the ninth rib in the posterior axillary line.

Three weeks later the wound being healed, a large pulsating hæmatoma was noted in the axilla. Signs of injury to the musculo-spiral were also observed. The swelling altering little, Major Burton, R.A.M.C., cut down upon it through the pectorals a fortnight later. The aneurysm was of the third part of the axillary, and a ligature was applied at the lower margin of the pectoralis minor. The wound healed by primary union, and when the man left for England a month later, the musculo-spiral paralysis was improving.

Aneurysmal Varix and Varicose Aneurysm. The frequency with which these occurred and the larger proportion of the latter has already been alluded to. With regard to treatment Mr. Makins (p. 145) warns us that "while modern surgery has lightened the difficulties under which our predecessors approached these operations, none the less the experience of this campaign fully supports the objection to indiscriminate and ill-timed surgical interference, as accidents have followed both direct local and proximal ligature." The following are Mr. Makins's chief conclusions: (1) In aneurysmal varix there should be no interference in the early stage, in the absence of symptoms. "In many cases an expectant attitude may lead to the conviction that no interference is necessary, especially in certain situations where the danger of gangrene has been fully demonstrated. In connection with this subject Mr. Makins relates two cases in which an aneurysmal varix, in one patient of the femoral vessels, in the other of the axillary, had existed for years, and had not interfered with the patient's work. In the second case, after twenty years' existence of the varix, the patient as a combatant in South Africa was subjected to very hard manual work. This brought about increase in size, cervico-brachial neuralgia, &c., and in consequence, the man was invalided. (2) The arteries of the upper extremity are the most suitable for operation, and the axillary may, perhaps, be the vessel in which interference is most likely to be useful. The vessels of the arm and forearm may in almost all cases be interfered with, but in many instances the absence of any serious symptoms renders operation unnecessary. (3) The operation most in favour consists in ligature of the artery above and below the varix, the vein remaining untouched. . . . Failure is due to the presence of collateral branches, which are not easy of detection. Even when the vessels lie exposed, the even distribution of the thrill renders determination of the exact point of communication difficult, and the difficulty is augmented by the temporary arrest of the thrill following the application of a proximal ligature. . . . If the vein cannot be spared, excision of a limited part of both vessels may be preferable, especially in those of the upper extremity." Single ligature or proximal ligature is useless in aneurysmal varix. (4) "Given suitable surroundings and certain diagnosis, the ideal treatment of this condition, as of the next, is preventive—*i.e.* primary ligature of the wounded artery. Many difficulties, however, lie in the way of this beyond mere unsatisfactory surroundings It suffices to mention the two chief: uncertainty as to the vessel wounded, and the necessity of always ligaturing the vein as well as the artery in a limb often dissected up by extravasated blood, to show that this will never be resorted to as a routine treatment."

(5) *Arterio-venous aneurysm.* Many of the above remarks find equal application here, but in the presence of an aneurysmal sac non-intervention is rarely possible or advisable. . .. In the early stages the proper treatment in any case consists in as complete a position of rest as possible, and affording local support to a limb by a splint, preferably a removable plaster of Paris case. Should no further extension, or what is more likely, should contraction and diminution occur, it will be well to continue this treatment for some weeks at least. When the aneurysm has reached a quiescent stage, the question of further treatment arises, and whether this should consist in local interference or proximal ligature. . . . In the case of arterio-venous aneurysms in the limbs the possibilities of treatment are enlarged, and here the alternatives of (*a*) local interference with the sac and direct ligature of the wounded point; (*b*) simple ligature above and below the sac; (*c*) proximal ligature (Hunterian operation) present themselves.

[1] *Loc. supra cit.*, p. 129.

Mr. Makins's opinion is strongly "to the effect that none of these operations should be undertaken before a period of from two to three months after the injury, unless there is evidence of progressive enlargement. In every case which came under my own observation, progressive contraction and consolidation took place up to a certain point under the influence of rest. When this process has become stationary, and the surrounding tissues have regained to a great extent their normal condition, the operations are far easier, and beyond this more likely to be followed by success."

Writing five years later in a paper, in which a later history of several of his cases of arterio-venous aneurysm are given, Mr. Makins, speaking of operative treatment generally, says: "A ligature placed as near as possible above the aneurysmal sac has been shown to be safe, to afford a reasonable prospect of cure, and not to prejudice a further operation, should this become necessary." And with more especial reference to the arteries of the upper extremity, the same authority writes: "My personal experience of published cases shows that a proximal ligature may with safety and a good chance of success be applied to the vessels above the elbow, and for wounds at the elbow itself, this procedure is to be generally preferred. In the midarm a local operation is simple, and in the forearm the same may be said. In either of the latter situations a local is to be preferred to a proximal operation, as more nearly approaching the ideal and necessitating no obvious risks."

LIGATURE OF THE FIRST PART

Collateral circulation (Fig. 86). (*a*) If the artery be tied in its first part, and the ligature be placed above the acromio-thoracic, the vessels concerned will be the same as those which carry on the blood-supply after ligature of the third part of the subclavian (*q.v.*).

(*b*) If the artery be tied in its third part, and the ligature be placed below the circumflex arteries, the anastomosing vessel will be the same as after ligature of the brachial above the superior profunda (*see* p. 173).

(*c*) If the artery be tied in its third part, and the ligature be placed between the subscapular and the circumflex arteries, the chief vessels concerned are:

Above		*Below*
The supra-scapular The acromio-thoracic	with	The posterior circumflex.

(*d*) If in tying the third part of the artery the ligature be placed above the subscapular, the anastomoses are more numerous, viz. in addition to those just given:

Above		*Below*
The supra-scapular The posterior scapular	with	The subscapular.

Operations. Ligature of the first and the third parts of the artery will be first described, and then the old operation.

(1) **Ligature of the first part** (Figs. 93 and 94). This operation is very rarely performed on the living subject. Owing to the depth of the vessel here, its most important and intimate surroundings, and the risk of secondary hæmorrhage from the vessels which lie so close to the knot, ligature of the third part of the subclavian is preferred if ligature be required for axillary aneurysm. On the dead subject the

student should always take the opportunity of tying the first part of the axillary, as it is an excellent test of anatomical knowledge and skill.

Line. From the centre of the clavicle (with the arm drawn from the side) to the inner margin of the coraco-brachialis.

Guide. The above line, the coracoid process, and the inner margin of the coraco-brachialis.

Relations.

In Front

Skin; fasciæ; fibres of platysma. Supra-clavicular nerve.
Pectoralis major with the external anterior thoracic nerve.
Costo-coracoid membrane.
Cephalic vein.
Acromio-thoracic vessels.

Outside		*Inside*
Outer and inner cords of brachial plexus.	Axillary artery first part.	Axillary vein.

Behind

First digitation of serratus magnus.
First intercostal space and muscle.
Posterior thoracic nerve.

Operation. The vessel may be secured in the following ways:

A. *By a curved incision below the clavicle.* This gives the necessary room, but has the disadvantage of dividing the pectoralis major and its large muscular nerve.

B. *By an incision in the interval between the pectoralis major and deltoid.* This method scarcely gives room, especially if the parts are displaced by effused blood, &c., and it is well to supplement the incision in the interval by one partly detaching the pectoralis from the clavicle. While this plan involves less hæmorrhage from the pectoralis major, care must be taken to avoid the cephalic vein and acromio-thoracic branches which lie in this interval. This end is best secured, whichever method be adopted, by going down on the artery as close to the clavicle as possible, the sheath of the subclavian being opened, and some of its fibres detached, if needful.

C. *By an incision in the line of the artery, viz. one three and a half to four inches long, starting from just outside the centre of the clavicle and passing downwards and outwards.* This has the disadvantage of cutting the muscular branches to the pectoralis major, and gives less space than the first two.

A. The limb being at first abducted, the surgeon, standing between it and the body, which is brought to the edge of the table, makes a curved incision, with its convexity downwards and about half an inch from the clavicle, reaching from just outside the sterno-clavicular joint to the coracoid process, the knife being used lightly at the outer end of the incision, so as to avoid wounding the cephalic vein and branches of the acromio-thoracic vessels. The clavicular origin of the pectoralis major is then divided in the whole extent of the wound, and any muscular branches which require it tied or twisted at once. The arm should now be brought down to the side to relax the parts. The cellular tissue beneath the muscle being next explored with the tip of the finger and

director, the upper border of the pectoralis minor is defined, and this muscle drawn downwards. The costo-coracoid membrane must next be most carefully divided in the vertical direction, the acromio-thoracic vessels and the cephalic vein being most scrupulously avoided. The latter forms a useful guide to the position of the axillary vein. The wound all this time must be kept dry, and, if needful, a large laryngeal mirror or an electric head lamp may be usefully employed in throwing light into the bottom of the deep wound. The pulsation of the artery

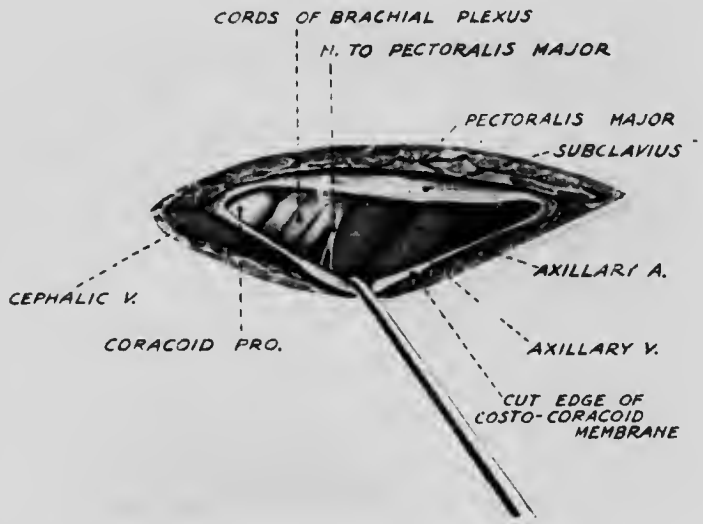


FIG. 95. Ligature of the first part of the right axillary artery.

being felt for in the living, and its flattened cord-like feel made out in the dead subject, the sheath is exposed, and the vessel itself carefully cleaned and separated from the vein, which lies below and in front, and from the brachial cords, which are above the artery. The needle should be passed from below so as to avoid the vein.

B. By an incision made between the pectoralis major and the deltoid. The limb and the surgeon being in the same position as in the operation just given, an incision is made obliquely downwards and outwards between the above muscles, commencing at the clavicle opposite to the coracoid process. Care being taken to avoid the cephalic vein and branches of the acromio-thoracic vessels, the muscles are separated and, to gain more room, a transverse incision is made running inwards along the lower border of the clavicle, and detaching as much as is required of the clavicular origin of the pectoralis major. This flap can be turned inwards and downwards without any interference with the nerve-supply of the muscle, and, owing to its division high up, less hæmorrhage is met with by this method. The deltoid being strongly drawn outwards with a retractor, the upper border of the pectoralis minor is defined, and the operation completed as in the account already given, the parts being relaxed at this stage by abduction of the arm.

(1) **Ligature of the third part of the axillary artery** (Fig. 96). *Line.* From the centre of the clavicle, with the arm in the abducted position, to the inner margin of the coraco-brachialis.

Guide. (1) The above line. (2) A line drawn from the junction of the middle and anterior thirds of the axilla, along the inner border of the coraco-brachialis.

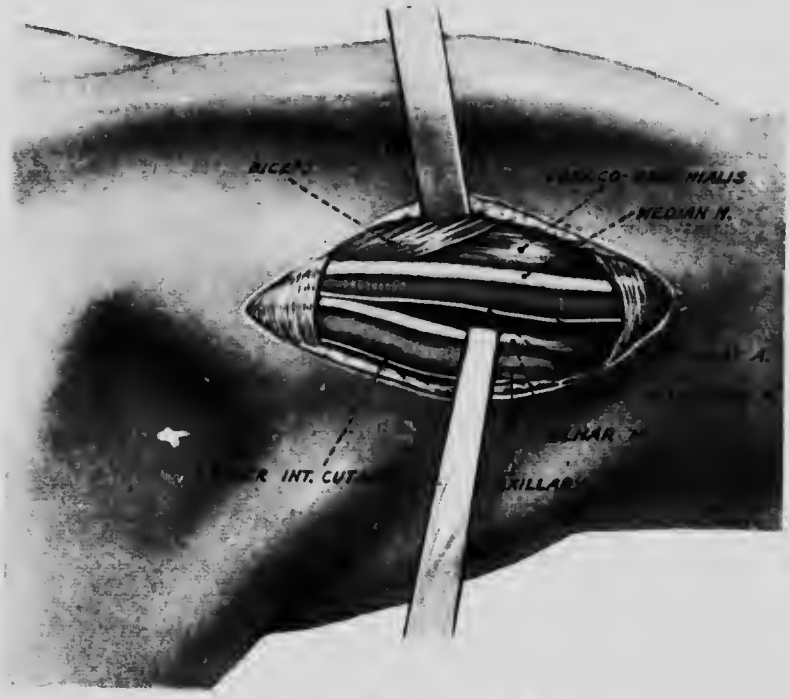


FIG. 96. Ligature of third part of the left axillary artery.

Relations.

In Front

Skin ; fasciæ.
Pectoralis major (at first).

Outside		*Inside*
Musculo-cutaneous, median.	Axillary artery third part	Internal cutaneous ; ulnar.
Inner border of coraco-brachialis.		Axillary vein or venæ comites.

Behind

Subscapularis. Latissimus dorsi. Teres major.
Circumflex nerve. Musculo-spiral.

Operation (Fig. 96). This resembles somewhat that for ligature of the brachial in the middle of the arm. As with the brachial, so with the axillary here ; though the vessel is comparatively superficial, it is not an easy one to hit off at once, owing to the numerous surrounding nerves, which may resemble the artery closely, especially if blood-stained. The axilla having been shaved and thoroughly cleansed,

the arm being extended from the side and rotated slightly outwards (not too forcibly, as this will alter the relations), the surgeon, sitting between the limb and the trunk, makes an incision three inches long at the junction of the anterior and middle thirds of the space along the inner border of the coraco-brachialis (Fig. 96). The incision may be begun above or below, as is most convenient. Skin and fasciæ being divided, and the point of a director used more deeply, the coraco-brachialis is identified, and the axillary vein and the median nerve are distinguished from the artery, the former drawn inwards, and the latter, together with the coraco-brachialis, outwards.[1] The artery is then clearly defined, the sheath opened, and the needle passed from within outwards, the neighbourhood of any large branch, such as the subscapular or the circumflex, being avoided, and the needle being kept very close to the artery. Instead of one axillary vein, two venæ comites and the basilic as well may be present.

(3) **"Old" operation of ligature of the axillary artery ("Operation of Antyllus") for some cases of axillary aneurysm and injured axillary artery.** This method may be called for (1) in the following cases of spontaneous aneurysm (*a*) when pressure is considered undesirable or has failed, (*b*) when, owing to displacement of the clavicle, ligature of the subclavian is not practicable; (*c*) when the condition of the coverings of the aneurysm is such that this step, even if carried out, will not avert suppuration, sloughing, &c. Professor Syme[2] quotes the following case, in which this method was employed.

"I made an incision along the outer edge of the sterno-mastoid through the platysma myoides and fascia of the neck, so as to allow a finger to be pushed down to the situation where the subclavian lies upon the first rib. I then opened the tumour, where a tremendous gush of blood showed that the artery was not effectually compressed; but while I plugged the aperture with my hand, Mr. Lister, who assisted me, by a slight movement of his finger, which had been thrust deeply under the upper edge of the tumour and through the clots contained in it, at length succeeded in getting command of the vessel. I then laid the cavity freely open, and with both hands scooped out nearly seven pounds of coagulated blood. The axillary artery appeared to have been torn across, and as the lower orifice still bled profusely, I tied it in the first instance, next cut through the lesser pectoral muscle close up to the clavicle, and, holding the upper end of the vessel between my finger and thumb, passed an aneurysm-needle so as to apply a ligature about half an inch above the orifice. The extreme elevation of the clavicle, which rendered the artery so inaccessible from above, of course facilitated this procedure from below. Everything went on favourably afterwards."

(2) In many cases of traumatic aneurysm and injury of the artery.

Lieutenant-Colonel Sylvester[3] collected five cases of injury to the axillary artery followed by traumatic aneurysm, treated in this way, all of which recovered. The following is a good example. Wounded at Elandslaagte. Seen at Wynberg fourteen days later. Anterior-posterior wound (Mauser) at upper end of humerus, bone not damaged; no severe hæmorrhage at time of wound. Diffuse aneurysm, occupying axillary space, suddenly formed on twelfth day, and anterior wound began to ooze blood. An incision was made over line of vessel, large quantity of

[1] Farabeuf (*loc. supra cit.*, p. 44) gives the following directions for making sure of the artery. Make an incision running just behind the anterior wall of the axilla. Identify the coraco-brachialis by opening its sheath. Draw it outwards, and with the finger of the left hand sunk in the wound, depress the whole bundle of vessels and nerves. The first cord which escapes upwards, when the finger is withdrawn a little, is free, perforating no muscles: this is the median. Isolate it and have it drawn outwards with the coraco-brachialis. The second large cord, uncovered by withdrawing the first, is the artery.

[2] *Observations in Clin. Surg.*, p. 148.

[3] *Rept. on Surg. Cases in the South African War.*

clot turned out, and wound found in third part of axillary artery. The outer coats of the vessel had been grazed for the space of an inch, and the artery had given way in the middle of this. Vessel ligatured above and below, and divided between. Uninterrupted recovery.

Sir J. Paget and Mr. Callender[1] made a ⊣-shaped incision, cutting parallel with the lower margin of the pectoralis major, and a second, at right angles to the first, straight up through the whole width of the pectoralis major.

Mention may also be made here of that most important accident which has happened to so many surgeons, viz. **rupture of the axillary artery while dislocations of the shoulder are being reduced.**

Körte, of Berlin,[2] is of opinion that in many cases the injury to the artery is caused at the time of the accident, but haemorrhage does not come on till after reduction is brought about, as the vessel is compressed by the head of the bone. As to the exact cause of the injury to the vessel when it takes place at the time of the reduction, it is probable that some condition exists to account for it, *e.g.* atheroma; adhesion of the artery to the head of the bone; too great or misapplied force in reduction, viz. use of the boot in elevation; projection of a fragment or a spicule of bone. It is usually the axillary artery, or one of its branches, which gives way; much more rarely (four out of forty-four cases, the axillary vein.

The following case, under the care of Dr. N. Raw, of Liverpool,[3] teaches a point which may be most valuable in the treatment of these rare but very grave cases, viz. putting a temporary ligature round the axillary artery until it is certain whether both this and the vein have given way.

The patient was aged 45, and, five weeks after a dislocation of the humerus had been reduced, a surgeon had manipulated the arm with his heel in the axilla. The arm began to swell the same night. There was slight pulsation in both radial and ulnar arteries. As the accumulation of symptoms had been gradual, rupture of the axillary vein was diagnosed. The swelling increased, and burst with serious loss of blood. An incision was made from the clavicle to the anterior fold of the axilla, dividing the pectoral muscles. The axillary vessels were ligatured under the clavicle, the artery with a temporary ligature. The incision was then prolonged through to the axilla, down the inner side of the arm to the elbow, and several pounds of clot turned out. The axillary vein was found torn completely across, and was tied at both ends; arterial blood was seen to be flowing, and the subscapular artery was found cut across about one inch from the main trunk, and tied. The temporary ligature was then removed from the first part of the axillary artery, and followed by redness and warmth in the limb, but no pulsation in the radial artery. The patient made an excellent recovery, and, six months later, had a fairly useful limb.

Treatment should be on the lines indicated above, though in some cases, especially in elderly patients, disarticulation at the shoulder joint may be called for.

AMPUTATION AT THE SHOULDER-JOINT

Indications. (1) *Compound comminuted fractures, e.g.* railway and machinery accidents.

(2) *Gunshot injuries.* Amputation here is divided by Dr. Otis[4] into (1) primary, or before the third day; (2) intermediate, or cases in which the operation was performed between the third and the thirtieth days; and (3) secondary, in which the operation was performed later than the thirtieth day.

[1] *St. Bartholomew's Hosp. Reports* vol. ii.
[2] *Arch. f. klin. Chir.*, Bd. xxvii, Heft 3.
[3] *Liverpool Med. Chir. Journ.*, July 1899, p. 328.
[4] *Med. and Surg. Hist. of the War of the Rebellion*, pt. ii, p. 613.

(1) *Primary.* The indications for amputation so soon after the injury are chiefly: (*a*) a limb torn off partially, but too high to admit of any other amputation; (*b*) Severe comminuted fracture of the upper end of the humerus, with extensive injury to the vessels and nerves; (*c*) Such a fracture high up, with severe splintering extending down below the insertions of the pectoralis major and the latissimus dorsi.[1]

(2) *Intermediate.* The mortality here was nearly double that of the primary. This seems to have been brought about largely by the fact that the operation was now performed through soft parts, the seat, at this time, of unhealthy inflammation, and thus prone to lead to secondary hæmorrhage, pyæmia, sloughing, &c.

(3) *Secondary.* The causes for this deferred operation were chiefly hæmorrhage, gangrene, profuse suppuration, hopeless disease of the humerus, sometimes with consecutive implication of the joint, chronic osteo-myelitis, or necrosis of the entire humerus.

(3) *New growths.* If these involve the scapula or its processes the upper extremity should be removed by the method of interscapulo-thoracic amputation (*see* pp. 234 239). The question of the possibility of saving the limb and removing the growth by excision of the head of the humerus is considered at p. 214.

(4) Disease of the shoulder-joint unsuited for, or persisting after failure of, excision.

(5) For osteo-myelitis and necrosis of humerus resisting other treatment or complicated with early blood-poisoning.

(6) For rapidly spreading gangrene or gangrenous cellulitis with threatening septicæmia.

(7) For removal of the upper extremity when painful, œdematous, and heavy owing to pressure on the axillary veins and brachhial plexus by recurrent carcinoma. Here removal of the upper extremity by M. Paul Berger's method (*see* p. 234) is to be preferred. For the advisability of such operations *see* "Removal of the Breast."

(8) Amputation at the shoulder-joint may be called for in the following cases of aneurysm:

A. *In some cases of subclavian aneurysm* where other means have failed are impracticable; where the aneurysm is rapidly increasing; where the pain is constant and agonising; and where the limb is threatening to become gangrenous. While the principle of this operation appears to be physiologically sound, *i.e.* to enable distal ligature to be performed on the face of the stump, and that, by removal of the limb, the amount of blood passing through the aneurysm may be diminished—the results hitherto have not been very successful.

Thus, in Prof. Spence's case[2] a man, aged 33, with a subclavian aneurysm, probably encroaching on the second, if not the first, part of the artery, with excruciating pain and threatening gangrene, amputation at the shoulder-joint was followed by diminution in the pulsation size of the sac, but with little formation of coagula. Death took place for terwards, probably from extension of the aneurysm to the innominate In this case the operation, though it had but little effect in consolida sac, undoubtedly prolonged life, as gangrene was threatening, and the second part of the artery was almost certainly affected, thus rendering the case a most unfavourable one.

B. With the same objects in view, amputation at the shoulder-joint may be required *in some cases of axillary aneurysm* complicated with e: ion of the sac upwards, much elevation of the shoulder, conditions which may render compression or ligature of the subclavian impossible, removal of the limb being additionally called for if agonising pain or threatening gangrene be present.

Prof. Syme[3] briefly alludes to two such successful cases, in one of which gangrene was threatening: "In a case of axillary aneurysm in a gentleman of about 52 years of age, where ligature was prevented by intense inflammation of the arm, rapidly

[1] In some of these the adoption of the Furneaux Jordan method (p. 191) might lead to diminished loss of blood.

[2] *Med. Chir. Trans.*, vol. lii., p. 306.

[3] *Ibid.*, vol. xliii, p. 139.

running on to gangrene. I performed amputation at the shoulder-joint, cutting through the sloughy sides of the aneurysm and tying the artery where it lay within the sac."

C. *In some cases of inflamed axillary aneurysm* threatening suppuration, Sir J. E. Erichsen[1] pointed out that the question of this amputation may arise. As the old operation of opening the sac, turning out the clots, and securing the vessel above and below is impossible, owing to the fact that the coats of the vessel, now softened, will not hold a ligature, two course only are open to the surgeon—viz. ligature of the third part of the subclavian, or amputation at the shoulder-joint. While the former may be followed when the aneurysm is moderate in size and when there is no evidence of threatening gangrene, amputation must be resorted to when less favourable conditions are present.

If haemorrhage occur from an inflamed axillary aneurysm which has ruptured after the subclavian has been already tied, the same writer, of the two courses open—viz. either to open the sac and try and include the bleeding spot between two ligatures, or to amputate at the shoulder-joint—strongly advises the latter.

D. In the words of Sir J. E. Erichsen,[2] "there is another form of axillary aneurysm that requires immediate amputation at the shoulder-joint, whether the subclavian artery have previously been ligatured or not; it is the case of diffuse aneurysm of the armpit, with threatened or actual gangrene of the limb.

Different methods. Of some thirty-six methods which have been described, most will be found to differ in some unimportant detail. Five alone will be given here; they will be found amply sufficient, if modified when needful, for all cases; and of these five, Spence's, for the reasons given below, is the best, and the one with which all operators should be familiar. The circumstances under which this operation is performed do not admit of any one definite method being followed. Thus, after a railway accident or gunshot injury, the soft parts will be destroyed on at least one surface. In amputating for malignant disease, skin flaps must be made use of, transfixion being usually inadmissible, as the muscles should be cut as short and as close as possible to their upper attachments, to minimise the risk of extension and recurrence. Instead of remembering the length and size of differently named flaps, the surgeon will have to be familiar with the anatomy of the parts, the position of the vessels, and the best means of meeting haemorrhage.

The joint is so well covered that sufficient flaps[3] can nearly always be provided, while the blood-supply is so abundant that sloughing very rarely occurs, and even if it does, the tissues of the chest will come forward sufficiently to close the wound. While the cavity of the axilla favours exit of discharges below, the abundance of cellular tissue opened up favours diffuse inflammation and calls for adequate drainage.[4]

The following methods will be described here: in the first two, skin flaps are made; in the others (save in the Furneaux-Jordan method), transfixion is made use of, in part at least. In all cases of doubt, the conditions of the bone and, if needful, that of the vessels and nerves, should be first cleared up by a free incision as if for excision (Figs. 109 and 110, p. 215).

(1) By lateral skin flaps. The oval or *en raquette* method.
(2) Spence's method.
(3) Superior and inferior flaps.

[1] *Surg.*, vol. ii, p. 217. [2] *Loc. supra cit.*, p. 218.

[3] In some cases of gunshot injury it is necessary to get the chief flap from the axillary region, and to bring this up and unite it to the cut margin of the skin over the acromion.

[4] Finally the tendency of the skin to retract when this has been much stretched, as over a large growth, should be remembered.

(4) Superior or deltoid flaps.
(5) Anterior and posterior flaps.
(6) Furneaux-Jordan method.

While the most rapid methods are those of superior and inferior (Figs. 106 and 107), or anterior and posterior flaps, in each case cut by transfixion, these require the presence of an assistant who can be thoroughly relied upon to seize the artery just before it is cut.

Fig. 97.

Where there is time, and where the soft parts admit of it, one of the methods with a vertical incision—*e.g.* Spence's method, the *en raquette*, or that by lateral skin flaps—is far preferable, as (1) it allows of securing the artery before this is cut, thus dispensing with the preliminary pressure on the subclavian, in many cases a difficult procedure, or the seizing of the artery in the flap; (2) of exploring the condition of the head of the bone; (3) one flap can be cut longer, according to the state of the soft parts.

Means of arresting hæmorrhage in amputation at the shoulder-joint. Any of the following may be employed. The first two are by far the best.

(1) *Ligaturing or twisting the vessels on the inner aspect of the limb before they are cut* (Figs. 99 and 102). This method is an excellent one and suitable to all cases. The ligature should be placed as high as possible, so as to get above the circumflex arteries. The surgeon must be careful in the final use of the knife, high up in the axilla, not to prick the artery above his ligature.

(2) *Compression by an assistant of the inferior or anterior flap, and so of the vessels before they are cut* (Figs. 106 and 107).

(3) *Pressure on the subclavian as it crosses the first rib.* Pressure is, however, always liable to be inefficient in short, fat necks; in thin patients, however well applied at first with the thumb aided by a

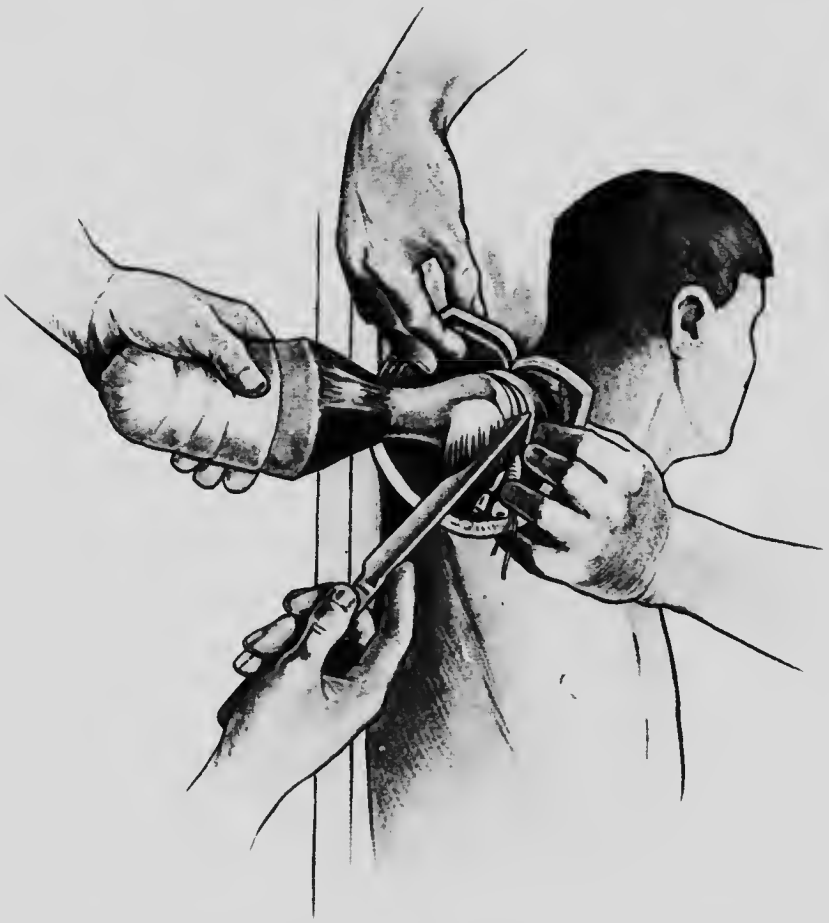


Fig. 98. Disarticulation at the shoulder-joint, the humerus being fractured high up. The operator with his left hand twists the humerus outwards, while, with his right, he divides the capsule and insertion of the scapularis. (Farabeuf.)

padded key or weight, it is too often rendered uncertain by the necessary changes in position of the limb during the operation, a violent gush of blood at the last showing the surgeon that his confidence in the artery being secured is misplaced. Furthermore, an assistant so employed is necessarily much in the way. For the above reasons one of the first two methods is to be preferred.

(4) *Ligature of the subclavian artery.* Circumstances may render this desirable as in a case of Mr. Howard Marsh's, in which he amputated at the shoulder-joint for an enormous "osteo-sarcoma" of the humerus.

(5) *Ligature of the first part of the axillary artery.* This step, originally recommended by Delpech and more recently by Professor Keen, may be used in those cases where a growth has extended high up into the axilla. A free incision between the pectoralis and the deltoid will then give free access to the apex of the axilla, and enable the extent of the growth to be determined.

(6) *Wyeth's method by pins and elastic tubing.* This method will be described in the section dealing with amputation through the hip-joint.

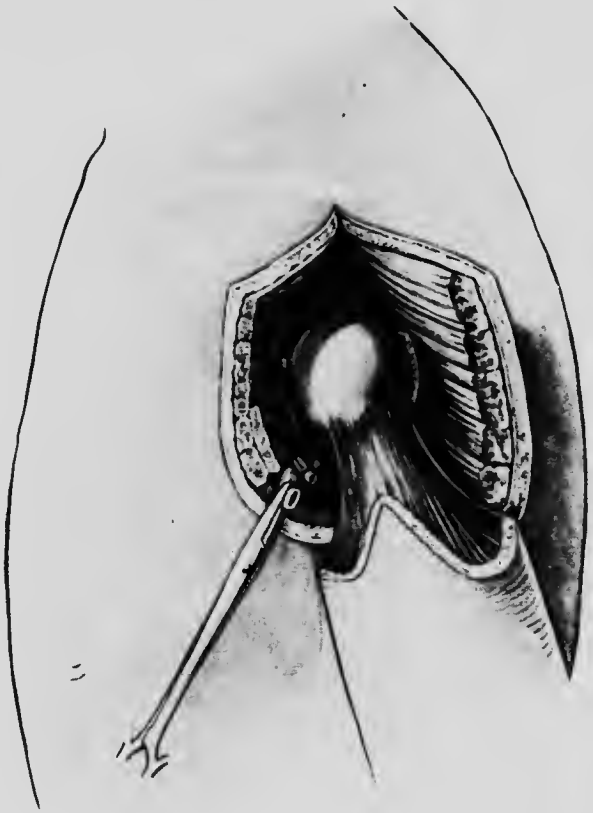


FIG. 99. Amputation at the shoulder-joint by lateral flaps. These are turned aside, while the axillary artery is secured by torsion before disarticulation is completed.

It is not recommended, for, unless the pins are inserted very exactly — not an easy matter in operations of emergency — the tubing may slip.

(7) Securing the vessels lower down, in the Furneaux-Jordan method (*see* p. 209).

(8) *Use of an india-rubber band.* This is applied in the same way as that fully described in "Amputation at the Hip-joint." It is not a reliable method, especially in those cases of accident in which, the limb being mutilated high up, this operation is largely required. For in these the band, being applied under the axilla and across the body,

slips up as soon as the head is disarticulated, allowing of bleeding from the vessels, and coming, itself, most inconveniently, and as a possible source of infection, into the way of the operator.

(1) **Lateral flaps.** The patient having been propped up sufficiently, brought to the edge of the table, and rolled over to the opposite side, the surgeon, standing outside the abducted limb on the right side, and inside it on the left, and having marked out with his left forefinger and thumb a point just below and outside the coracoid process and a corresponding point behind (Fig. 97), then reaches over and, entering

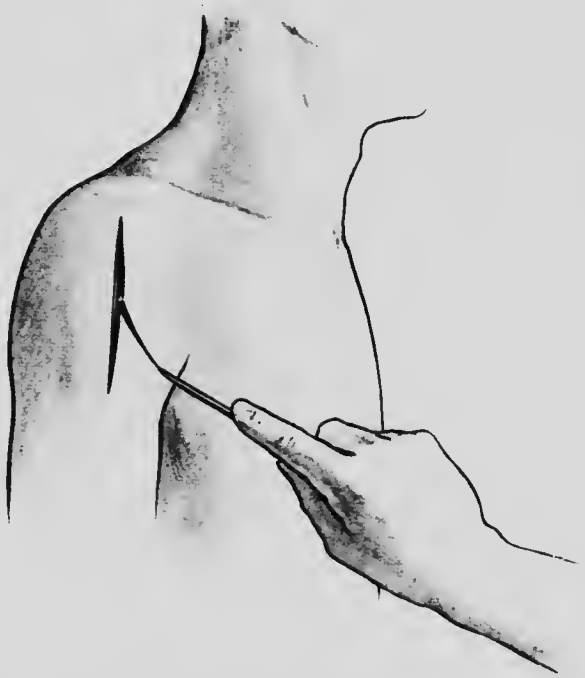


Fig. 100. Amputation at the shoulder-joint by the *en raquette* method.

the knife in the axilla, close to the thumb, cuts an oval flap, about four inches long, consisting of skin and fascia from the side farthest from him, and ending close to his finger. Without removing the knife the surgeon next marks out a similar flap on the other side, cutting from above downwards, commencing just below the finger, and ending where the first flap began in the mid-axilla. The assistant in charge of the limb aids the above by rotating the arm into convenient positions. The flaps are then dissected up and held out of the way. The vessels are next exposed, separated from the surrounding nerves, and secured, either by applying two pairs of Spencer-Wells forceps, dividing the vessel between them and twisting both ends, or by passing an aneurysm needle, threaded with catgut, under the artery, and thus securing it with two ligatures. The limb being then carried across the chest, the outer part of the capsule is freely opened by cutting on the head of the

bone, and the muscles attached to the outer tuberosity thoroughly severed. The limb is next rotated outwards, and the subscapularis tendon severed; the biceps tendon being cut and the capsule freely divided the joint is well opened on the inner side. The head being then dislocated,[1] by an assistant pressing the elbow forwards and against the side, the knife is passed from the outer side behind the dislocated head, and, being kept close to the inner side of the bone, is brought out through the structures on the inner aspect of the arm, care being taken, as the knife cuts its way out that it does so below the point where the large vessels have been secured.

In this or any other amputation here for tuberculous or malignant disease, it will be needful to scrutinise carefully the condition of the parts left, to dissect out any glands, whether enlarged or not, together with the synovial membrane, and in some cases, to remove the glenoid cavity with bone forceps, or preferably a fine sharp saw.

(2) **Method en raquette with preliminary exploration** (Farabeuf) (Figs. 100–103). In this modification the point of the knife having been sunk just below and in front of the tip of the acromion, an incision is made downwards, sufficiently long and deep to admit of exposing the head of the humerus. The condition of the bone is then explored: If amputation is decided on, the above is converted into one *en raquette* by making an oblique incision which passes from about the centre of the longitudinal one (Figs. 100 and 101) across the inner or the outer aspect of the limb (according as it is right or left), and the ends behind on a level with the lower extremity of the longitudinal one. A second exactly symmetrical to the first is next made over the opposite aspect of the limb, beginning where the first ended, and terminating in the longitudinal incision opposite to the first (Fig. 101). The next step is the exposure of the artery by division of the muscles. In the curved inner incision (Fig. 102 are seen the anterior fibres of the deltoid almost blended with the insertion of the great pectoral. This is raised with the finger, and the insertion of the great pectoral detached from the bone. If now the inner flap be folded inwards, the coraco-bicipital fasciculus comes into view. The aponeurosis over it being

Fig. 101. Amputation at the right shoulder-joint by the *en raquette* method.

[1] In any case where the leverage of the humerus is wanting owing to this bone having been broken higher up, the use of lion-forceps will facilitate disarticulation.

opened by a free longitudinal incision, the muscular fasciculus is drawn over the front of the humerus and cut across. If an assistant now thoroughly retract the inner flap the axillary vessels and nerves are exposed. The artery should be isolated and tied as high up as possible, so as to get above the posterior circumflex. The knife being again inserted into the outer oblique incision, the deltoid is boldly cut through as far as the back of the axilla. An assistant retracts the outer and inner flaps, while the surgeon opens the capsule freely, the limb being rotated as directed (*see* p. 203). The head is next thrown out of the socket,

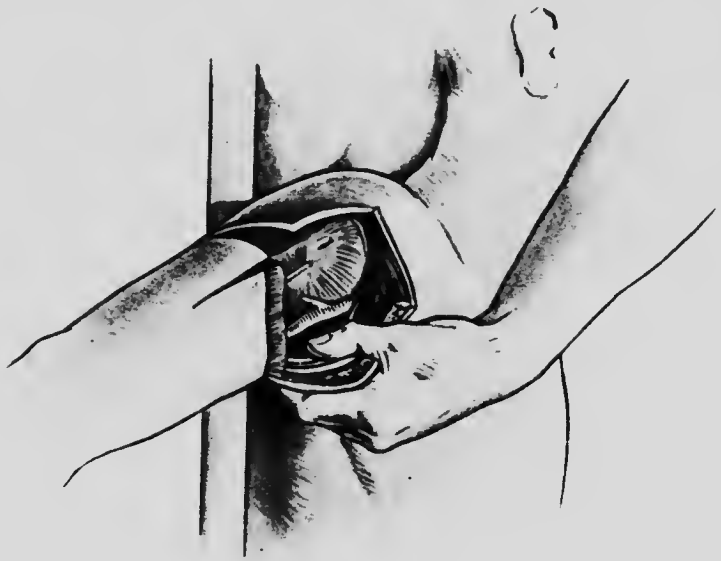


Fig. 102. The anterior fibres of the deltoid, the insertion of the pectoralis major, and the coraco-brachialis and biceps have been cut. The left hand of the operator draws the large nerves downwards, and thus exposes the axillary artery for ligature. (Farabeuf.)

and the knife is carried behind the head, skirting the posterior-internal aspect of the humerus very closely, so as not to cut the secured artery, and finally brought out through the incision on the inner side, severing the latissimus dorsi and teres major. If the artery has not been tied, an assistant secures it between his thumb, sunk deeply into the wound, and his fingers, which are in the axilla, or by using both hands.

(3) **Spence's method** (Fig. 104). This excellent method is strongly recommended on account of its simplicity, and the ease with which the vessels may be secured. It is further especially suited to cases of failed excision,[1] or to cases of injury, *e.g.* gunshot, where the surgeon has to cut into and explore the condition of the joint before deciding on excision or amputation. By its means an excision can readily be

[1] At the present day, in cases of failed excision, the surgeon will often prefer to make use of the modification of the Furneaux-Jordan method (p. 209).

converted into a disarticulation, if this step be found needful. It has other advantages, but less important ones:

(1) The posterior circumflex artery is not divided, except in its small terminal branches in front, whereas, both in the large deltoid flap and the double flap methods, the trunk of the vessel is divided in the early steps of the operation and, retracting, often gives rise to embarrassing hæmorrhage.

(2) The great ease with which disarticulation can be accomplished.

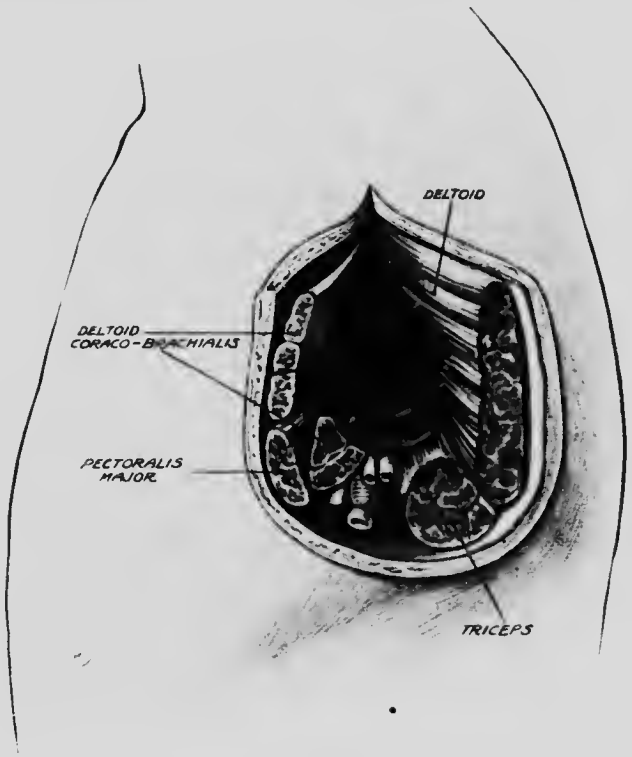


Fig. 103. [illegible]ts composing the flaps made in the *en raquette* method.

(3) The better shape of the stump. Professor Spence pointed out that, however excellent are the results soon after other methods, later on, the shape of the stump is much altered, not merely from the atrophy common to all stumps, but from retraction of the muscular elements of the flaps, the pectoralis major retracting towards the sternum, and the latissimus dorsi and teres major towards the spine and scapula. Thus a deep, ugly hollow results under the acromion.

Fig. 105 shows an instance of this, in a case of amputation of both limbs in a young subject. E. D., age 10, was admitted under Mr. Jacobson's care in Guy's Hospital for a terrible crush of both upper extremities, from his having been run over by a timber-waggon. Amputation was performed at once through the left shoulder-joint by superior and inferior flaps. An attempt was made to save the right limb, but

owing to gangrene setting in, amputation became necessary, and was performed high up through the humerus by Mr. G. A. Wright. The resulting projection of the left acromion from wasting of the muscles was well shown when, nine years later, he was again admitted for a conical and tender stump on the right side, due here to the unbalanced growth of the upper epiphysis. The writing below the figure was done by the lad with his teeth.

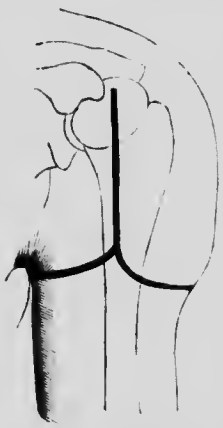


Fig. 104. Amputation at the shoulder-joint by Spence's method. (Stimson.)

(4) Professor Kocher[1] points out that the longitudinal incision in this method has the advantage of being situated in the interval between two muscular groups supplied by different nerves and that muscular atrophy is thus avoided.

The operation is thus described in Professor Spence's words:[2] "Supposing the right arm to be the subject of amputation. The arm being slightly abducted, and the head of the humerus rotated outwards if possible, with a broad strong knife I begin by cutting down upon the head of the humerus, immediately external to the coracoid process, and carry the incision down, through the clavicular fibres of the deltoid and pectoralis major, till I reach the humeral attachment of the latter muscle, which I divide. I then, with a gentle curve, carry the incision across and fairly through the lower fibres of the deltoid towards the posterior border of the axilla, unless the textures be much torn. I next mark out the line of the lower part of the inner section by carrying an incision *through the skin and fat only*, from the point where my straight incision terminated, across the inside of the arm, to meet the incision at the outer part. This ensures accuracy in the line of union, but is not essential. If the fibres of the deltoid have been thoroughly divided in the line of incision, the flap so marked out can be easily separated (by the point of the finger, without further use of the knife) from the bone and joint, together with the trunk of the posterior circumflex, which enters its deep surface, and is drawn upwards and backwards, so as to expose the head and tuberosities. The tendinous insertions of the capsular muscles, the long head of the biceps, and the capsule are next divided by cutting directly on the tuberosities and head of the bone, and the broad scapular tendon especially, being very fully exposed by the incision, can be much more easily and completely divided than in the double flap method. By keeping the large outer flap out of the way by a broad copper spatula or the finger of an assistant, and taking care to keep the edge of the knife close to the bone, as in excision, the trunk of the posterior circumflex is protected. Disarticulation is

Fig. 105.

[1] *Operative Surg.*, p. 376.

[2] *Lancet*, 1867, vol. i. p. 143; and *Lec. on Surg.*, vol. ii, p. 662.

then accomplished, and the limb removed by dividing the remaining soft parts on the axillary aspect. The only vessel which bleeds is the anterior circumflex divided in the first incision, and here, if necessary, a pair of catch-forceps can be placed on it at once. In regard to the axillary vessels, they can either be compressed by an assistant before completing the division of the soft parts on the axillary aspect or, as I often do in cases where it is wished to avoid all risk, by a few touches of the knife, the vessel can be exposed, and then tied and divided between the two ligatures, so as to allow it to retract before dividing the other structures."[1]

Fig. 106.

(4) **Amputation by superior and inferior flaps.** (Figs. 106 and 107.) The patient having been brought to the edge of the table, turned sufficiently over, and his shoulders supported by pillows the assistants are arranged as before. The arm being a little raised so as to relax the deltoid, the surgeon standing inside the limb on the right side and outside it on the left, lifts the deltoid muscle with his left hand, and sends the knife (narrow, strong, and no longer than needful) across beneath the muscle, entering it on the right side, just below the coracoid process, and bringing it out a little below the most prominent part of the acromion[2] or *vice versa*, according to the side operated upon. The knife should pass close to the anatomical neck of the humerus, without hitching upon it, and the flap should be cut broadly rounded, and well down to the insertion of the deltoid. It is then raised and retracted and, the capsule being now exposed, the joint is opened by cutting strongly upon the head of the bone. The arm being now rotated vigorously outwards by an assistant or by the surgeon, the subscapularis,

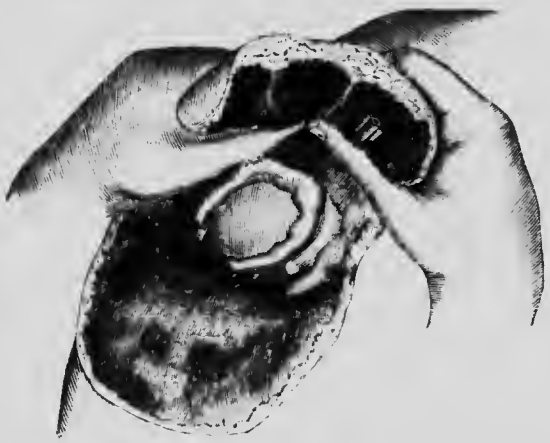


Fig. 107. To show the manner in which bleeding is controlled in the inferior flap; the axillary vessels are compressed by one thumb, the posterior circumflex by the other.

[1] Where the limb is very muscular, Prof. Spence recommended to raise the skin and fat from the deltoid at the lower part, and then to divide the muscular fibres higher up by a second incision, so as to avoid excess of muscular tissue.

[2] Unless care is taken to keep thus below the acromion process there will be some tendency for this bone to protrude in the wound.

thus made tense, and the biceps are brought into view and severed; the limb is next rotated inwards, being carried across the chest, and the muscles attached to the great tuberosity are divided. The capsule is then still more freely opened, and the head of the bone, now freed, is pushed up by the assistant and pulled outwards from the glenoid cavity. The knife is next slipped behind the head (Fig. 106), and cuts its way along the under aspect of the neck and shaft of the humerus, so as to shape an inferior flap half the length of the upper one.[1] As soon as the knife is passed behind the bone, an assistant slips his hands in behind the back of the knife (Fig. 106), following it so as to grasp firmly the soft parts in the inferior flap, and thus control the axillary vessels (Fig. 107).

Fig. 108. Amputation by deltoid flap.

The large vessels are next secured, then the circumflex, and muscular branches that require it; any large nerves that need trimming are then cut short, drainage, if necessary, provided, and the flaps brought into position.

This amputation has the advantage of being very quickly done, and of giving a flap which keeps in position by its own weight, and thus gives good drainage. If the soft parts below the humerus are much damaged, the upper flap must be cut proportionately long.

(5) **Amputation by deltoid or upper flap.** This is merely a modification of the last. The deltoid or upper flap may be cut by transfixion, or made by cutting from without inwards. In either case it must be of very full size, and thus is useful when the axilla is damaged, but it has the disadvantage of leaving next to no flap in which an assistant can seize the axillary vessels; and, owing to the powerful retraction of the muscles in the axillary folds, unless the upper flap is cut full in length and size, it will not cover the resulting wound. Finally, as the trunk of the posterior circumflex is cut, sloughing of the large deltoid flap may take place, especially if the tissues composing it are at all damaged previous to the amputation. Owing to these disadvantages which outweigh its rapidity, this method is not to be recommended, a short under-flap being always cut if possible. When the surgeon, having disarticulated, is cutting straight down, unable to make any flap below, an assistant should try to draw up the skin of the axilla, otherwise, owing to the laxity of the skin in this situation, any downward traction will bring the skin of the thoracic wall under the knife.

(6) **Amputation by anterior and posterior flaps.**

This is only indicated when the soft parts on the front and the inner aspects are damaged. The position of the patient being as advised at p. 307, and the limb being

[1] The surgeon should not cut this till he is told that the flap is held firmly; and, in cutting it, he must be careful of his assistant's fingers.

carried somewhat upwards, backwards, and outwards, the surgeon, standing, if on the left side, behind and outside the shoulder, enters his knife just in front of the posterior fold of the axilla, thrusts it across the back of the humerus as near the head as possible, so as to get in front of the tendons of the teres major and latissimus dorsi, and bringing it out close to the acromion, cuts with a sawing movement, a flap four to five inches long,[1] which is next well retracted. The arm being then carried across the chest, the joint is freely opened behind, the muscles attached to the tuberosities severed, the knife passed between the head and the glenoid cavity (to facilitate this, the limb should now be carried over the chest, and the head of the bone pushed backwards), then between the bone and the pectoralis major, and an anterior flap,[2] four inches long, cut from within outwards. Haemorrhage from the large vessels is arrested either by an assistant grasping this flap as it is cut, much as at p. 207, Fig. 107, or by the surgeon isolating the axillary vessels (the biceps and coraco-brachialis will guide him), and securing them by torsion or ligature (p. 204) before he completes the operation by cutting the anterior flap. When operating on the right limb, the patient being turned well over on to his left side, the surgeon, standing here inside the arm, which is held upwards and backwards so as to relax the deltoid, lifts this muscle up with his left hand, and then passes his knife from just below the acromion, transfixing the base of the deltoid, grazing the back of the humerus, and finally thrusts the point downwards and backwards through the skin till it comes out at the posterior margin of the axilla. This flap, four or five inches long, should be dissected up, the joint opened behind, and the operation completed as before.

(7) **Furneaux-Jordan method.**[3] This may be made use of both as a primary and a secondary amputation. The following are suitable cases:

(*a*) Certain cases of injury. Where, though the parts about the shoulder-joints are intact, the humerus is badly split up into the joint. The soft parts are divided down to the bone by the circular method, three to four inches below the axilla, the main vessels secured, and the humerus then shelled out by a longitudinal incision along the outer and posterior aspect of the limb, meeting the circular one at a right angle.

(*b*) In cases of failed excision. Here, after amputation of the limb by the circular method, the rest of the bone is turned out through the excision wound prolonged into the circular one.

(*c*) After amputation in the middle of the arm in some cases. *E.g.*, when the stump is the seat of osteo-myelitis, necrosis, or otherwise does not do well.

EXCISION OF THE SHOULDER-JOINT (Figs. 109–115)

This operation is but rarely performed: (1) Owing to the comparative infrequency of disease of the above joint, especially of tuberculous disease, which requires operative measures; (2) from the fact that epiphysitis and infective synovitis usually give, after free incision and drainage, as good a result as can be obtained after excision. This is mainly owing to the fact that much of the stiffness that otherwise would be present is made up for by the supplementary mobility of the scapula, especially in young subjects. Generally speaking, the objects of the operation will be for the removal of a tuberculous focus, to improve the mobility of the joint, or in some cases for the relief of pain. The above remarks lead up to the consideration of the amount of movement which is gained after the operation of excision. The arm cannot usually be abducted and elevated beyond the horizontal line; too often it lies close to the chest. Even if the deltoid retained its power of elevation, it could not often exert it, as in most operations, owing to the amount

[1] In the posterior flap will be the posterior part of the deltoid, the latissimus dorsi, and teres major.

[2] In this anterior flap will be the remaining fibres of the deltoid, the pectoralis major, and the large vessels and nerves.

[3] For the details of this method see "Amputation at the Hip-joint."

of bone removed, the fulcrum of the head of the humerus against the glenoid cavity has gone.

Sir J. E. Erichsen[1] spoke of the four chief movements of the shoulder-joint, viz. "(1) abduction and elevation, (2) adduction, (3) and (4) movements in the anterior-posterior direction—these are requisite in all ordinary trades for the guidance of the hand in most of the common occupations of life. The movements of elevation are seldom required save by those who follow climbing occupations, as sailors, masons, &c. Now, the mode of performing the operation, as well as the operation itself, will materially influence these different movements. Thus, if the deltoid be cut completely across, the power of abduction of the arm and of its elevation will be permanently lost. If its fibres be merely split by a longitudinal incision, they may be regained in great part.[2]

"All those movements of rotation, &c., which are dependent on the action of the muscles that are inserted into the tuberosities of the humerus will be permanently lost; for, in all cases of caries of the head of the humerus requiring excision, the surgeon will find it necessary to saw through the bone below the tuberosities—in its surgical, and not its anatomical, neck.[3] Hence the connections of the supra-spinatus and infra-spinatus, the teres minor, and subscapularis will all be separated, and their action on the bone afterwards lost. But those muscles which adduct, and which give the anterior-posterior movements—viz. the coraco-brachialis, the biceps, the pectoralis major, latissimus dorsi, and teres major—will all be preserved in their integrity; and hence it is that the arm, after this excision, is capable of guiding the hand in so great a variety of useful underhanded movements."

Dr. Scudder in a paper on excision of the shoulder-joint,[4] has collected the late results after this operation in nineteen cases, fifteen for injury and four for tuberculous disease. "Following the excision of the upper end of the humerus there will be limited power in the shoulder; a distinct diminution in strength; muscular atrophy; possibly the formation of plaques of new bone about the old joint from detached periosteum. These pieces of new bone may seriously impair the motion. Deformity and pain may follow an excision of the shoulder-joint. . . . After injury the result following an operative reposition or reduction is better always than the result of an excision."

Indications. (1) Different forms of arthritis disorganizing the joint, resisting careful treatment, in subjects whose age, general condition, &c., are satisfactory, viz. (*a*) Tuberculous disease, resisting other treatment and, as in all excisions the stages of advanced caseation, sinuses and mixed infection should be ante-dated. Another reason for early excision here is given by Watson Cheyne and Burghard:[5] "Shoulder-joint disease is very frequently associated with or followed by disease of the lungs; the exact connection of the two is difficult to understand.

[1] *Surgery*, vol. ii, p. 251.

[2] Prof. Longmore (*Resection of the Shoulder-Joint in Military Surgery*, p. 12) writes: "The loss of the elevating power of the deltoid must be accepted, like the loss of the rotating power from the division of the muscular insertions into the two tuberosities, as a necessary consequence of resection of the head of the humerus. But the supporting power of this muscle exerted upon the whole upper extremity owing to its position, its extensive origin, and the manner in which it embraces and protects the mutilated parts, as well as its faculty of assisting in carrying the arm backwards and forwards, are all functions which may still remain, and serve to point to the great importance of preserving its integrity as fully as possible."

[3] This opinion appears to be too definite and inelastic. The reader is referred to the remarks below on the site of section of the bone, and on subperiosteal resection (220).

[4] *Ann. of Surg.*, vol. xlix, p. 696.

[5] *Man. of Surg. Treat.*, vol. iii, p. 237

but it is certainly a clinical fact that a large number of patients suffering from this affection suffer also from phthisis and, in a very considerable proportion, the latter affection only occurs after the joint disease has lasted for some time." (*b*) Disorganization of the joint after rheumatic fever, gonorrhœal arthritis, wrenches, &c., resulting in crippling ankylosis, in a young subject. (*c*) Epiphysitis, or infective arthritis where the long continued suppuration is exhausting the patient, and the outlook as to natural cure is not good.

(2) Gunshot injuries, where the large vessels and nerves have escaped, where fragments of shell, bullets, &c., are lodged in the head of the bone, especially if the shaft of the bone is not much damaged (*see* p. 223).

(3) Compound dislocation and compound fracture with much damage to the capsule and cartilage of the head of the bone, the larger vessels and nerves being intact. In some such cases primary excision is indicated. Generally replacement should be effected after careful cleansing of the damaged parts. Secondary incision may be required for suppuration or necrosis.

(4) Some cases of ankylosis, *e.g.* after acute rheumatic or traumatic arthritis and suppuration. Here the question of operative interference will mainly turn on how far the additional movements of the scapula and humerus together have made up for the ankylosis, and the degree of atrophy of the muscles.

Dr. E. Souchon, of New Orleans, has dealt with this subject.[1]

He considers that operation is only justifiable in recent cases in full-grown subjects or in patients of sufficient age to ensure that the removal of the head of the humerus will not be followed by too great shortening. It is especially indicated in ankylosis following arthritis with a rapid course (dry, acute arthritis), observed sometimes in subjects affected with acute rheumatism, and especially blennorrhagic arthritis; also in cases consecutive to suppurating traumatic arthritis. In these cases the ankylosis occurs before the atrophy of the muscles. The cases of ankylosis which should not be operated upon are—(1) those with a fairly useful limb as it stands, unless there is positive assurance of improving the movements, especially those that are particularly needed for the patient's work; (2) where atrophy of the muscles is present. The application of electricity and massage may be required for some time before it is decided that the operation will be useless. Operation is contra-indicated, especially when the muscles are irretrievably degenerated, as is the case in a great number of old ankyloses, and particularly those following long articular suppuration.

(5) In some cases of unreduced dislocation of the head of the humerus.[2] In such a case there will be serious loss of power and movement, and not infrequently, especially in sub-coracoid dislocations, severe symptoms of pressure on the axillary vessels or the nerves of the brachial plexus. In such a case, if of only a few weeks' duration, an attempt may be made to effect reduction by manipulation or by traction under an anæsthetic; the greatest care must be taken, or the axillary vessels may be injured. If this does not succeed, an open operation should be carried out and every effort be made to replace the bone by leverage and by dividing any structures which hinder reduction. Should this fail excision of the head of the humerus is indicated.

While this operation is one of recent date in England, credit should be given to those surgeons who have practised it, years ago, elsewhere. Cases will be found recorded by Post, of New York, 1861; by Warren, of Baltimore, in 1869. In Germany, Langenbeck, Volkmann, Cramer, Kuster, Kronlein, and others operated for recurrent dislocation and

[1] *Trans. Amer. Surg. Assoc.*, 1896, p. 409.

[2] Reference may be made to a paper by Dr. A. F. Jonas on "Old Irreducible Dislocations of the Shoulder" (*Ann. of Surg.*, 1910, vol. li. p. 890).

old dislocation of the humerus. M. Leon Tripier published a successful case of resection of the head of the humerus, which, fractured as well as dislocated, was pressing on the brachial artery and threatening gangrene. A full bibliography is appended to Dr. Southon's Article, the best on this subject (*vide infra*, p. 213).

Mr. Sheild brought before the Medico-Chirurgical Society[1] a man,

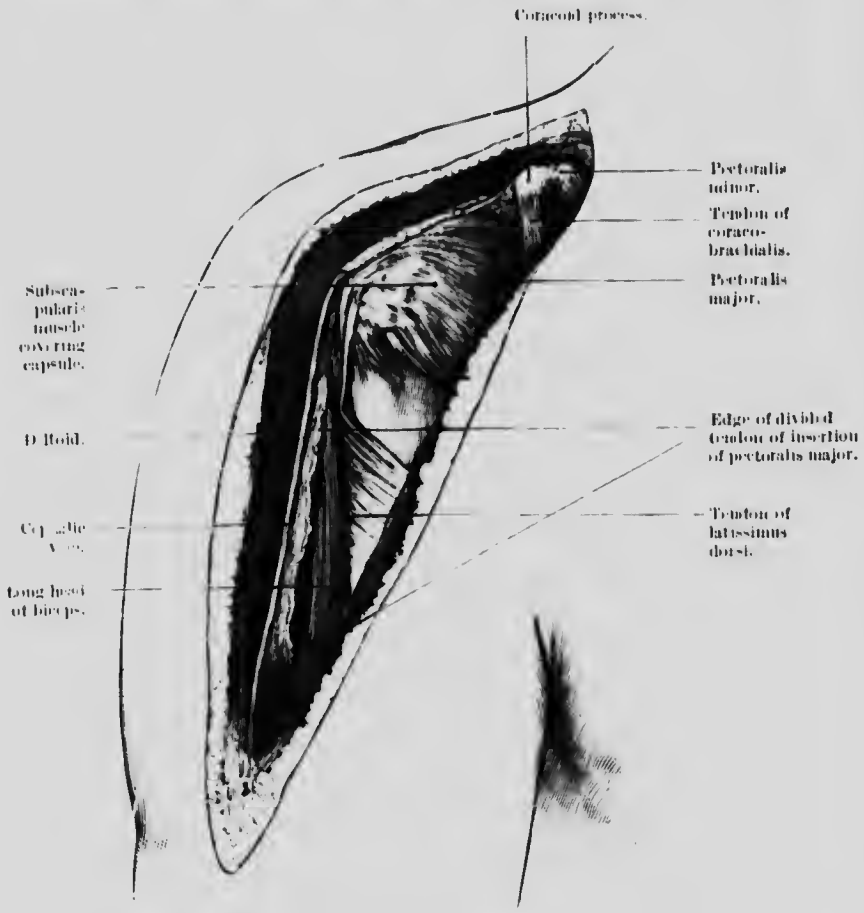


FIG. 103. Field of operation in habitual dislocation of the shoulder. (Burrell.)

aged 45, on whom he had performed excision for a neglected sub-coracoid dislocation of twelve weeks' standing.

Owing to pressure on the median and ulnar nerves, the hand was almost useless. Moderate attempts at reduction having failed, the head was removed through the anatomical neck, this site being chosen in order to disturb the parts as little as need be. The end of the bone was made as like the real head as possible by careful rounding. Twelve weeks afterwards the patient was able to resume work as a waiter. The movements of the shoulder were satisfactory, and the hand gradually regained strength.

Lord Lister published[2] two similar cases treated by operation, but somewhat differently.

[1] *Trans.*, vol. lxxi. 1888, p. 173.

[2] *Brit. Med. Journ.*, 1890, vol. i, p. 1.

Mr. Pearce Gould and Sir W. Watson Cheyne showed cases at the Medical Society.[1]

Reduction was in each case effected after division of the muscles. In one case the range of movement was somewhat defective, and there was a tendency for the head of the humerus to slip forward. But here four months had elapsed between this dislocation and the reduction; it was needful in this case to clear out the glenoid cavity, and the patient failed to attend subsequently.

Mr. Thorburn[2] excised the head of the humerus through the surgical neck, in a case diagnosed as subclavicular dislocation and fracture with irregular formation of callus. He points out that division of tendons would here have been insufficient, as such a deformed head, if even thus reduced, would not have fitted into the glenoid cavity.

Mr. F. C. Wallis published[3] a case in which an instructive condition was found at the operation. The patient had had a dislocation of the shoulder reduced three weeks after the accident. The joint was ankylosed. The muscles of the arm were wasted and paralysed, the movements of the elbow and wrist-joint very limited and the fingers quite stiff. The limb was the seat of neuralgic pains. When the head of the humerus was excised, the cords of the brachial plexus were adherent to the inner side of the bone and required detachment. Massage was begun early. The patient lost all her pain, regained good movements of the shoulder-joint, and could again dress and feed herself. The fingers, remaining stiff, still required her attention.

The most complete contribution on this subject is a paper by Dr. E. Souchon, of New Orleans. "Operative Treatment of Irreducible Dislocations of the Shoulder-Joint, Recent or Old, Simple or Complicated."[4] This elaborate study, based on 154 cases of operation, abounds with those details which are so valuable to surgeons who may have to deal with these occasional but most difficult cases. The following are the chief conclusions of Dr. Souchon:

"The anterior incision is the route. Reduction of the dislocation is the more desirable operation, because it preserves the head and all the movements depending thereon. Reduction should be done only in cases where the head and glenoid cavity are in good condition: when no extensive dissections have to be made; when it is easily effected without any great effort; when the head does not need to be trimmed, or the cup to be too deeply scooped or enlarged; when the head readily remains in place, but not too tightly. All this, regardless of the time of standing of the dislocation. It should, however, always be attempted conscientiously, because many have resected, perhaps, when the dislocation could have been reduced.[5]

Disregard of these rules may lead to necrosis of the head, recurrence of the dislocation, or in ankylosis, with their inevitable consequences. Resection should be practised in all other cases. When in doubt, it is preferable to resect. How much to resect—*i.e.* when to saw through the anatomical neck or obliquely and downward outside the tuberosity, or horizontally on a level with the lower margin of the head—must be determined in each case; it is better to remove too much than too little. Of course, all efforts should be made to secure aseptic results. A most important point is to get primary union."

The following are the chief obstacles to reduction. (1) The capsule may be replaced by a thick fibrous mass. (2) Adhesions of the capsule to the glenoid cavity. (3) Such complete healing of the rent in the capsule as to prevent reduction. (4) Strong adhesions between the new cavity and the neck or head of the humerus. Such bands may be adherent to the vessels and nerves (*see* p. 212). (5) Sclerosis of the muscles, rendering their section necessary. (6) Alteration in the shape of the head of the humerus. Usually several of the above causes combine

[1] *Lancet*, 1892, p. 474.
[2] *Med. Chron.*, vol. xiv, p. 8.
[3] *Clin. Soc. Trans.*, vol. xxxi, p. 291.
[4] *Trans. Amer. Surg. Assoc.*, 1897, p. 311.
[5] In young subjects reduction should always be preferred to resection, and if the latter is employed the epiphysial cartilage should not be injured if possible.

to interfere with reduction or resection. Dr. Souchon shows that amongst the difficulties and complications which may be expected during the operation the chief are: A very thickened capsule or much fibrous tissue about the head of the humerus, necessitating a tedious dissection, with persistent oozing. The head may lie very deep and be adherent to the adjacent parts, *e.g.* the ribs, and the deeper the position the greater the risk of serious hæmorrhage. When thus firmly fixed, the head may be prised into its natural position by elevators, scoops, or blunt scissors, and this failing, division of the bone may be needful, the head being then lifted out by the above-mentioned instruments or loosened with lion-forceps. In other cases it may be wiser to remove it piecemeal. The glenoid cavity may be so filled up as to need refashioning.[1] The vessels and nerves may lie across the head of the bone. In the manipulations needful to get the head into place, the neck of the humerus may give way.

(6) In some cases where dislocation of the head of the humerus is associated with fracture of the upper extremity of the bone, especially through the anatomical neck. In these cases reduction of the dislocation by such an incision as that described at p. 215, combined with wiring or plating of the fracture will be preferable to resection of the fractured head. Occasionally the head is completely separated, or it may become detached during manipulation; under these circumstances it should be removed. Resection may also be called for as a secondary operation if union fails and the joint is stiff. The small size of the upper fragment may render its manipulation a matter of difficulty. To overcome this the upper fragment may be grasped by Peter's bone-forceps or McBurney's traction hook may be employed.

(7) A few cases of growth (*e.g.* exostosis, chondroma, myxochondroma, myeloid growths, and ossifying sarcoma) connected with the upper extremity of the humerus. Whilst the priceless value of the hand fully justifies the attempt in some instances, such cases must be extremely rare.

A well-reported case is one in which the late Sir W. Mitchell Banks[2] endeavoured to save the upper extremity of a patient by excising the upper end of the humerus, the site of a sarcomatous growth originally regarded as a chondroma. After removal in 1878, the growth recurred, and in three years had attained a very large size, filling up the axilla and extending beneath the pectorals. An attempt was made to excise the upper half of the humerus, but owing to the involvement of the brachial vessels and nerves this had to be abandoned and the limb was amputated at the shoulder-joint. Though the shock was severe, the patient recovered and was alive and well two years after the operation.

Mr. Southam[3] has recorded a successful case of resection of the upper end of the right humerus for an endosteal (mixed-cell) sarcoma:

A large deltoid flap was made, and the head and four inches of the shaft of the humerus removed. Six months later, the patient, aged 30, could raise her hand to her mouth, and employ her arm for household work and in using a small sewing machine. Though, with the arm hanging by the side, there was an interval of about four inches between the acromion and upper end of the humerus, the distance could be considerably diminished by the action of the biceps and triceps, and coraco-brachialis. A good illustration accompanies this instructive case

[1] If both the glenoid cavity is refashioned and the head of the humerus resected, and the two are then placed in contact, ankylosis is likely to follow.

[2] *Clinical Notes upon Two Years' Work in the Liverpool Royal Infirmary*, p. 6.

[3] *Med. Chron.*, Jan. 1887, p. 291.

M. Ollier[1] mentions a most interesting case in which, by early intervention, resection of the upper half of the humerus for a sarcoma, central and subperiosteal, saved both the life and the limb of a child, 6½ years old. The growth made its first appearance as a filbert-like swelling close to the insertion of the deltoid. As the swelling increased slowly and resisted treatment, it was explored by M. Heurtaux. The sarcomatous nature of the swelling having been made clear, the upper half of the humerus was removed, this step being thought safer, though the joint itself was not involved. No enlarged glands could be felt in the axilla. Three years later the condition, locally and generally, was excellent. There was no reproduction of the part removed. The resected end terminated in a small osteophytic prolongation joined to the scapula by a fibrous band. The humerus was thus unable to find any steadying point so essential for its movements. The limb was therefore a flail, but a very useful one, thanks to the mobility of the elbow and fingers, and to a supporting apparatus.

FIG. 110. Anterior oblique incision for excision of the shoulder.

Methods. (1) By an anterior incision (Figs. 110–113). (2) By a posterior incision, straight or curved. (3) By a deltoid flap.

The first two only will be referred to at any length here. The third interferes so seriously with the after-power of the deltoid that the indications for its use must be of the rarest.

(1) *By anterior incision.* The patient being rolled a little over and the humerus abducted from the trunk to an angle of 60 or 80 degrees, according to the mobility of the joint, the surgeon, standing at the shoulder facing the body, with an assistant opposite to him, and another seated to manipulate the limb, makes an incision three and a half inches long, commencing at the base of the coracoid process and on a level with it through skin and fasciæ; the interval between the deltoid and great pectoral[2] is then looked for, and opened up for the same length,

[1] *Loc. supra cit.*, t. ii. p. 57.

[2] The advantage of an anterior incision starting from just outside the coracoid instead of from the acromion is that the deep incision is made either in the inter-muscular space or through the anterior fibres of the deltoid. In the latter case all the posterior and outer part of the deltoid (so powerful in abduction) is left intact, together with the circumflex vessels and nerve, with the exception of the terminal filaments going to the anterior part of the muscle, which alone is interfered with. M. Ollier (*loc. supra cit.*) prefers the incision through the anterior part of the deltoid, as owing to the varying width of this muscle the above inter-space does not always correspond to the coracoid process, and because the cephalic vein lies between the muscles. Where the soft parts are much swollen and where the arm cannot be abducted so as to bring the deltoid into relief, the operator must take as his landmarks the position of the coracoid process and the junction of the upper and middle third of the shaft of the humerus, and make his incisions carefully. If the incision in the muscular inter-space does not sufficiently expose the joint, a flap [illegible]

retractors inserted and, if the arm has been rotated outwards, the bicipital groove will usually be seen lying at the bottom of the wound.[1] The condition of this important tendon will vary much: (1) It may be normal; (2) it may be surrounded with tuberculous material; (3) it may be frayed and adherent to the bone; (4) it may be ulcerated or absent.

The bicipital tendon having been identified, the capsule is opened by a free incision, the head examined with the finger, and the incision in the capsule next carried downwards along the bone just outside the bicipital groove to the level at which it is proposed to saw the bone. With a sharp-pointed, curved, periosteal elevator (Fig. 80) the three muscles attached to the greater tuberosity are now carefully detached

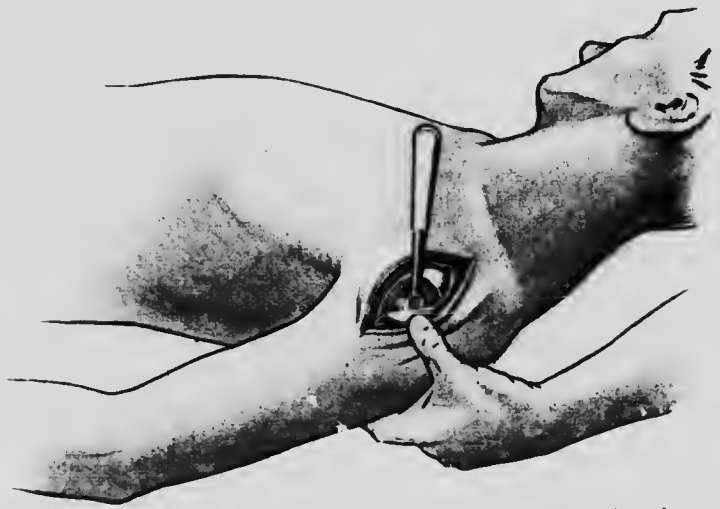


FIG. 111. Separation of the periosteum from the great tuberosity, the arm being turned inwards. (Farabeuf.)

from it. The assistant in charge of the limb, by strenuous rotation inwards, brings each part of the tuberosity in contact with the elevator. The operator next turns his attention to the lesser tuberosity, the limb being now rotated outwards, and separates the attachment of the subscapularis. The left thumb, aided by retractors, protects the soft parts. The biceps tendon and its sheath, if healthy, are detached bodily with the soft parts and the periosteum on the inner aspect of the incision. If diseased the sheath must be opened, and the tuberculous material removed with curved scissors or a curette while the tendon is carefully held aside with a blunt hook or aneurysm-needle. In detaching the tendons, and also, later on, in sawing the bone, if this be done *in situ*, care must be taken, by keeping the arm somewhat separated from the body, and the elbow a little raised, to relax all the parts of the capsule. Unless this be done, the edges of the wound in the capsule are stretched tight.

deltoid may be turned outwards from its insertion, if vigorous retraction of this muscle does not suffice.

[1] Farabeuf advises, to ensure the bicipital groove being found easily, that the arm be kept midway between abduction and adduction, a position secured by placing the hand (the body being horizontal) on the anterior superior spine.

the finger is nipped, and there is no room for working with a saw, knife, or elevator.

The bone may be divided in two ways: (1) *In situ* (Fig. 113). A blunt dissector is passed under the bone from within outwards, so as to protect the soft parts: the bone is completely sawn through with a narrow-bladed or a Gigli's saw (Fig. 127), seized with lion-forceps and twisted out, the levering movements of an elevator, or a few touches with the knife, aiding this. The actual bone section (*see* p. 220) should be made so as to remove the worst of the disease: usually

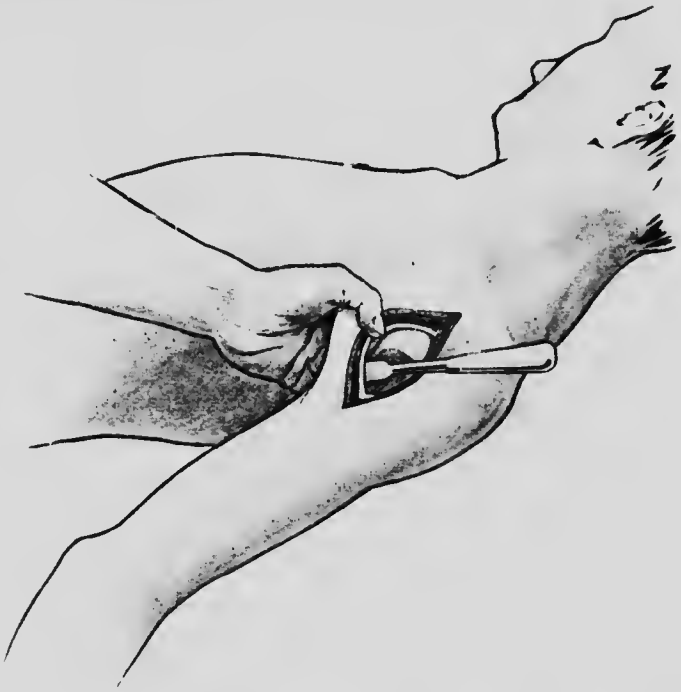


FIG. 112. Separation of the periosteum from the lesser tuberosity, the arm being turned outwards. (Farabeuf.)

it will pass through the tuberosities, any remaining mischief *e.g.* in the tuberosities—being thoroughly dealt with by the gouge. (2) The head is first thrust out of the wound by an assistant, who pushes the elbow upwards and backwards and holds the humerus almost vertical, and then sawn off. This method is certainly the easier, but disturbs the soft parts more. The former is perfectly safe, and inflicts less damage on the surrounding tissues; finally, where ankylosis is present, it may be most difficult to thrust the head out. Sir F. Treves, on the other hand, considered that this method is less precise, that it gives little opportunity of examining the parts fully, and that the tissues around may be damaged by the saw. Whichever plan is adopted, the soft parts should be scrupulously protected. The truncated end of the shaft should be carefully rounded off with a saw or cutting-forceps, especially in the neighbourhood of the nerves, and Mr. Sheild's plan of trying to reproduce the shape of the old head may be adopted.

(2) As tuberculous disease of this joint, which alone is likely to need access to every part, is not common, and as the anterior method by a free incision and the careful use of retractors allows of sufficient exposure of the parts operated upon, this method has hitherto been generally adopted. The excellent results obtainable by **Professor Kocher's posterior curvedincision** (Fig. 115) more than justify a trial of his method. Professor Kocher figures a patient who, after excision of the head of the humerus by the above method, was able to raise the arm vertically by the side of his head. The operation was here performed for fracture through the tuberosities with rotation of the head of the humerus. The skin incision is carried from the acromio-clavicular joint over the top of the shoulder and along the upper border of the acromion to the outer part of the spine of the scapula, and from thence downwards in a curved direction towards the posterior fold of the axilla, ending two fingers'-breadth above it. The upper limb of the incision passes through the superior ligament right into the acromio-clavicular joint (the strong fibres of which are divided), and in the rest of its course divides the insertion of the trapezius along the upper border of the spine of the scapula. The descending limb of the incision divides the dense fascia at the posterior border of the deltoid, and exposes the fibres of the latter. The thumb is now introduced beneath the smooth under-surface of the deltoid, so as to separate it from the deeper muscles (with which it is connected merely by loose cellular tissue) up to its origin from the acromion and its posterior fibres are divided. The finger is now carried along the upper border of the infra-spinatus muscle, so as to free it opposite the outer border of the spine and the root of the acromion. In a similar manner the supra-spinatus is detached with a blunt dissector from the upper border of the spine of the scapula, in order that the finger may be passed from above underneath the root of the acromion. The root of the acromion, which is now freed, is chiselled through obliquely and, along with the deltoid, is forcibly pushed forwards with the thumbs over the head of the humerus. In chiselling through the bone care must be taken not to injure the supra-scapular nerve, which passes under the muscles from the supra-spinous into the infra-spinous fossa: the nerve is also protected by the transverse ligament of the scapula. It is desirable before chiselling the bone to bore the holes required for the subsequent suture. Instead of dividing the root of

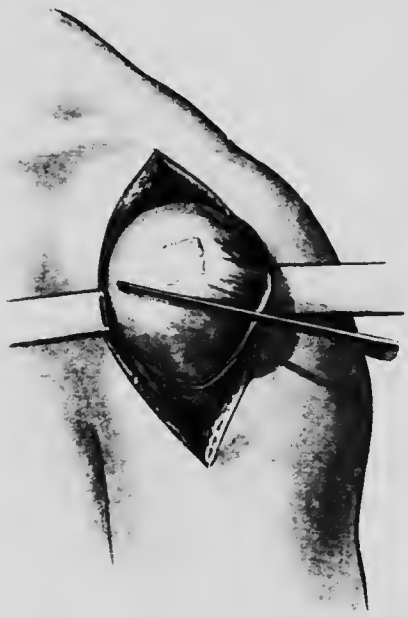


FIG. 113. Excision of shoulder. Section of the bone.

the acromion. the formation of the posterior flap may be simplified by merely detaching the scapular origin of the deltoid subcortically; this allows of a very firm union subsequently. After reflecting the acromio-deltoid flap, the head of thebone is readily accessible in its upper, outer, and posterior aspects, covered by the tendons of the external rotators, viz. the supra-spinatus, infra-spinatus, and teres minor muscles. The posterior surfaces of these muscles are also exposed.

An incision is now made over the head of the bone and, in order to avoid unnecessary injury, this must be done accurately. The arm being rotated outwards, a longitudinal incision is carried down to the bone in the coronal plane. Commencing at the upper part of the lip of the bicipital groove, it extends upwards through the capsule along the anterior edge of the insertions of the external rotator muscles and over the highest part of the head of the humerus, so as to expose the tendon of the biceps as far as its attachment to the upper edge of the glenoid cavity. The insertions of the external rotators are now separated from the greater tuberosity and drawn backwards. The biceps tendon is freed from its groove and drawn forwards, so that its sheath may be inspected. The whole procedure is made easier by carrying the elbow backwards, and at the same time rotating the arm outwards. In this way the entire head of the humerus and the glenoid fossa can be freely exposed and, if it is not necessary to do a complete excision, the anterior wall of the capsule and the insertions of the anterior muscles can be preserved. In other cases the insertion of the subscapularis into the lesser tuberosity is detached upwards and inwards. The circumflex vessels and nerve which come out from under the teres minor can be preserved; indeed, if the operation be properly performed, there need be no fear of injuring them. When the head has been thoroughly cleared, and especially if it be excised, an excellent view of the glenoid cavity is obtained, much better than is possible by the anterior incision; and as it is most important to remove all infected tissues in tuberculous disease, this complete exposure of all parts of the joint is the great advantage of the method. Moreover, this free exposure is obtained without interfering with the function of the deltoid or other muscles of the shoulder. Yet another advantage over the anterior is, that when the disease in the head is limited or absent only the posterior muscles require to be separated, while the anterior part of the capsule, the coraco-humeral band, and the subscapularis muscle are preserved intact,

FIG. 114. The above represents a fair average amount of movement, such as may be expected after incision in children, in whom the securing of adequate active and passive movement is always difficult. The disease was tubercular mischief in the upper epiphysis. Numerous sinuses were present in front and in the axilla.

and in this way there is no tendency of the head of the bone to be displaced upwards towards the coracoid, which so frequently occurs as the result of the anterior operation. The method is, therefore, especially valuable in partial arthrectomies.

(3) **The deltoid flap** gives more room, and thus facilitates the operation considerably, but the larger scar and, far greater, in fact almost total, impairment of deltoid power, are such serious drawbacks that it is, nowadays, hardly ever used. If the head of the humerus is very much shattered, if the soft parts are much matted and thickened, if there is any special reason for completing the operation rapidly, in the rare cases of excision attempted for large growths, for the sake of more complete exposure, this method may, though very seldom, be made use of.

Fig. 115. Kocher's posterior incision for excision of the shoulder.

Site of section of the bone (Fig. 113). It being most important to leave the humerus as long as possible, not an atom more than is needful should be removed. The section should be made just below the articular surface in every case where this will remove the whole of the disease, and where all the head must go. The advantages of sawing here over division through the surgical neck are: (1) A long humerus is left to be brought against the glenoid cavity and aid, as a fulcrum, the action of the deltoid in elevating the arm. (2) The section is made within the capsule, after, of course, freely opening this, but not damaging its attachments to the neck of the bone. (3) The tendon in the bicipital groove is less likely to be interfered with. In every case of excision, save the rare one for new growths, it is advisable to begin by removing as little as possible, then plugging the wound with sterilised gauze to test the freedom in abduction, rotation, &c., of the humerus and only to resort to further removal of bone if mobility is much restricted.

The late Mr. J. N. Davies-Colley has related[1] a case of partial resection followed by unimpaired movement of the joint.

As, at the time of the operation, a portion of the head of the humerus seemed healthy, and the disease consisted chiefly of a carious erosion of the great tuberosity and the adjacent portion of the articular surface, these portions only were removed, without dislocating the head of the bone. The part removed was chiefly the articular surface above the greater tuberosity, together with what remained of that process. The lesser tuberosity appears not to have been touched. About three-fifths of the articular surface was left, being healthy. There was some erosion of the

[1] *Guy's Hosp. Rep.*, third series, vol. xx, p. 525.

bone below the epiphysial line, but the greater part of the disease was situated in the epiphysis. The section of the bone was hard. Seven months later the movement of the joint "was perfect in every direction. He swings the arm round above his head, and rotates it and performs every action with as great freedom and rapidity as with the left shoulder-joint."

If the disease extends lower down, gouging may be resorted to or if needful one or two further sections may be made till healthy tissue is reached, but as in the case of the elbow, periosteal deposits or roughenings, which will subside when the irritation is removed, must not be mistaken for disease which calls for extirpation.

The glenoid cavity is then examined and gouged, or its cartilage peeled off with a blunt knife, if carious. Cases where its complete removal is called for must be most rare. If really called for, it may be effected by an osteotome, fine sharp saw, or cutting bone-forceps, after the glenoid insertion of the capsule has been peeled off to a sufficiently high level; but taking away the glenoid cavity must interfere with attachments of the biceps and triceps, and cause risk by the opening up of additional cancellous tissue.

The above operation must be somewhat modified in cases of ankylosis and new growths. In cases of bony ankylosis the operator may adopt one of the two following courses: he may divide with a chisel or gouge the line of fusion and then, the humerus being movable on the scapula, complete the operation on the lines already given; or, having sawn through the humerus *in situ*, he may seize the bone with lion-forceps, or drill a hole and insert McBurney's hook, and strip it out of its periosteo-capsular covering. Much care must be taken to put the humerus freely through its different movements before it is decided that sufficient bone has been removed,[1] lest ankylosis recur.

In those rare cases of resection of the upper end of the humerus for new growths (*see* p. 214), the operation must be outside the periosteum, and the vessels and nerves will require additional attention. More room will be required now and, to gain this, the pectoralis major and deltoid may each be detached from the clavicle. The shoulder-joint itself is very rarely invaded by the growth. Owing to the free removal of the humerus, which is necessary, the after-result is often imperfect, though, if the insertion of the deltoid can be preserved, the limb will still be very useful.

Any vessels which require it, *e.g.* branches of the circumflex arteries, are then secured, sinuses are laid open, tuberculous tissue, any remnants of diseased capsule and synovial membrane removed, and the subdeltoid bursa, if involved, dissected out, drainage provided, and the upper part of the wound closed. The drainage-tube should pass from the lowest part of the wound in front (whether this be within or below the capsule), by means of a counter-puncture, to the back of the upper arm, so that the site of the operation may be well drained while the patient is recumbent. In making the counter-puncture, from within outwards, the close contiguity of the circumflex vessels and nerve must be remembered.[2]

Where excision has been performed for tuberculous disease, with sinuses, iodoform emulsion, and small tampons of iodoform gauze, which

[1] In young subjects the epiphysial cartilage must be left undamaged, if possible.

[2] At least two cases of fatal injury to the circumflex artery have been recorded. One is given by Gurlt (*Obs.*, 175, p. 750), the other by Prof. Annandale (*Med. Times and Gaz.*, May 29, 1875).

has been kept in a solution of carbolic acid (1 in 20) or lysol (2 per cent.) will be employed. At other times, where the tissues are healthy, the above tampons will be much less needed, and the wound may be sutured in the upper part. In every case a triangular pad of sterilized gauze, three or four inches thick at its base, should be placed in the axilla, and the arm carefully secured to the side, the elbow being kept a little forward, and comfortably kept away from the thorax by a sufficiently thick layer of salicylic wool. The first dressing should not be changed for five or six days if possible, especially in children. After the first dressing the limb should not be fastened to the side, the forearm only being supported in a sling. The tendency to displacement forwards must be met by a firm pad over the front of the joint. The axillary pad is of the greatest importance and should be worn for six weeks. Otherwise, a limb fixed to the side is almost certain. Where the parts are lax, as in old tuberculous disease, the necessary interference with the bone, attachments of tendons, &c., has been extensive, less liberty must be given, or the new joint will be too loose. While the fingers and elbow-joint must be gently exercised daily from the very first, the date of commencing movements of the shoulder-joint will depend on the lesion for which the operation was performed, and the condition of the parts around. Where these are healthy, when but little bone has been removed, where it is probable that new bone will be quickly reproduced, the date must be an early one. As a general rule it is of no use to begin before the deep parts of the wound are sufficiently healed; and this should be some time between the second and third weeks. The chief points to pay attention to are: (1) Care in carrying out abduction, lest the new head of the bone be lodged close to the coracoid process instead of in the glenoid cavity; (2) massage and electricity to the muscles, especially the deltoid and the muscles attached to the tuberosities; (3) exercise of the rotator muscles; (4) making the patient carry out the movements of his humerus independently of those of the scapula—an end very difficult to ensure in the case of a child or in cases where the ankylosis has long existed. The above must be daily and assiduously carried out, with the occasional aid of an anæsthetic if needful. The practice of such movements as bringing a gun up to the shoulder, sweeping with a short brush, lifting and carrying light weights with the limb abducted, are valuable aids.

Question of subperiosteal resection. As one of the chief drawbacks of the operation is the poor amount of abduction and elevation which remains owing, in large measure, to the humerus being too short to be brought into the glenoid cavity when the deltoid acts, it may be strongly urged that in this joint a trial of the subperiosteal method should be carefully made, to ensure as much reproduction of bone as possible. Von Langenbeck[1] gives more than one case in which the arm could be raised vertically, and the movements were excellent. While it is true that these were cases of resection for gunshot injury, and therefore the patients probably healthy adults, on the other hand preservation of the periosteum is not likely to be so easily effected here as in those cases where it is softened by disease. Even if the periosteum cannot be completely preserved, an additional half inch or inch in length gained, and an irregular knob or nodule-like mass which may be moulded into a rudimentary head within the new

[1] *Arch. f. klin. Chir.*, 1874, vol. xvi.

capsule, may make much difference in the future mobility and usefulness of the limb. M. Ollier[1] figures and describes a specimen of a resected humerus nine years after the operation.

The patient, æt. 26, had had mischief in the joint for three years, with, latterly, suppuration and live fistulæ. Five centimetres of the humerus, measured from the summit of the head, were removed. After the operation he was able to follow his work as a hawker, and to use both arms equally well in lifting weights. The upper end of the humerus was irregularly expanded, showing numerous bosses and depressions into which the insertion of the capsule and different muscles could be followed.

Treatment of gunshot injuries of the shoulder-joint. Lieutenant-Colonel Hickson, R.A.M.C.,[2] writes:

"From the small number of reported cases, wounds of this joint seem to be relatively rare. Only twenty-seven cases have been noted, of which nine were perforations and eighteen comminutions or fissures of various degrees of severity. Of the nine perforations all were aseptic, and of the eighteen comminutions sixteen were septic, one was aseptic, and the remaining one, in which a primary amputation proved fatal, has been classed as doubtful.

(1) *Perforations.* As in other joints, the issue of pure perforations was most favourable. Eight of these cases recovered without any operative measures being necessary, the treatment consisting of antiseptic dressings, with rest; they remained aseptic throughout. Incision for the extraction of a retained bullet in the dorsal region was required in one case of perforation; in this case also sepsis did not occur.

(2) *Comminuted Fractures.* These resulted either from serious fractures of the upper end of the diaphysis of the humerus with fissures extending into the joint, or from the impact of the larger-bore bullets, such as the Martini-Henry, from expanding bullets, or from fragments of shell. The very destructive nature of some of the injuries of this type will be seen from the fact that in sixteen of the eighteen cases of this description of wounds, operative interference was called for. Thus, in three cases recovery followed the removal of fragments; in eight, excision of the shattered head of the humerus was successfully carried out; in four, amputation at the shoulder-joint was required, one of which died, and in one Berger's interscapulo-thoracic amputation was successfully performed. The two remaining cases which recovered without any operative measures were the two examples of aseptic comminutions. It will be seen from the above analysis that either partial or complete excision of, or amputation at, the shoulder-joint was carried out in sixteen septic comminutions out of a total of eighteen such wounds, or in nearly one-half of the total number of reported cases of every variety."[3]

The following advice of Professor Ollier as to the treatment of gunshot and other injuries of the shoulder-joint will be found most useful.

If the head only be fractured, and not in more than two or three fragments, and if these are held together and not widely separated he would trust to antisepsis. If suppuration occurred, he would advise resection; and he points out that a deferred excision has one advantage, *i.e.* that time may have elapsed for inflammation of the periosteum to have occurred, and thus its osteogenetic properties may be aroused. If the head of the humerus be badly shattered, and the fragments much separated from each other and from their periosteum, he would perform a primary excision, endeavouring to reshape the extremity into a new head. If the splintering and damage to the bone does not affect more than three or four

[1] *Loc. supra cit.*, t. i. p. 35, t. ii. p. 85.

[2] *Rept. of Surg. Cases noted in the South African War.*

[3] Mr. G. H. Makins (*Surg. Experiences in South Africa*, 1899-1900, p. 236) gives the following experience of the results of small bullets of high velocity: "Wounds of this articulation were by no means common. This depended, I think, on two points in the architecture of the joint: first, a bullet to enter the front of the cavity and transverse the joint needed to come with a great exactitude from the immediate front; secondly, wounds received from a purely lateral direction calculated to pierce the head of the humerus and the glenoid cavity were naturally of very rare occurrence. Wounds of the prominent tip of the shoulder received while the men were in the prone position were not uncommon, but it was remarkable how rarely the shoulder-joint was implicated in these.

centimetres of it, all the damaged bone may be resected; but if the mischief extends lower down, some risk must be run and the injured bone left.

And his course would be the same in the case of a compound fracture of the neck of the humerus with dislocation. If part of the head had escaped splintering, he would leave this attached to the shaft. Removal of splinters Prof. Ollier directs to be done with the greatest care of the periosteum, every atom of this being left in the wound. While bullet-wounds may be used for drainage, it is rarely well to enlarge them or to throw one into another so as to employ them as the operation wound; this should be made in the usual place. With regard to the comparative value of primary and later excision, Prof. Ollier allows that bone production is less likely in the former owing to the periosteum being uninflamed and more difficult to save. On the other hand, he points out that, as yet, we scarcely know what antiseptic precautions are. The use of proper periosteal elevators will effect. Moreover, in primary resection for gunshot injuries the patients are usually young adults, and their muscles in excellent order.

In the case of gunshot and other injuries in which the damage is not limited to the head and surgical neck of the humerus, but splinters the upper half or three-quarters of the humerus, resection is still urged by Prof. Ollier (*vide supra*) as long as the soft parts are sufficiently sound to survive. Though the function of a limb thus preserved will be very imperfect, the result will be far superior to that of amputation at the shoulder-joint. In any such resection the antiseptic precautions should be as complete as possible, and any long splinters, which, however much the bone be shattered, preserve their relation to the periosteum should be left, as, with the aid of the bone production of the periosteum around them, they will maintain the continuity of the bony column.

Recurrent dislocation of the shoulder. Dr. Burrell and Dr. Lovett, of Boston, have contributed a paper on this subject, with six cases, two of which were operated upon, with an excellent result in each case.[1] Amongst the pathological conditions, which vary widely, these writers consider the following to be established:

(1) Laxity of the capsule; (2) Tearing away of the capsule from the glenoid cavity; (3) and 4) Partial fracture of the head of the humerus or the glenoid cavity; (5) Tearing away of muscular insertions, or rupture of the biceps tendon; (6) Altered shape of the head of the humerus, probably the result of chronic inflammation.

The following are the chief steps of the operation performed by Dr. Burrell in the two cases referred to above. Where a trial of primary fixation for a few weeks, combined with massage of the muscles, followed by careful movements of the joint, fails after ten weeks, partial resection and suture of the capsule[2] is recommended, unless any abnormalities be found which require removal of the head of the humerus. A free incision having been made in the pectoro-deltoid interval, the cephalic vein drawn aside, the coraco-brachialis and biceps are recognised in the upper and the pectoralis major in the lower part of the wound. Division of the upper three-quarters of the insertion of the latter muscle is recommended so as to expose thoroughly the head and neck of the bone. The long tendon of the biceps will be seen and felt through its sheath. The incision should be carried in its whole depth up to the coracoid process, and the tendons of the biceps and coraco-brachialis cleared up to this point. By rotating the head outwards and dropping it backwards, the insertion of the subscapularis is stretched over the bone. A portion of this insertion should be divided. The arm is next abducted, raised to a horizontal position, and the head of the bone pressed backwards so as to prevent its coming up under the coracoid process, which it tends to do in these cases,[3] and also to relax the front of the capsule. If the joint appear normal the loose part of this ligament is then grasped with vulsellum forceps, and a fold three-quarters of an inch in length and three-eighths of an inch wide excised. The gap is then sutured, rendering the capsule distinctly tighter and shorter.

Mr. Southam[4] published a case in which he had excised the shoulder-joint for a frequently recurring dislocation in a woman, aged 45,

[1] *Trans. Amer. Surg. Assoc.*, 1897, p. 293.

[2] The credit of first taking this step is due to Dr. Gerster, of New York.

[3] Two details in the operative and after-treatment intended to meet this displacement are given at pp. 219, 222.

[4] *Brit. Med. Journ.*, 1892, vol. ii, p. 1193.

Nothing abnormal, beyond slight grating, could be detected on examination, but under anæsthesia, a sub-coracoid dislocation could be readily produced, and as readily reduced.

At the operation a small part of the anterior rim of the glenoid cavity was absent. The head of the humerus was sawn through the anatomical neck; gentle passive movements were begun three weeks after the operation, and, twelve months later, there had been no recurrence of the dislocation. The arm was then very useful, with good movements, the patient being able to perform her ordinary household duties.

Operative treatment of simple fractures of the upper extremity of the humerus. In these injuries, especially fractures of the surgical neck and through or of the tuberosities, it may, owing to the small size of the upper fragment, be impossible to secure good position by manipulation. Owing to the proximity of the articular surface, which may itself be involved, any excess of callus is likely seriously to impair the mobility of the joint. Under these circumstances, if the age and general condition of the patient are satisfactory, the joint should be opened by an anterior incision similar to that above described, the fragments manipulated into position and secured by a plate or sutured by silver wire. The arm must be bandaged to the chest to immobilise the joint. Massage and passive movements are commenced on the tenth day when the stitches are removed. Needless to say, a careful consideration of radiograms should be made before operative measures are decided upon. Reference should be made to the remarks on p. 213 on the advantages of reposition over excision.

In fractures of the great tuberosity the small fragment will be displaced backwards and rotated outwards while the shaft of the humerus is rotated inwards. Satisfactory union is very unlikely to occur with splints or by fixing the arm in a position of external rotation. An incision should be made over the tuberosity which is then fixed in position by a screw or peg.

Operative treatment of separation of the upper epiphysis of the humerus. This is often a difficult lesion to treat. Under certain circumstances operative treatment, with the safety that modern precautions, duly carried out, give nowadays, should be resorted to. We may divide the cases that call for it into the following groups: A. Cases of simple injury. B. Cases of compound injury.

A. *Simple.* These may be further divided into: (*a*) Those of recent date. (*b*) Those of longer standing.

(*a*) *Simple cases of separation of recent date.* Here interference is justified when there is very great difficulty in effecting reduction owing to complete separation of the two parts, aided by the rotation of the epiphysis and the very small size of the upper fragment. Mr. Poland, in his "Traumatic Separation of Epiphyses" (p. 226), states that "one of the chief difficulties in reduction occurs from the insertion between the fragments of bands of periosteum, fascia, or muscle, or from the penetration of the periosteal sheath by the diaphyseal end." Other cases are those where, if the displacement is corrected, there is much difficulty in maintaining the reduction, when a sharp portion of the lower fragment, having penetrated the deltoid, projecting under the skin, and where there is evidence of pressure the vessels and nerves.

The operation should be performed on some such lines as these. An incision is made freely in the interval between the pectoral and

deltoid; the cephalic vein is drawn aside or tied between double ligatures. The soft parts having been widely retracted, the ends of the two fragments are next identified and examined, any rent in the periosteum being carefully enlarged if needful. It will now be found possible, in some cases, to replace the fragments in position, and then, owing to the conical shape of the epiphysis, fixation by plate or wire will not be necessary. The edges of the rent in the periosteum and capsule should be carefully sutured, and it may be well at the same time to close any opened-up periarticular planes of connective tissue. It may be needful, when the fragments cannot otherwise be brought into position, to remove any projection from the lower fragment. If there is any difficulty in retaining the fragments in position it will be best to wire them together.

In those cases where the epiphysis is not only separated, but dislocated owing to the severity of the injury having lacerated the capsule freely, Poland[1] advises as follows: "Seeing that it is almost impossible to reduce the head of the bone in these extremely rare cases, an incision should be made through the skin and deltoid down to the seat of separation, and the epiphysis replaced in position. It will be found necessary to open the capsule of the shoulder-joint before the epiphysis can be reduced. This should be accomplished by direct manipulation of the head into its place by pressure of the thumb and fingers, or by means of a traction hook inserted into a hole drilled in it after the method advocated by McBurney. The fragments should then be fastened together in their normal position by means of pegs or sutures."

(2) *Cases of older date.* Here, where some weeks or months have elapsed, interference may be called for, owing to the limitation of movement, especially as regards abduction, elevation, and rotation, brought about by the overlapping of the fragments, their union in a faulty position, and the projecting callus. Here, after exposure of the seat of union, and free retraction of the soft parts, the surgeon will have to follow the advice of M. C. Walther,[2] and then decide between the necessity of completely resecting the callus in order to place the fragments absolutely in position, or to freely remove any projecting ends of the diaphysial fragment, and plane away any excessive callus.

B. *Compound cases.* Here resection of the projecting end of the diaphysis will usually be required before reduction can be effected, a step that will facilitate the thorough cleansing of the parts which is so much required. Wiring with sufficiently stout wire, and suture of the rent in the periosteum, will be required, as already indicated above. About a fortnight after any of these operations, passive movements should be begun, and persevere ly continued, together with friction and massage.

Arthrotomy of the shoulder. This operation will be indicated in cases of acute suppurative arthritis, usually pyæmic in origin.

In order to avoid the tendon of the biceps an incision should be made for two inches just below the acromion, dividing the skin and the fibres of the deltoid. The capsule is then easily exposed and may be opened by a vertical cut. For effective

[1] *Loc. supra cit.*, p. 243.

[2] *Rev. d'Orthop.*, Jan. 1897, p. 43, quoted by Poland, *loc. supra cit.*, p. 240.

drainage a counter incision is required in the lowest part of the capsule. Burghard advises that this should be made as follows: "The best plan is to raise the arm above the head so as to render the head of the humerus as prominent in the axilla as possible, and then to cut down upon this by an incision about two inches long just below the axillary vessels. These are identified and pulled upwards so as to expose the capsule below and behind. The head of the bone can be made out by the finger in the axilla. The capsule may be opened by cutting down directly upon the head of the bone; this may be facilitated by bringing the arm down, and passing a long pair of crossing forceps across the joint from the upper incision and making their points project beneath the capsule so that they can be cut down upon and made to seize the drainage tube and pull it into position."

CHAPTER X

EXCISION OF THE SCAPULA

Indications. (1) New growths, especially sarcoma. (2) Caries and necrosis. (3) Accidents, *e.g.* railway and machinery accidents.

(1) As the first of the above is practically the only condition which calls for the removal of the bone, and as these cases present the greatest difficulties, it is to removal of the scapula for new growths that most of the following remarks will apply.

A. **Partial removal of the scapula.** In a very few cases (*e.g.* where the surgeon, operating on an exostosis, is uncertain as to the nature of its base and does not feel satisfied with gouging this, or where he is certain that he is dealing with a chondroma and not with a chrondrifying sarcoma, partial removal of the bone may be sufficient. Caries or necrosis, too, will only in very rare cases call for more than a partial excision. The chief points here are: (1) To expose freely the growth by appropriate flaps, so that the limits may be clearly defined: (2) to be provided with reliable instruments of keen temper, owing to the exceeding hardness which may be met with here.

While some continental writers have given elaborate directions for partial removal of the scapula, it is only in the above few cases that this operation is likely to be used by English surgeons. Mr. Pollock, in a paper on two cases of removal of the scapula,[1] thus advises on this matter: "If a portion of the scapula be removed, it should only be the lower portion. But even if this be attempted, the loss of blood would probably be much greater than if the whole bone were removed: for the wound is more confined, and the wounded arteries are more apt to retract behind the bone above, and offer great obstacles to their being secured. However, should the lower angle be alone the seat of disease, the attempt to remove the lower portion only is justifiable." It must, however, be borne in mind that, when a bone is once the seat of disease which requires removal, the disease is very apt to recur in the portion left, and is less liable to re-appear if the whole bone be removed.

When in doubt as to partial or complete removal of the scapula for a cartilaginous tumour, the surgeon will be chiefly guided by the duration and the rate of progress of the growth, its density, how far it is strictly localised, and whether there is any evidence of adjacent nodules of cartilage, pointing to an infection of the medulla.

B. **Removal of the entire scapula by itself** (*e.g.* cases where the growth is primary in the scapula, and where there is no extension to the humerus or into the axilla).[2] Preparations against shock should be taken, the

[1] *St. George's Hospital Reports*, vol. iv. p. 236.

[2] In cases where the question lies between removal of the scapula and interscapulo-

extremities being bandaged in cotton wool, the head kept low, and the materials for infusion in readiness. The patient is placed at the edge of the table and rolled over to the opposite side. If the growth is very vascular, or the patient weakly, pressure on the subclavian, if effectual, may help; or if, from the extension of the growth, this is rendered difficult, it may be effected by making an incision down to and through the deep fascia over the artery itself, in order to enable an assistant to put his thumb or finger directly upon it. This may be done by a separate incision, or by an extension of that by which the clavicle is divided. But as movements of the limbs may easily dislodge the assistant's finger, the operator will do better to trust to plenty of Spencer-Wells forceps and tying the vessels as they are divided. Sir W. Watson Cheyne recommends preliminary ligature of the subscapular artery. This surgeon has made use of a preliminary anterior incision in the removal of the scapula for a large chondroma which filled up the axilla, "projecting the pectoralis forwards to a marked degree," an incision which he recommends in all cases.[1] "In the first instance an incision was made, beginning below at the junction of the axillary and brachial vessels, and running up in the line of the former, so that the axilla was freely opened in its whole extent. The anterior fold of the axilla was raised so as to expose the coracoid process; the three muscles attached to this were next divided with blunt-pointed scissors kept close to the bone. This fully exposes the axillary artery and its subscapular branch is at once ligatured. The patient was then turned over, and the operation completed in the ordinary way. . . . The ligature of the subscapular artery answered admirably. In this case the patient lost extremely little blood, probably not more than an ounce altogether. The detachment of the muscles attached to the coracoid process also enabled the operation to be completed very rapidly, for after the posterior scapular muscles had been divided, and the trapezius and the deltoid had been raised, the acromio-clavicular joint and the muscles going to the head of the humerus were practically the only things which had to be divided."

The patient being turned over, flaps are quickly and freely turned back, usually by a T-shaped incision, one limb running from the acromio-clavicular joint inwards to the superior angle of the scapula, while the other and longer is made at right angles to the first down to the angle of the scapula. In another case the surgeon may prefer to make an incision along the vertebral border of the scapula, and the other at right angles to it across the centre of the growth.[2] (Fig. 116). In either case care must be taken not to open the capsule of the tumour.

thoracic amputation. J. L. Buchanan, who has considered fully the three operations of partial and complete removal of the scapula and interscapulo-thoracic amputation (*Philadelphia Med. Journ.*, 1900), advises that the proposal of Jeanne (*Le Mid. Mod.* 1895, vol. i, p. 251) be followed. "In every case in which it is suspected that the axillary vessels and nerves may be involved in a growth of the scapula, the operation should be so conducted that it may, if desirable, be converted into a formal interscapulo-thoracic amputation. He makes the posterior and clavicular incision of Berger, divides the attachments of the deltoid, and through this incision makes a digital examination of the relation of the growth to the vessels and nerves. If satisfactory information cannot be thus gained he resects the outer third of the clavicle, separates the muscular attachments to the coracoid, and thus gains better access to the vessels and nerves." Probably it would be safer to follow Berger, and in all doubtful cases to begin with resection of the clavicle.

[1] *King's College Hospital Reports*, vol. ii, p. 83; *Clin. Soc. Trans.*, 1895, vol. xxviii, p. 284.

[2] If the skin is involved the flaps must be shaped so as to isolate this.

When the whole mass is thoroughly exposed, the trapezius and deltoid are first severed, the arm being pulled away from the trunk. The levator anguli scapulæ and the rhomboids are next cut through,[1] the posterior scapular artery secured, and the serratus magnus divided, being first made tense by lifting the scapula off the ribs upwards and outwards. The muscles on the upper border are now dealt with, viz. any remains of the deltoid, the omo-hyoid, and the supra-spinatus—and the supra-scapular artery secured. The acromio-clavicular joint is next opened, or else the acromion or clavicle, according to the extension of the growth in this direction, severed by bone forceps or a narrow saw. If the acromion can be safely left, the resulting deformity—viz. dropping of the shoulder and entire loss of the action of the trapezius—will be lessened.

FIG. 116. Incision for excision of the scapula.

The lower angle being freed and the latissimus dorsi (if involved) resected, the scapula can now be dragged away from the chest by slipping two or three fingers over the upper or vertebral border. Thus, by tilting the scapula outwards, the axillary border can be inspected, the teres and infra-spinatus muscles severed, the position of the subscapular artery defined by a finger passed beneath it, and care taken that this vessel, already tied through the preliminary incision, remains safely secured. The scapula being still further pulled away from the chest, the muscles attached to the coracoid process will be seen severed, and the scapula is removed by cutting into the shoulder joint and severing the capsule and the tendons of the biceps and triceps. The coracoid process may become detached at this stage if partially eroded by extension of the growth, or if the patient be young. If this happens it must be carefully dissected out afterwards.[2]

The different arteries, besides the subscapular, must be secured if

[1] It is a bad sign if any of the muscles severed are infiltrated with growth. That this is not incompatible with a good recovery is, however, shown by the case quoted on p. 232.

[2] If the growth has involved the axillary vessels and nerves, this outlying portion may be dealt with later on, after the main mass has been separated and removed. If it is desired to remove this extension of the disease now while in continuity with the scapular growth itself, the surgeon will have both his hands free for what is a troublesome dissection, by asking an assistant to drag the main mass strongly backwards. But it will be well, in cases where there is evidence of the scapular growth having encroached upon the large vessels and nerves, to obtain leave for the performance of an inter-scapulo thoracic amputation. The first step in the operation should now be divisible and sufficient removal of the clavicle, so as to clear up the state of the above important structures. If they are involved by the growth the more extensive operation should at once be resorted to.

possible before they are cut. Too many Spencer-Wells forceps must not be left in at one time, or they will be found to interfere with the needful manipulation of the bone. Every vessel must be carefully secured by ligature; otherwise oozing is liable to occur a few hours later.

Hæmorrhage may be best avoided by attention to the following points: (1) Making use of Sir W. Watson Cheyne's method and securing the subscapular artery early. (2) Where this method is not available a trial of adequate pressure on the subclavian, this being effected by a special incision, if needful, to command the vessel. Reasons for not trusting to this have been given at p. 229. (3) Dealing with the axillary border and scapular artery last. (4) In any case rapid use of knife or scissors by the operator, aided by intelligent help from assistants in securing bleeding-points, and from an anæsthetist who will not be unduly anxious, is essential. (5) Taking care not to cut into the growth itself. (6) By some it is recommended to make the incisions gradually, not larger than are required at the time, as a means of minimising the hæmorrhage. It must be remembered, with regard to this point, that small and cramped incisions interfere with a free and rapid hand and sufficient exposure of the parts, conditions which conduce to thorough dealing with bleeding-points, and thus facing one of the chief difficulties of this important operation.

Adequate drainage is now provided on account of the liability to subsequent oozing, the attachments of the trapezius and deltoid sutured together with fine sterilized silk, the flaps united, and the arm secured to the side for a few days, after which it may be supported in a sling if the head of the humerus does not tend to protrude.

The malignancy of these sarcomata is well known,[1] together with their tendency to involve surrounding parts and to creep into regions inaccessible to the surgeon. Early operation is imperatively required.

In the case of operation, the prognosis will be best, however large the growth, when the rate of progress has been slow, when the growth is uniformly hard, or if only a certain amount of elasticity is combined with the hardness, when the outline is distinct and well defined, and the mass movable upon the ribs.[2]

[1] The malignancy of these cases and the indifferent results of excision of the scapula are shown in a paper by Dr. Charles B. Nancrede, on the End Results of Excision of the Scapula for Sarcoma (*Ann. of Surg.*, 1909, vol. i. p. 1). Dr. Nancrede collected 65 cases. Of these 26 died in less than one year, 3 inside eighteen months, 2 in two years; 2 survived for three years and 1 for five years. Only one case was certainly cured and 6 probably cured.

[2] That this mobility is a matter of great importance is shown by the following case, quoted by M. Sédillot at p. 550 of his Traité de Médicine opératoire: "Nous refusames un jour d'opérer un jeune homme atteint d'un cancer énorme du scapulum, dont les limites n'étaient pas nettement fixées, et nous dûmes nous applaudir de notre abstention en découvrant plus tard, à la nécropsie, que la tumeur avait pénétré dans la poitrine et envahi un lobe pulmonaire." The following case, under the care of the late Mr. Marmaduke Shield, shows how easily a sarcoma of the subscapular fossa may implicate the thorax, without any exact diagnosis of the position and extent of the growth being possible. A boy, æt. 10, was admitted under his care with a swelling, the size of an orange, on the axillary border of one scapula. This swelling was somewhat fixed, moving but slightly when the arm and scapula were raised at the operation. The intercostals and pleura were found to be blended with the growth. In the attempts to separate them the pleural sac was opened. Pneumothorax ensued, and death took place the next day. The specimen which illustrates this instructive case will be found in the Hunterian collection, R.C.S., No. 586B.

On the other hand, the prognosis is less favourable when the outline is uniform rather than nodulated or bossed, the feel semi-elastic instead of hard, the progress rapid and painful, the different parts of the scapula much obscured and its mobility much impaired, the outline of the growth ill defined and lost indistinctly in the axilla. Pulsation, bruit, enlarged glands, infiltration of the skin, and any local rise in temperature are also of evil omen. In these cases, when the prognosis is unfavourable, the surgeon will do well to resort to interscapulo-thoracic amputation.

Condition of the limb after removal of the scapula. A limb thus preserved will be strong and useful. If the clavicle has not been much interfered with, the clavicular fibres of the deltoid will remain, and these, especially if sutured to the trapezius, together with the latissimus dorsi and pectoralis major, will probably confer a fair amount of movement on the limb. In one of Professor Syme's cases, after removal of the scapula and the outer third of the clavicle and, by a previous operation, the head of the humerus, the patient was able to lift heavy weights, and to fill the appointment of provincial letter-carrier.

In a very successful case of Mr. Symonds,[1] in which the scapula was removed for osteosarcoma, the man was in good health two years and a half after the operation.

He was able to do all the light work of a carpenter, including the use of a plane. Overhead work he could not do. In this case the articular surface of the humerus had also been removed about a month later, as it was thought to be the cause of prolonged suppuration.

The following case is of interest from the extension of the sarcoma into one of the scapular muscles, the ill-defined outline and soft feel of the growth, its long duration, and yet the long period of relief which has followed:

In March 1892 one of the nurses at the Canterbury Hospital was sent to Mr. Jacobson by Dr. Alexander of Faversham. The outline of the left scapula was replaced by a large mass, of uniform outline, fairly defined over the lower two-thirds of the bone, but above very indistinct, semi-elastic to the feel, without any nodules or bosses of harder growth. The scapula was movable upon the ribs. The history was one of pain for eight months. For the last three months the increase in the size of the swelling and in the pain had, alike, been rapid. The scapula was removed in Guy's Hospital. The most interesting point about the case was that the sarcoma, which appeared to have begun in the infraspinous fossa, had perforated the bone, and in many places greyish masses of growth could be seen blending with and replacing the delicate fascienli of the subscapularis. The chief difficulty met with in the after-treatment was keeping the patient quiet. The wound did not run an aseptic course. Ten days later, incisions were required for drainage of the suppuration which followed. Later on, the articular surface and epiphyses of the head and tuberosities of the humerus became detached. Two years after the operation the antero-posterior movements of the shoulder-joint were good. The patient could nurse a delicate mother, use her needle, &c., but abduction and elevation were almost completely abolished. In spite of infiltration of one at least of the muscles, there was no evidence whatever of any recurrence.

Age of the patient. The scapula has been successfully removed for growth at ages varying between "about seventy" and "about eight." The former was a patient of Professor Syme, who died about two months after the operation, apparently of internal deposits. The latter case

[1] *Clin. Soc. Trans.*, vol. xx, p. 24.

occurred in India, the upper extremity being removed at the same time. Mr. Stephen Paget has recorded[1] a successful case of excision of the scapula for sarcoma in a boy æt. 9.

Dangers of the operation and causes of death. These will be the same as those given at the end of the next chapter.

(2) *Removal of the scapula for caries.* This, which will be very rarely called for, needs no especial mention. The parts being sufficiently exposed, the operation will be conducted, as far as possible, subperiosteally, by means of appropriate blunt dissectors or periosteal elevators.

[1] *Clin. Soc. Trans.* vol. xxxvi. p. 244.

CHAPTER XI

REMOVAL OF THE UPPER EXTREMITY, ARM, SCAPULA, AND GREATER PART OF THE CLAVICLE

INTERSCAPULO-THORACIC AMPUTATION[1]

This operation, performed chiefly for growths of the humerus which cannot be completely removed by amputation at the shoulder joint,[2] occasionally for growths of the scapula, and for those of the axilla, as in Mr. Stanley Boyd's case (*see* p. 237). More rarely it may be called for in cases of injury, for persistent carcinoma of the breast (*see* p. 756), for tuberculous disease, or for spreading gangrene. It has been advocated and described by M. Paul Berger, by whose name it is commonly distinguished[3] amongst continental surgeons, and by Sir F. Treves and others in this country and America. The method described below is that of M. Berger; a very clear account is also given by M. Farabeuf, by Sir F. Treves,[4] and by Professor Kocher. These have been largely consulted.

First step. Division of the clavicle and securing the vessels. The patient being brought to the edge of the table, with his shoulders raised, the surgeon, standing outside the limb, makes an incision with a stout scalpel along the whole length of the clavicle, from just outside the sterno-mastoid to a point immediately beyond the acromio-clavicular joint. The incision divides the periosteum down to the bone over the middle of the clavicle. At this stage venous oozing from the large superficial veins here met with may be very free. With a curved elevator the periosteum is separated from the middle portion of the clavicle.[5] A large blunt hook or a blunt dissector being passed under the inner end of the bared part of the clavicle, this is divided with a narrow saw. The outer part of the clavicle being now raised and steadied with lion-forceps, and the periosteum completely separated from its under surface,

[1] Dr. Norman B. Carson has published (*Ann. of Surg.*, 1913, vol. lxvii, p. 796) an interesting paper on this subject giving details of a number of cases.

[2] As in Mr. Barling's case (*Brit. Med. Journ.*, 1898, vol. i, p. 883), any surgeon in doubt as to the necessity of submitting his patient to so severe an operation, should begin by an incision between the deltoid and the pectoralis major, and then, when the muscles are thoroughly retracted, examine the condition of the axilla, the glands, and determine the extent of the growth and whether the large vessels and nerves are involved. In other cases division and partial removal of the clavicle may be required to clear up the doubtful point. In every case this preliminary incision should be made at the time when the operation is to be completed, not as a preliminary step. On this point see a paper by Dr. Cobb, of Boston (*Ann. of Surg.*, February 1905, p. 267).

[3] *L'Amputation du membre supérieur dans la contiguité du tronc*. Paris, 1887.

[4] *Oper. Surg.*

[5] Preliminary detachment of periosteum was recommended by M. Ollier as a safeguard against wounding the vessels. It, however, obscures the subclavius and has to be divided immediately. In addition in malignant disease it may favour recurrence of the growth.

the bone is again divided at the outer end of its middle third. If resection of part of the clavicle is performed, the removal of bone must be free enough to facilitate the finding of the subclavian vessels. Limited removal of bone will much increase the difficulties of the above step. The tendency of the upper extremity to fall outwards after division of the clavicle will increase the space between the two parts of this bone. The exposed subclavius with its sheath is now isolated and cut through close to the site of the inner section of the clavicle, dissected up so as to expose the large vessels, and turned outwards.[1] Fasciæ of varying thickness will have to be divided before the vessels are reached. During this step the great pectoral should be freely divided, especially in muscular subjects, and the upper border of the pectoralis minor should, if possible, be defined; the surgeon must be prepared for troublesome bleeding from the cephalic vein and branches of the acromio-thoracic vessels, and he may find a guide recommended by Berger viz. the external anterior thoracic nerve – easy to see or feel. This nerve, if followed upwards leads to the interval between the artery and vein.[2] These large vessels are then secured and divided between double ligatures, pushed well apart in each case and tied securely before the vessel is cut. The ligatures should be placed upon the subclavian vessels themselves, at a point to which the tubercle on the first rib will be a guide. The artery should be secured first, and the arm well raised while the ligatures are placed around the vein, so that as little blood as possible be left in the extremity. Tying the artery first will lessen the size of the vein and render the securing of it less difficult; furthermore, as pointed out by Professor Keen, if the vein be injured, as happened in his case, while it is being tied, the wound will not be flooded with blood. If, however, the vein be so much distended as to obscure the artery, the former vessel must be taken first. In either case the greatest care must be taken not to injure this vessel for fear of air entering the circulation. If any such accident occurs, the spot must be instantly closed and the wound flooded with sterile saline solution. While exposing the subclavian vessels, the supra-scapular artery and vein will probably be seen crossing the upper part of the wound and should be secured. The nerve-cords should be cut square and as high up as possible. Before they are severed each should be injected with novocain or eucaine to guard against shock. Mr. Stanley Boyd in his case (*vide infra*) finding that removal of the inner third of the clavicle was insufficient to permit of easy ligature of the vein, which lay beneath the inner third, removed another inch from the bone. He also found that division of most of the brachial plexus facilitated ligature of the artery, the plexus at once starting into relief on division of the clavicle.

Dr. Le Conte, of Philadelphia,[3] recommends disarticulation of the sternal end of the clavicle as preferable to resection. In the latter the large vessels are exposed in a narrow field and at a considerable depth. Disarticulation he believes to be simpler, quicker, and safer, by giving a much fuller exposure of the vessels. The incision is begun over the sternal end of the clavicle, carried to its middle, and then curved downwards to the anterior axillary fold. The skin and superficial fascia are dissected up, exposing well the inner two-thirds of the clavicle. The bone is then disarticulated by severing its attachments to the sternum and rhomboid ligament, the clavicular part of the sterno-mastoid and pectoralis major. The clavicle is

[1] The subclavius must be thoroughly divided in order to obtain room for securing the vein.

[2] Feeling for the pulsation of the artery will be another guide.

[3] *Ann. of Surg.*, September 1899.

now pulled upwards and outwards, and the subclavius stripped off or divided, and the vessels thus well exposed.[1]

Second stage. Formation of the flaps. These are pectoro-axillary and cervico-scapular, and in forming them the surgeon must be guided by the extent of the disease. The patient being so placed and steadied that the whole of the scapular region is free of the table, and the surgeon standing to the inner side, *i.e.* between the limb and the trunk, the pectoro-axillary flap is cut as indicated in Fig. 117. As there

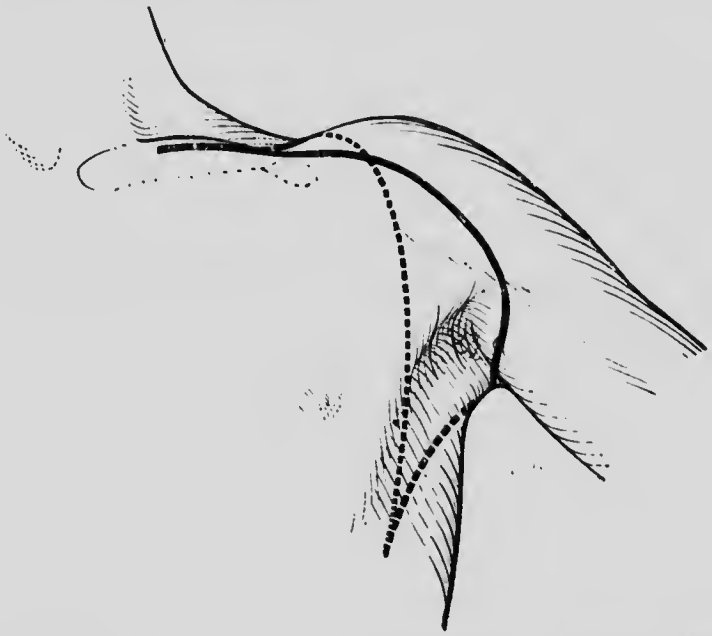


Fig. 117. Interscapulo-thoracic amputation. Outline of the flaps (left side). The posterior or cervico-scapular flap is shown dotted. (Farabeuf.)

shown, it commences at the middle of the incision over the clavicle, runs downwards and outwards just above the coracoid process, and then parallel with, but a little external to, the depression between the deltoid and the pectoralis major. On reaching the point where the anterior fold of the axilla and the arm join, the knife is carried over the lower edge of the pectoralis major across the axillary aspect of the arm (Fig. 117), and then backwards and downwards (the limb being well raised by an assistant) so as to pass over the lower edges of the latissimus dorsi and teres major and end over the apex of the scapula (Fig. 117). The above incision only divides skin and fasciæ. The pectoralis major is next cut, and the pectoralis minor found and severed near the coracoid process. The top of the axilla being now well opened up, the cords of the plexus, if not already severed, are divided at the same level as the great vessels, great care being taken of the central ligatures on these, the patient being rolled over on to his sound side.

[1] Dr. Le Conte also points out that complete removal of the bone is safer in cases of growth than leaving the sternal end. This step would also be indicated where there are great difficulties in finding the subclavian artery where the clavicle itself is involved. In the latter case, however, it may be questioned whether any operation is advisable.

and the limb drawn across the chest. The cervico-dorsal flap is now made by drawing the knife from the outer extremity of the clavicular incision, straight back over the spine of the scapula to the lower angle of this bone, where it meets the first incision. The skin and fascia divided by this incision are reflected to the vertebral border of the scapula.

Nothing now remains but the *third and last stage*, viz. the removal of the limb. This is effected by the division of the trapezius, omohyoid, latissimus dorsi, levator anguli, rhomboids, and serratus magnus. While these muscles are severed the flaps are well held back, and the limb suitably manipulated, partly by an assistant and partly by the left hand of the operator.

During this stage the posterior scapular and the supra-scapular may or may not require ligatures, according as they spring from the first or the third part of the subclavian, in the latter case being on the distal side of the ligature (Spencer). But, of course, the mere mention of normal arteries gives no idea of the number of both veins and arteries that will be met with, enlarged, in cases of new growths. This makes it all the more important to secure first the subclavian artery and vein.

The flaps and all the recesses of the large wound are most carefully scrutinized for any evidence of infiltration or extension of new growth. The muscles, especially the pectorals, should be cut short to avoid any possibility of infiltration. Where it is thought advisable to shorten the nerve-cords, each of these should again be injected with eucaine (*see* p. 235). The condition of the glands in the posterior triangle should also be investigated. Drainage should always be employed on account of the subsequent oozing.

Mr. Stanley Boyd[1] has reported the following instructive case:

> Five weeks previously a man, æt. 25, had come under his care at the Charing Cross Hospital for sarcoma of the axilla, which had attained the size of two fists in three months. It was not fixed to bone, but was closely attached to some soft parts. There was no evidence of pressure on the great vessels or nerves, of involvement of the supra-clavicular glands, or of secondary growths in the viscera, &c. Operation proved that the great vessels and nerves were so surrounded by growth that only an interscapulo-thoracic amputation would remove the disease. As consent had not been obtained, nothing further was done then. Four weeks later the mass round the vessels had increased considerably, and amputation was performed on Berger's lines, with certain improvements in two or three details, which have been mentioned above. The patient, at the time of the report, was making an excellent recovery.

Dangers of the operation and causes of death. These are:

(1) *Hæmorrhage*.[2] This may be met with from the main trunk, the scapular branches of the subclavian, the branches of the axillary, and the enlarged anastomizing veins in cases of growth. The first two of

[1] *Brit. Med. Journ.*, vol. i. 1898, p. 883.

[2] Control of this is the key to the situation. The following cases show what difficulties may be met with in meeting it. Mr. Macnamara (*Lancet*, vol. i. 1878, p. 669), after resecting part of the clavicle, was unable to find the artery owing to the large veins exposed. The hæmorrhage was very great, and the patient died on the following day. A portion of growth was found to have passed upwards behind the scaleni muscles. Prof. Keen (*Amer. Journ. Med. Sci.*, June 1894) met with great trouble in securing the subclavian vein. "A large vein under the inner sawn end of the clavicle tore, and gave me much trouble, but finally, partly by a ligature round the tissues in which lay the vein, and partly by a ligature which was applied temporarily round the tissues and round the sawn end of the clavicle in a groove sawed in the bone, so as to prevent the slipping of the ligature, I was able to control it."

Another most instructive case is given by Prof. Keen (*Ann. of Surg.*, June 1895).

these dangers and the third, to a large extent, will be met by tying the subclavian vessels after Berger's method. This also prevents entrance of air into the large veins, allows of section of vascular muscles like the great pectoral with scarcely any bleeding, while division of the posterior muscles, where the arterial supply has not been cut off, is reserved for the last step of the operation.

If, after resection of the clavicle, it is found impossible to secure the third part of the subclavian vessels owing to the profuse venous oozing, or to the displacement of the parts from invasion of the growth, Sir F. T. Chavasse advises proceeding at once to make the upper part of the anterior flap, dividing the two pectoral muscles and, after fully exposing the first part of the axillary vessels, tracing these up to the scalenus anticus and tying the subclavian artery and vein. Other courses open are to tie the subclavian vessels in their part in the usual way. If all the precautions described above be taken, the amount of blood lost will be very small. Professor Kocher[1] says:

"We performed this operation in 1902 on a boy for a diffuse sarcoma of the scapula, which involved the shoulder-joint and the upper portion of the humerus. Only two teaspoonfuls of blood were lost, and in five days the wound was simply covered with a strip of collodion, a single glass drainage tube having been inserted through a special opening in the posterior fold of the axilla."

(2) *Shock.* This will be met by taking every step to prevent shock and hæmorrhage, bandaging the limbs and abdomen, keeping the body warm on a hot-water table, administering ether, emptying the limb of venous blood before the vein is tied, and completing the operation as speedily as possible. Afterwards, infusion of saline fluid should be resorted to, while subcutaneous injection of strychnine, ether, or brandy, enemata of port wine and beef-tea, and bandaging of the other limbs may also be employed.

This will be a fitting place to refer to an important point raised by Harvey Cushing[2] in the avoidance of shock in major amputations by cocainization of large nerve-trunks preliminary to their division as first advised by Crile.[3] "The term 'shock' represents a peculiar state of depression of the central nervous system. Such a condition is usually brought about by injury of one sort or another to peripheral afferent nerves, the impulses from the injury having acted reflexly upon the vaso-motor mechanism in the medulla, so as to cause a marked fall in the blood-pressure. While shock may be diminished by perfect hæmostasis and preventing chills, in cases where shock is already present before operation, the possibility of prolonged anæsthesia and some further loss of blood render it certain that a further especial risk is attendant upon the division of important sensory nerve-trunks. As cocaine injected into a nerve-trunk effectually blocks the transmission of all centripetal or sensory impulses, cocainization of main nerve-trunks central to the proposed site of their division in a major amputation prevents the conduction of those impulses resulting from this further injury, which otherwise, by acting reflexly through the medullary centre, might become further factors in the production of shock."

In illustration of the above principle, Cushing relates two cases of interscapulo-thoracic amputation, one of which was done without, the other with cocainisation of the chief nerve-trunks. In both hæmostasis was complete, and, except for the

[1] *Oper. Surg.*, p. 382. [2] *Ann. of Surg.*, September 1902.
[3] *Problems Relating to Surgical Operations, Philadelphia*, 1891.

above difference in operative technique, the cases were in every respect similar. Two charts recording the pulse-rate are given, showing distinctly that in the case in which the nerve-trunks were divided without cocainization there was marked evidence of shock, which was absent in the case where cocaine was employed.

Lund [1] relates a case of the above operation for sarcoma of the brachial plexus, probably dating to an injury and originating in the median nerve, in which each cord of the brachial plexus was injected with ten minims of a 0·25 per cent. solution of cocaine before division. The pulse was unaffected.

(3) *Septicæmia.* This is a very probable danger, if the flaps (perhaps left needlessly full) slough, or if retention and lagging of discharges are allowed to occur in the large cavity which will be present in the stump, unless this is obliterated by pressure, or sufficient drainage employed.

(4) *Entrance of air into veins.* This very nearly proved fatal in a case in which Mr. Jessop, some years ago, removed the scapula, outer half of the clavicle, and the upper extremity.[2]

In this case the scapula seems to have been removed owing "to considerable deficiency of cover" after removal of an upper limb much damaged by a machinery accident. "Whilst cutting through the last attachments of the scapula, two distinct loud whiffs were heard, caused by the rush of air into the subclavian vein." The operation was completed while artificial respiration [3] was being performed, and the lad recovered.

(5) *Recurrence.* While the results of this severe operation are, as far as immediate recovery goes, good, recurrence, in the case of periosteal sarcomata, takes place, as a rule, within six or twelve months. Sir F. Treves [4] writes on this point: "Although interscapulo-thoracic amputation is probably the best measure in all cases of sarcoma (ossifying or not) of the upper part of the humerus, the prognosis is very gloomy. In at least 75 per cent. fatal recurrence has followed within a year." The statistics collected for M. Berger show that the prognosis is better in cases of sarcoma of the humerus than in those where the growth affects the scapula or the soft parts, and that it is best of all in chondromata.

(6) If the patient survive, an artificial limb should be fitted at an early date. It may not admit of active usefulness, but it will be of service in preventing the feeling of most irksome lopsidedness which in the convalescence and early getting about causes these patients so much discomfort in balancing themselves.

(7) With regard to the mortality of the operation, some recent statistics are those collected by MM. Jeanbrau and Riche for M. Berger and brought by him before the Society of Surgery of Paris.[5] It will be seen that it varies widely according to the origin of the growth. In cases of growth of the humerus the mortality is stated to have been 2·75 per cent.; in growth of the scapula 23·80 per cent.; and in growths of less certain origin, *e.g.* soft parts, glands, &c., 11·76 per cent.

[1] *Boston Med. and Surg. Journ.*, April 16, 1903.
[2] *Brit. Med. Journ.*, 1874, vol. i, p. 12.
[3] Unless the wound is kept flooded, this step is not without risk of drawing in more air.
[4] *Oper. Surg.*, 2nd ed., vol. i, p. 381.
[5] *Bull. et Mem.*, May 16, 1905, p. 435.

CHAPTER XII

OPERATIONS ON THE CLAVICLE

REMOVAL OF THE CLAVICLE

REMOVAL may be occasionally required for new growths or necrosis. In either case it is but rarely called for. That for necrosis differs in no way, save for the importance of surrounding parts, from the same operation elsewhere.

Removal of the entire clavicle for new growths. The following are the chief points to bear in mind, viz. that (1) the degree of malignancy of sarcomata of bone varies here, as elsewhere, within very wide limits. (2) That slowness of growth, a well-defined outline, regularity of expansion, together with absence of swelling of the hand, will be favourable. (3) A free incision is needed along the curves of the bone, with any additional one that is required. (4) Plenty of sponge-forceps must be at hand. (5) The acromial end should be set free first, either by opening the joint or by sawing the bone, if healthy. (6) The freeing of the coraco- and costo-clavicular ligaments is often a matter of much difficulty owing to their depth and the way in which the bone may be tied down by the growth. (7) With periosteal sarcomata of any duration, outlying processes may be present. (8) If this be the case towards the inner end of the growth, it will require the greatest caution to avoid opening up connective tissue which is continuous with that of the mediastina. (9) Division of the clavicle, a step sometimes taken to facilitate its removal, should be avoided, if possible, as the wound may thus become infected with growth. (10) As in all removal of bones infiltrated with growth, the clavicle may fracture during operation; the outer end should therefore be seized with lion-forceps and dissected out so as to give more room for dealing with the sternal extremity.

Operation. A horizontal incision is made along the whole length of the clavicle, with a vertical incision if necessary over the most prominent part of the growth. The skin and fascia are reflected so as to thoroughly expose the superficial aspect of the tumour. The clavicular head of the sterno-mastoid, the clavicular attachments of the pectoralis major, the deltoid, and the trapezius are then divided close to the limits of the growth. The acromio-clavicular joint is then opened and the outer extremity of the bone drawn strongly forwards and upwards by means of a blunt hook. The subclavius muscle and the costo-clavicular and rhomboid ligaments are then severed by a knife or scissors, the greatest care being taken to avoid injury to the subclavian vein. These points are illustrated in the following case by Mr. Bilton Pollard Jessett[1] of removal of the entire clavicle for a large periosteal sarcoma.

[1] *Lancet*, 1889, vol. i, p. 1077.

The patient was a girl of 16. The growth was of more than a year's duration, and extended over the inner two-thirds of the clavicle. The following were the chief points which led the surgeon to recommend operation. The age of the patient. The fact that the growth extended much further on to the chest wall than it did into the neck. It had perforated the front of the clavicle and had only lately caused any pressure on the vessels. The skin was not implicated. A —-shaped incision was made, the base including the clavicle and the sheath over the sterno-clavicular joint and with this being protected, the muscles were detached from the bone as far as possible and the latter fibres of the sterno mastoid divided. The bone was next divided at the junction of the outer and middle third by a narrow saw and bone forceps. The inner fragment was then pulled forward with bone forceps, when the subclavius was carefully detached with scissors and left on the rib. Some difficulty was met with in opening the sterno clavicular joint as this was overlapped by the growth. A further extension of this cut through the bones made it difficult to divide the costo-clavicular ligament, which was eventually cut with scissors after suitable dragging up and rotation of the fragment by the growth. Care was taken to leave untouched the sternal head of the sterno mastoid. The outer part of the clavicle was then seized with bone forceps and removed after division of the muscular and ligamentous attachments. There was very little loss of blood. The patient made a good recovery, the wound healing by the end of a month. Later "the movements were equally good with those of the opposite side." In 1893, speaking at a meeting of the Medical Society, Mr. Jessett exhibited several small recurrent growths that had been removed.

In Prof. Mott's case[2] the subclavius could not be separated from the tumour mass. This greatly increased the difficulty of dissecting the subclavian vessels which, though firmly adherent, was finally freed by the cautious use of the handle and blade of the knife alternately. The patient lived for twenty-two years after the removal of the growth, but made a good recovery. The osteo-sarcoma was the size of two adult fists. The necropsy, however (the patient's death not being due to the growth), showed that only so much of the sternal end had been left, the rest of the site being occupied by a gummatous deposit. And the latter, no doubt, is the explanation in other cases where the after use of the limb has been so good and the result is said to have been perfect.

Dr. Bingham performed complete excision for a recurrent sarcoma. Twelve months after the man was in good health, and was following on his work as a fireman on a steamboat. Here it was thought that the stump of the detached sterno-mastoid and trapezius to corresponding points of the pectoralis and deltoid had contributed to the excellent functional result.

In February 1899 Mr. Symonds removed the clavicle for a mixed cell sarcoma. The outline of the bone was here masked by the growth, and the boundaries of the latter not well defined. The operation was rendered difficult throughout by the very free bleeding at all points, the extent to which the bone was dissected down, and the consequent difficulty of getting at the costo-clavicular and costo-clavicular ligaments. The patient made a rapid recovery and remained well a year later.

A case of angeio-sarcoma of the clavicle is recorded by Dr. Beatson, of Glasgow.[4] The drawing accompanying the paper shows the usual globular swelling, and gives as good an idea of the fixity which may be met with as it is possible for an illustration to do. The second rib, where eroded by the growth required gouging, and some enlarged glands, the nature of which is not given, were removed from the posterior triangle, and six months later a further removal of glands was performed which the microscope left undecided whether they were sarcomatous or inflammatory. Yet the patient was alive and well two years after the first operation.

[1] In a case of Mr. Cubby's (*Lancet*, November 19, 1892), in which the inner two-thirds of the clavicle were removed for a periosteal sarcoma, the pleura and innominate vessels were exposed in dissecting away a portion of growth which passed down behind the manubrium. The patient recovered with perfect movement of the arm.

[2] *Amer. Journ. Med. Sci.*, vol. iii. O.S. p. 100.

[3] *Med. News*, January 8, 1898.

[4] *Brit. Med. Journ.*, 1902, vol. i. p. 128.

A good instance of partial removal of the clavicle is recorded by Sir J. Bland Sutton:[1]

Here the acromial half was removed for a myeloid growth in a woman, aged 26. The chief difficulties met with were, first, the tightness with which the bony capsule was tied down over the coracoid process by the coraco-clavicular ligaments, these structures requiring careful division with scissars. Secondly, the supra-scapular nerve ran in a shallow groove in the capsule of the tumour, and was reflected without injury. Nearly four years later there was no evidence of recurrence. A fibrous band united the remains of the clavicle and the acromion, and the patient could perform all movements of the extremity perfectly.

Mr. S. B. Radley and Mr. W. Duggan give an account[2] of an interesting case of a thyroid tumour of the clavicle treated by excision. The patient, a muscular man aged 46, had been operated upon for an adenoma of the thyroid in September 1910. In October 1912 he was admitted to the Manchester Royal Infirmary for a painful swelling of the right shoulder; the thyroid was then normal in size and moved freely. The operation of total excision of the clavicle was performed by Mr. Thorburn. Histologically the tumour closely resembled a secondary thyroid carcinoma, though colloid material was absent.

OCCASIONAL CONDITIONS OF THE CLAVICLE, ACROMION, OR THEIR JOINTS WHICH MAY CALL FOR OPERATION

A. **Fractures of the clavicle.** Operative interference may, very rarely, be called for in some of the following cases: (1) In recent cases with very marked displacement difficult to reduce or keep in position, as in fracture of the acromial end, outside the coraco-clavicular ligaments. (2) In compound and comminuted cases, after the wound has been enlarged so as to promote asepsis, wiring of the fragments will be quite justifiable, especially if they are comminuted. (3) In cases where there is injury to, or pressure upon, the vessels or nerves, either at the time of the accident, or later owing to excessive callus. (4) In rare cases of pseudarthrosis, the non-union being probably due to the interposition of a portion of the subclavious. (5) Where an ugly union or pointed process of bone presses on the skin or causes disfigurement.

An excellent instance of pseudarthrosis[3] in which pressure on the nerves supervened later, most successfully treated, has been recorded by Mr. Barker.[4]

A boy, aged 12, was noticed soon after birth to have a fracture of the right clavicle the cause of this being uncertain. Up to nine years of age the child had no inconvenience. He was then gradually more and more troubled with pressure on the brachial plexus, pain down the arm, and a tendency of the fingers to become stiff and fixed in a flexed position in writing, this condition soon amounting to one of painful spasm, rendering the writing quite illegible.

Mr. Barker made an incision about two inches long, with its ends on the clavicle and its convexity downwards. The flap of skin thus formed was turned upwards to expose the false joint. The outer end of the inner fragment was then divided obliquely in a plane running from within outwards and from before backwards. The inner end of the outer fragment was divided in a plane corresponding to that of the section of the inner fragment. The inner end of the outer fragment was then separated from the brachial plexus and its cut surface placed upon that of the inner portion of the bone. The two were then united by silver wire. The wound was closed, and after the dressing was applied the arm was fixed to the side by a plaster of Paris bandage. This was removed at the end of fourteen days, when the healing was complete and a mass of callus could be felt at the seat of the operation. A week

[1] *Clin. Soc. Trans.*, vol. xxiv, p. 12.

[2] *Brit. Journ. Surg.*, vol. i.

[3] As a rule, non-union or pseudarthrosis of the clavicle does not cause the patient much trouble, if it has occurred in early life. Though the ends of the bone may be atrophied, the muscles will be found hypertrophied.

[4] *Clin. Soc. Trans.*, vol. xlx, p. 104.

later the power of writing was found to be much improved, and the arm eventually became perfect in all its functions.

Mr. Bilton Pollard [1] records a case of ununited fracture of about four months' duration, in an infant aged eighteen months, in which he resected and wired the fragments with an excellent result. Sound union followed, and the arm, previously hardly used at all, was moved as well as the other.

In those cases where much deformity has followed union of a fractured clavicle, especially where a pointed process of bone projects under the skin, it will be quite justifiable, with strict aseptic precautions, to explore and to remove the projecting bone with an osteotome or saw.

B. **Dislocations.** It is well known that occasionally dislocations of the clavicle, especially those of the sternal end, are most difficult to maintain in place after reduction. In these cases, especially where the sternal end has been displaced backwards or upwards, in which situation it is liable to press upon the trachea, œsophagus, or large veins, operation is indicated. The displaced bone is exposed by a suitable incision, and then, after resection of a portion of the extremity, the dislocation can be reduced and the bone wired in position.

In 1899 Mr. Jacobson removed the sternal end of the clavicle for an old dislocation upwards and backwards in a patient at Guy's Hospital. Only the cartilage required to be removed from the sternal facet. The wire was removed in three weeks. When the patient left the hospital, five weeks after the operation, the deformity was entirely removed and the parts were soundly consolidated. Four weeks later he had resumed his work. He could raise his arm to a right-angle, and the movements were increasing.

Resection of the acromion-clavicular joint was performed as long ago as 1861 by an American surgeon, Cooper of San Francisco.[2] He resected the joint in three cases of acromio-clavicular dislocation. In each case the lesion was of several years' standing, and the usefulness of the limb much impaired. In all three the result was excellent. Mr. Jacobson has operated by resection and wiring in three cases of acromio-clavicular dislocation, two of these being primary and one a secondary operation. In two the result was perfect. In the third, one of the primary cases, infection followed, and the wire had to be removed. The deformity was, however, removed, and the union was secure.

C. **Disease of the joints.** It is well known how obstinately tuberculous disease sometimes attacks the sterno-clavicular joint. The simplicity and the superficial position of this joint render erasion, followed, if need be, by removal with a chisel or osteotome of one or both bone ends, a most successful operation.

[1] *Brit. Med. Journ.*, 1887, vol. i, p. 676.
[2] *Amer. Journ. of Med. Sci.*, April 1861.

PART II

THE HEAD AND NECK

CHAPTER XIII

OPERATIONS ON THE SCALP

But few – viz. those for large fibro-cellular growths and the vascular tumours known as aneurysms by anastomosis or cirsoid aneurysms, &c. – will require mention in a work like this.

FIBRO-CELLULAR GROWTHS, MOLLUSCUM FIBROSUM, OR PACHYDERMATOCELE OF THE SCALP

These rare growths, occasionally require removal, on account of their hideous deformity.[1] The chief points of importance in such operations are: (1) The hæmorrhage. This may be terrific,[2] copious, and weeping from every part, owing to the huge size of the growth and the vascularity of the parts. It is best met by an ingenious precaution of Mr. Hutchinson's,[3] who prevented all arterial hæmorrhage during an extensive operation of this kind by applying round the head, just above the ears, a Petit's tourniquet with a narrow strap, cotton-wool being placed over the eyes. Nowadays india-rubber tubing which can be sterilised, or Makka's clamps (*see* Fig. 118, p. 255) would be preferable. (2) The need of maintaining strict asepsis. As nearly the whole thickness of the scalp affected must usually be sacrificed, the pericranium may be damaged and the bone necessarily exposed. The risk of septic osteitis and then phlebitis of the veins of the diploe is well known, with the inevitable result of pyæmia. In very large growths two or more operations may be required. Thiersch's method of grafting (*see* p. 43) will be very useful, either at the close of the operation or later on.

Recurrence is not unlikely even after extensive operations, and von Recklinghausen has shown that the proliferation of the connective tissue takes place along the nerves; it is therefore obviously possible that such tissue left along any of the nerves may serve as a fresh starting-point.

[1] A good illustration of these growths is given by Mr. Hutchinson (*Lond. Hosp. Rep.*, vol. ii, *frontispiece*), and another by Sir J. E. Erichsen (*Surg.*, vol. ii, p. 533). The drawing in this case is said to be taken from a patient of Sir W. Stokes.

[2] It is so described by Sir W. Stokes (*loc. supra cit.*). The patient, a man aged 33, in good condition, almost died on the table.

[3] *Loc. supra cit.*, p. 118. The piece of scalp removed here was twice as large as the palm of the hand. Owing to the precautions taken, there was no arterial hæmorrhage.

In Sir W. Stokes' case the base of the growth was very wide, reaching from above and in front of the right ear to the left of the occipital protuberance, upwards as high as the vertex, and hanging down as low as the shoulder.

ANEURYSM BY ANASTOMOSIS (CIRSOID ANEURYSM)

The treatment of these sometimes most difficult cases is given under the head of "Ligature of the External Carotid."

QUESTION OF OPERATIVE INTERFERENCE IN GROWTH OF THE CRANIAL BONES AND DURA MATER

Under this heading reference will be made to (1) Exostoses; (2) those malignant growths, usually sarcomata, which, springing from the scalp (often the pericranium), the diploe,[1] the meninges, and, more rarely, the brain, are capable of perforating the skull from within outwards or in the reverse direction. (3) Epitheliomata. These growths are the ones in which the advisability of operation is most likely to arise.

(1) *Exostoses.* It is only the ivory variety that needs reference here. These exceedingly hard slowly growing tumours usually grow from the flat bones of the skull, especially in the walls of the frontal sinus or in the external auditory meatus. The best incision to expose it, in the former situation, is one transversely outwards from the root of the nose, through the eyebrow, and another upwards along the middle line of the forehead. The anterior wall of the frontal sinus must be freely removed with trephine or chisel, for it is essential to get at the root or base of the exostosis and to divide this, and not merely to break off pieces of the exostosis. For division of the extremely dense bone a burr worked by electricity is preferable to chisels and saws. Where the latter are relied upon several must be at hand. When the pedicle is detached there is often much difficulty in prising out the exostosis. The surgeon must be prepared for opening the posterior wall of the sinus and exposing the meninges, and perforating the roof of the orbit, and the delicate tissue of the ethmoid. In some cases it will be well to obtain leave to remove the eyeball. Careful drainage must be provided for the first few days in case of infection from the nose, and for the same reason the wound should not be too closely sutured at first.

(2) *Sarcomata.* Periosteal, endosteal, and those originating in the dura mater. The following remarks by von Bergmann,[2] by von Bruns, and von Mikulicz may be useful. Sarcomata of the skull may be periosteal or central. The temporal bone is most frequently attacked, after this the frontal, parietal, and occipital. Even at an early stage the surgeon has to face the question whether he is dealing with a sarcoma of the skull or one perforating from within. In the majority, whether periosteal, central, or from the dura mater, spindle-cells predominate. Those arising in the dura mater are characterized by calcification. In large periosteal sarcomata the abundant blood-supply may lead to distinct pulsation. At a very early stage this form shows a tendency to increase by secondary nodules, seated at first near the base of the original growths. This tendency to local dissemination, which can only be determined by the microscope, explains the frequency of recurrences. Metastases in the viscera, especially the lungs and in the bones, are very common. The lymphatic glands, as a rule, are not involved.

[1] While the vault is affected more often than the base, sarcomata of the skull may be present in both situations, simultaneously.

[2] *Syst. of Pract. Surg.*, by von Bergmann, von Bruns, and von Mikulicz (*Amer. Trans.*, by Drs. Bull and Martin, vol. i, p. 124).

Only in the early stages, and under conditions rarely present, is it possible to determine whether a sarcoma of the skull is central, periosteal, or arises from the dura mater. If the surface be hard and bone-like it can only be a central sarcoma or possibly a local periosteal hyperostosis. In central sarcoma the surface soon becomes altered by softer areas which bulge outwards; often the summit of the swelling is soft while the periphery remains hard. In this way the appearance is very similar to that of a perforating sarcoma of the dura mater. The latter, however, never lifts up the bony wall of the skull, but destroys it by infiltration; the growth is therefore surrounded by a bony ring. The latter is, however, on a level with that of the general surface of the skull, and does not, as in the case of the central sarcoma, extend from the base of the growth towards its summit. In the case of the central sarcoma the outer and inner tables feel as if they had been forced apart, while in that of the periosteal sarcoma the tables show a jagged edge. If every periosteal sarcoma were composed only of soft tissues it would be easy to distinguish it from a central sarcoma, as long as the latter possessed a bony shell at its base, if not at its summit. However, osteo-sarcoma of periosteal origin, a frequent growth, has a bony feeling also both at the periphery and summit. The latter possess no bony shell, but numerous spicules of bone extend into the growth from the site of its attachment. On palpation these growths give the impression of a bony capsule, and this leads to mistaking an osteo-sarcoma for a central sarcoma. The most certain indication of the origin of a new growth in the diploe is the presence of the bony wall rising above the level of the surface of the skull and extending towards the summit of the growth. Sarcoma of the dura mater is recognized in exceptional cases only by the above-mentioned peculiarities of the gap in the skull, its situation within the plane of the surface of the bone, and its sharp outline. It may be diagnosed earlier by other symptoms. "If previously existing symptoms, especially those of intracranial pressure, disappear as soon, or soon after, a tumour appears at the surface of the skull, the surgeon is safe in assuming that the growth originated in the dura. Such a tumour begins to develop within the cranial cavity, and brings about symptoms due to encroachment on the intracranial cavity. As soon as the tumour makes its exit from the interior of the skull the diminution of space and the combination of symptoms resulting therefrom cease. In the second place, perforating dural sarcoma usually pulsates as a result of the pulsation of the brain being transmitted to it. In the third place, such a tumour may be forced by pressure into the cranial cavity, causing temporary headache, slowing of the pulse, and loss of consciousness. If these three symptoms be present the surgeon can with certainty diagnose sarcoma of dural origin which has perforated the skull and continued to proliferate outside. Conversely, he cannot, however, exclude the dural origin of a growth in which the characteristic symptoms are absent. A tumour may be so closely adherent to the edge of the defect in the skull that no pulsation of the brain can be transmitted to it, or that pressure cannot force the growth into the cranial cavity. The presence of cerebral symptoms accompanying a tumour on the surface of the skull has no bearing on the differential diagnosis under discussion, for periosteal, as well as myelogenous, growths may proliferate inwardly as well as outwardly. The diagnostic importance of cerebral symptoms depends

upon the fact that they occur before the tumour becomes noticeable, and disappear after it has made its appearance on the surface. As soon as the tumour reaches the surface of the skull it spreads out to an extraordinary degree, the defect in the skull completely covered, and there is no longer anything to distinguish it from periosteal and myelogenous sarcomata, which similarly proliferate and attain an enormous size."

Treatment. It remains to be seen what operative attacks, aided by modern surgery, may avail in these cases, but for the present, unless an opportunity arise for attacking such growths quite early *e.g.* while they are only of small size it will be wiser not to interfere.[1] And this warning is especially true of those cases in which sarcomata of a specially malignant kind appear, often after an injury, on the crania on children,[2] where the swellings of the scalp are multiple, or where they are travelling out of the skull by any of the apertures, *e.g.* the orbit. Large size, any evidence of fixity, duration of any length will cause any operation to be set aside, owing to the dangers of the operation, the possibility of its being incomplete, especially where the brain is involved, and the risk of its being impossible to close the gap. In addition to the question of metastases in such cases, the frequent presence of minute local secondary nodules (*see* p. 245) must be remembered.

The necessary difficulty and tediousness in isolating the affected bone, if of any size, by sufficient trephine-crowns, and joining these with a Gigli's saw (*see* p. 314), or the forceps of De Vilbiss (*see* p. 312), or a chisel.[3] It must be remembered that the overlying soft parts were extremely vascular and perhaps (from the enlarged gland) already involved in the growth. The position of these growths will not always admit of the use of an india-rubber band round the head. In isolating and going wide of the affected bone, it was uncertain whether one or more sutures would not be crossed, and sinuses, such as the superior longitudinal, met with and need securing (this, whether by underrunning or otherwise, not being always an easy matter), thus leading to profuse hæmorrhage. In addition to this source of hæmorrhage there is that certain to be met with in dealing with the soft parts and with the diploe around the affected bone, unless this be extensively sclerosed, when another difficulty presents itself.

Then, supposing the bone sufficiently removed, wide of the growth, in many pieces, either because of its involvement in the disease, or to allow of further investigation in the case of a growth of doubtful origin, if this be found to arise from the dura mater, this membrane must certainly be dealt with, and the same would very likely be the case if, originating in the diploe, the growth had crept inwards. In further isolating the disease, if it had merely pressed upon the brain and not involved it most delicate work would be required; enlarged branches

[1] An interesting case is published by Sir. H. Morris (*Path. Soc. Trans.*, vol. xxxi, p. 259). The disease here certainly took six years in running its course; other deposits were present. The patient died away from London. The growth is stated to have begun in the diploe, and to have compressed, not involved, the brain. Dr. Drummond of Newcastle, published three interesting cases (*Brit. Med. Journ.*, 1883, vol. ii, p. 762). In none of them was operation possible. Other instances of sarcomata of the cranial bones or the dura mater are figured by Tilmanus (*Text-book of Surg.*, vol. ii).

[2] A good instance of such traumatic sarcomata is recorded, with illustrations by Mr. Hewetson, of York (*Lancet*, 1893, vol. i, p. 1441).

[3] The best means of removing bone from the skull on a large scale are given at pp. 311–313.

of the middle meningeal and, very likely, dilated sinuses would require to be dealt with. If the disease had involved, instead of merely displacing, the brain, new and special risks would have to be encountered just when the patient's condition, after an already prolonged operation, was least fitted to bear them. Thus the operator may find that he is dealing with a non-encapsuled growth of the brain itself, and all that he can do is to try and shell it out with the finger or sharp spoon. Lastly, the arrest of all haemorrhage and the possibility of closing the wound and gap in the skull, usually by a second operation, if the patient survive, have to be remembered.

Such are among the chief difficulties and dangers which are very likely, if not certain, to be met with.

Moreover, in these and in other prolonged operations which deal with the brain and its membranes, the fact must never be lost sight of that, with all the necessary interference with vital organs, and what with the anæsthetic, the margin left to the patient between life and death may be a very narrow one. Even if the growth is small and circumscribed, and there is good reason to believe that it is single, it will probably be wiser to divide the operation into two stages if the dura mater be involved.

The results given by von Bergmann,[1] especially when due weight is given to his unusual experience and operative skill, do not seem encouraging. The last sentence referring to "cases apparently permanently cured" is too vague to be of any real value. "The author has done extensive resections in four cases of cranial sarcoma; in one of these the patient died. The tumour had proliferated a considerable depth into the occipital lobe, and the profuse bleeding which resulted caused collapse. The three other patients recovered. Two died at the end of one and a half and two years, respectively, as a result of recurrence of the growth. Regarding the fate of the third, he was not able to obtain any information. Grunberg investigated the histories of all operations published during the last two decades. Twenty-two operations were performed on seventeen patients. In three cases two or more attempts at interference were made necessary by recurrence of the growths. The operation was completed in seventeen cases. Three of the patients died as a result of the operation, death being caused by entrance of air into sinuses, thrombosis of sinuses, and cerebral abscess. In seven cases recurrence took place soon after the operation. In two no information was obtainable. Of seventeen cases five were apparently permanently cured, which is a good result, considering the fatal termination otherwise."

(3) Another similar, but distinct, class of these growths is formed by those *epitheliomata* of the scalp which have extended through the cranium to the dura mater or even the brain. Tillmanns[2] gives good illustrations of two such epitheliomata involving the frontal region: one, in a girl of 14, which perforated the skull, was successfully removed by Braun; the other, in a man of 56, was operated on by Tillmanns. Here recurrence rapidly took place. A very instructive case of carcinoma of the frontal region, involving the skull, was successfully operated on by Mr. Battle and is fully described in the *Clin. Soc. Trans.*, 1899, vol. xxxii, p. 127. Mr. Shattock pronounced the growth to be a spheroidal-celled carcinoma, probably originating in the glandular structures of

[1] *Loc. supra cit.*, p. 148.

[2] *Surg.*, vol. ii.

the skin. Mr. Battle's remarks on the mode chosen for rem[illegible] the cranial bone are very noteworthy :

"Of the principal methods of removing large portions of the skull, the one which was brought to my notice by Messrs. Down—that of a circular saw worked by a motor—appeared the most likely to fulfil the object in a satisfactory manner. There was, however, much difficulty in guiding the saw along the line which I had selected, and it travelled slowly through the dense bone, whilst the cable attached to it was cumbrous and difficult to hold. Were I again called upon to perform a similar operation, or one requiring the excision of much bone, I should use the method, since suggested, of the wire saw, worked across from one trepine opening to another, and applied from within outwards."

CHAPTER XIV

TREPHINING

OPERATIVE INTERFERENCE IMMEDIATE OR LATER[1] IN FRACTURES OF THE SKULL

Indications. The chief are :

(1) *Compound depressed fractures.* Whether symptoms of compression are present or no these fractures should, as a rule, be explored by reflecting adequate flaps, then elevating any depressed fragments and removing any which are quite loose. At the same time the surface of the dura mater, where exposed, should be carefully scrutinized and, together with the rest of the wound, thoroughly cleansed.

Operative interference is indicated in these cases for two reasons : (*a*) Even if no symptoms of compression are present at first, secondary inflammation is very likely to follow in a few days, it not having been possible by expectant treatment completely to cleanse the wound. If, now, some minute fragment of the brittle inner table has pricked the dura mater, fatal infective meningitis is almost certain. Should, therefore, the surgeon, in these cases, wait for evidence of compression as a justification of operative interference, he will too often wait till it is too late. Evidence of the presence of dirt, especially of dirt ground down to, or into, the bone, is a reason for exploring the wound, even if no symptoms of compression are present. (*b*) If the patient recover from the immediate effects of the fracture, injury to the inner table, insufficient to cause symptoms at the time, and not detectable save by an operation, may be present all the time and cause serious future trouble. In the words of Professor Nancrede :[2] "Undoubtedly many patients recover in whom the bone is not elevated, but in too many epilepsy, insanity, chronic cerebral irritation, &c., render life a burden, and operations are then required, which often prove useless.[3] Operations for traumatic epilepsy show at times that in the effort to unite the irregular fragments, and from constant irritation due to the cerebral

[1] By these terms it is intended to make a distinction between those cases in which operative interference is made use of within a few days after a fracture, and those in which it is only employed a long time after the injury. (*See* "Trephining for Traumatic Epilepsy.")

[2] *Intern. Encycl. of Surg.*, vol. v. p. 24.

[3] Dr. Gunn (*Trans. Amer. Surg. Assoc.*, vol. i. p. 89), speaking of later trephining for the relief of old depressed fractures, says "Although results of these secondary operations do not show a flattering percentage of success, I think that the reason may be looked for in the late period at which the operation is performed. It is rare that the patient submits to the operation till years have been wasted in the vain endeavour to effect a cure by medication. In the meantime, the constant irritation has begotten a permanent impression upon the brain and nervous system which remains after the offending point of irritation has been removed."

pulsation driving the dura mater against the bony fragments. Nature throws out osteophytic masses, which eventually perhaps after years set up serious trouble." The surgical treatment of traumatic epilepsy is now, when a large number of cases operated upon have been carefully watched, found to be very disappointing (*see* p. 272). It is by a more frequent immediate exploration of all doubtful injuries to the head that we may best hope to bring about a diminishing frequency of traumatic epilepsy. (*c*) Locality is, of itself, an indication for interference. Thus aphasia may follow on a fracture over the region of the anterior inferior angle of the left parietal, and paresis on one, apparently trivial, over the moto. area. Moreover it is injuries to the frontal and parietal regions which, if left unexplored or insufficiently treated, are so liable to be followed by epilepsy.

A word of warning is needed here. While the more localized is the depression of a fracture over the motor area, the more will the surgeon be justified in interfering; he must not be certain that he will thereby prevent epilepsy in the future. Von Bergmann's words on this matter are weighty ones.[1] "As a matter of fact, epilepsy occurs as frequently in connection with head injuries in which no fracture exists. Depression is no more a factor in the etiology of this disease than any other scar of the brain or external soft parts that has become adherent to the skull. At present it is known that where an act of violence not exceeding the limits of elasticity of the skull flattens or bends in the latter without producing fracture, the portion of brain underlying the point of impact may be contused. The depressed fragment of skull, being elastic, springs back into its former position, but the portion of brain injured at the moment of depression undergoes a sclerotic degeneration from which may originate an attack of Jacksonian epilepsy; the same may take place as the result of damage to the cerebral cortex following depressed fracture."

(2) *Simple depressed fractures.* Where symptoms of depression are present, operative interference is the only course open. But where no such symptoms are present, the expectant treatment is by most surgeons held to be sufficient. We may perhaps come best to a decision as to using operative interference in simple depressed fractures, without symptoms, by dividing them into the three following groups:

(1) Where the depression extends over a considerable area, where it is slight in degree (*e.g.* not more than a sixth of an inch), especially if the patient be young and the bones yielding, expectant treatment is no doubt the best.

(2) But, on the other hand, where the depression is limited and defined, where the depressed fragment not only affects a small area, but is turned down angularly or edgeways, operative interference should be resorted to at once, even though no symptoms are present, and whether there is a wound or no, to prevent the onset of dangers, immediate and remote, fully alluded to later on.

(3) There is a large class of cases intermediate between the above, where the fracture is a simple one, where symptoms are absent, and where the depression is sufficient to cause anxiety, though not so sharply defined as to call imperatively for operation. Here, when in doubt as to the severity of the case, the surgeon, if able to rely on his operative

[1] *Syst. of Pract. Surg., Amer. Trans.*, by Dr. Bull and Dr. Martin, vol. i, p. 98.

skill and on the wound running an aseptic course, will do best to explore the fracture. This is especially the case in fractures of the frontal and parietal regions, owing to the frequency with which these are followed, at a later date, by epilepsy.

Finally, in any fracture in which the question of operative interference arises, the kind of violence must be remembered. Was this concentrated over a small area, and thus likely to bring about serious depression and comminution of the internal table, or was it indirect and diffuse, and thus likely to have produced a long fissure-fracture with little depression, but perhaps tearing open meningeal vessels or sinuses, opening up the middle ear, nose, or pharynx, and spreading far into the base?

Influence of site. It is often said that a depressed fracture, even if distinctly marked, over the frontal sinuses, does not require operative interference, and that any such steps should be avoided for fear of leaving a fistulous opening leading to passage of air and troublesome emphysema. But it must be remembered that these sinuses do not appear before the age of fifteen or sixteen, and that, even in adult skulls, the extent of their development is most uncertain, the sinuses being sometimes represented by a small unilateral cell instead of fair-sized bilateral cavities. Other sites, which it is well to avoid in trephining, if possible, are the positions of large venous sinuses,[1] that of the trunk and chief branches of the middle meningeal artery[2] and also the lines of the sutures, apart from any subjacent sinuses, as here the dura mater is firmly attached unless it chance to be loosened by a violent blow. Age, too, must have proper weight attached to it, it being well known that in the first few years of life a very considerable depression may take place after an injury, and yet be followed by absence of head symptoms and by spontaneous recovery.

(3) *Punctured fractures.* Here, however slight be the injury to the outer table, that inflicted upon the inner is certain to be much more serious. And the more the diploe is present, the more extensive will be the damage which its fragments, when driven down, will inflict upon the brittle inner table. It must be remembered that punctured fractures, with all their serious results, may be caused by blunt, though pointed, bodies as well as by sharp ones. Instances of these are, blows with a pickaxe, fragments of coal or stone, the trigger of a clubbed gun, or falls on a fender ornament. Immediate operative interference—and here owing to the limited injury to the outer table the trephine will be called for—is imperatively demanded in all punctured fractures, however insignificant be the damage to the scalp and outer table. The

[1] It is worth while to bear in mind that if a large venous sinus is opened, the haemorrhage can be, usually, at once arrested by very moderate pressure applied at the right spot. The pressure should at first be made by the finger, and kept up if needful by a strip of sterilised gauze left *in situ* for two or three days. Sir H. Cameron (*Lancet*, 1884, vol. i, p. 931) was able to complete a trephining while very slight pressure with lint controlled the bleeding from a wound in the superior longitudinal sinus. He points out that the imaginary fear of fatal haemorrhage may at times deter from a necessary operation with the trephine and it is well that it should be dissipated. Dr. Hopkins (*Ann. of Surg.*, vol. ii, p. 67) in a case of extensive compound fracture of the skull, found that a small lint plug, lightly applied to a wound in the superior longitudinal sinus exposed by elevation of fragments, readily arrested the haemorrhage, which persevering efforts had failed to control by a ligature. The strictest precautions should be taken when dealing with wounds of these sinuses owing to the risk of septic phlebitis and pyaemia.

[2] The treatment of haemorrhage from the middle meningeal artery is given at p. 262.

dangers of injury to the dura mater and septic infection must also be borne in mind. The following is an instructive case:

A child aged twenty months was left alone by its mother sitting in a chair. There were a number of articles left littered about on the floor among which was a metal boot-toe protector provided with three sharp points for its attachment to the sole of the boot. The child fell to the floor, striking the boot protector, which was firmly driven into its forehead. On admission to the hospital the plate was levered away and investigation with a probe showed that the outer of two punctures had reached the bone. The wound was accordingly explored and it was then found that the bone was perforated. The nail-like points were so short that it was thought that the dura mater could not possibly be damaged. The wound was therefore cleaned and drained without trephining. Three days later the child had severe convulsions, when the wound was again opened up and a disc of bone removed. The dura mater, which was inflamed and perforated, was freely incised, when some pus escaped. Unfortunately this was not localised, and the child died next day with diffuse suppurative meningitis.

(4) *In some cases of fracture about the inner angle of the orbit.* These grave injuries which may be caused by direct violence from thrust wounds at the inner angle of the orbit, or root of the nose, *e.g.* with scissors, slate pencils, ferrules of walking-sticks, &c., should always be explored at once.

An incision should be made from without inwards along the supra-orbital arch, just below the eyebrow, to a point within the puncture; a flap should be turned down, the eyeball gently depressed, and the inner wall of the orbit and adjacent parts carefully chipped away with a small chisel or gouge. The hæmorrhage from the angular vessels may be troublesome. Any foreign body or infective material is thoroughly removed; the dura mater is also inspected. If this be lacerated it should be thoroughly exposed, the damaged part excised, and the subjacent brain carefully cleansed with sterilised saline solution. The cavity is then drained with sterilised gauze, a drainage tube being used as well if needful. The dressings are changed daily, and if there is much discharge, hot boracic fomentations may be employed.

The apparent slightness of these injuries, the trifling wound owing to the mobility of the skin and the slightness or absence of any sub-conjunctival hæmorrhage, the wound may appear not to have perforated the orbit the period of latency of symptoms, and the onset of fatal brain mischief inevitable, though delayed, if let alone —should always be remembered when dealing with these injuries. Especially misleading are those cases in which an instrument has slipped under the lid, reaching the roof of the orbit and the base of the skull, leaving, it may be, merely a patch of ecchymosis on the conjunctiva.

(5) *For the removal of foreign bodies fissuring or fracturing the skull.* These are rare, *e.g.* penknife-blades, pieces of stone, bullets, &c. To ensure certainty of complete removal the trephine will usually be required. The following case of Professor Nancrede's shows how the gravest results may ultimately follow on the overlooking of a small piece of knife-blade. The apparent slightness of the injury, the long absence of symptoms, then their sudden onset, the difficulties met with during trephining, the results of promptly meeting them, and finally death, due to a hernia cerebri, are all deserving of careful attention.

J. Y., æt. 19, walked into the Episcopal Hospital, complaining of a sore on the top of his head, the result of a blow received two months previously. On examining the wound, in the centre of an ulcer, corresponding in position to the centre of the left parietal lobe, was found the broken end of a knife-blade. On being told of this he seemed thoroughly surprised. But little could be made out as regards the incidents of the attack, except that a man had struck him on the top of the head so forcibly that he had fallen on his hands and knees, but that he had recovered himself almost immediately. He said that he did not, at that time or afterwards, lose consciousness, nor had he suffered from headache. He did not complain of any pain or uncomfortable sensation when the knife-blade was removed, but in the afternoon of the same day he had slight pains in the head. The following day the temperature was 101°, and slight retinal hyperæmia was noticed. Epileptiform seizures set in next day, beginning with twitching of the right arm, but soon becoming general. The bone was trephined over the seat of injury, and the portion removed showed a slight depression of the inner table. The position which the blade had occupied could be seen in the dura mater, there being an opening surrounded with dense cicatricial tissue. The dura mater did not seem to be congested, and there was evidently no pus or fluid beneath it. During the next three weeks the fits ceased, but symptoms indicating cerebral abscess—viz., temperature subnormal, slow pulse, marked mental dulness—set in. The patient then developed right hemiplegia and became unconscious. The flap covering the trephine hole was reflected and was found to be occupied by the tense dura mater, pulsating strongly. It was incised and an aspirating needle introduced in several places but without success. Feeling convinced that pus was present, Prof. Nancrede trephined in front of and below the first opening, which was slightly behind the fissure of Rolando. Before the skull was divided both pulse and respiration ceased. The operation being rapidly completed, the dura mater was here incised without result. At this moment pus was observed to be oozing from one of the aspirator punctures. A knife being plunged into the brain substance, from one to two ounces of pus were evacuated. The patient revived after vigorous and prolonged artificial respiration. The next day a hernia cerebri as large as a walnut was protruding from the wound in the dura mater. This increased in size, and broke down, the patient dying four days later. At the autopsy the left parietal lobe contained an enormous abscess cavity which had destroyed the greater portion of the upper part of the left hemisphere.

TREPHINING[1] IN FRACTURED SKULL (Figs. 119, 120)

The scalp having been shaved and thoroughly cleansed, the patient anæsthetised with C.E. or chloroform,[2] unless a condition of unconsciousness renders this unnecessary; the head is supported on sand bags at a convenient height. The fracture is next exposed, the old-fashioned crucial, T- or Y-shaped incisions being now, when possible replaced by the semilunar flap of Sir V. Horsley. The flap should be so arranged as to fully expose the field of operation on the skull. Its base is usually below to ensure a good blood-supply. The incision goes down to the bone, and the pericranium is divided, with the flap raised cleanly and uniformly with an elevator. If it be needful to operate through the temporal muscle, its fibres must be sufficiently severed and raised with the flaps, it being somewhat more difficult to separate

[1] It has been already stated that in many cases of depressed fractures, after exposure of the fragments, a pair of dressing-forceps and an elevator may do all that is required. Where no trephine is at hand, a chisel and mallet should be used. As soon as the dura is exposed, the proper cranial chisel with a shoulder (Fig. 127) is always to be preferred. That the trephine itself is not always needed should be clearly understood, as it is probable that elevation of fragments might often most wisely have been performed had it not been for the absence of a special instrument, wrongly supposed to be essential.

[2] These anæsthetics are to be preferred in cases of trephining, on account of the greater excitement and congestion which are usually associated with ether. But whenever it is possible, and especially when the pulse and breathing are falling, anæsthetics should be dispensed with. Where there is any tendency to drowsiness or coma "the anæsthetist should attempt to secure an analgesic rather than a true anæsthetic state" (*Hewitt Anæsthetics and their Administration*, p. 54).

the periosteum here, on account of its thinness in this region, and more intimate adhesion to the subjacent bones.[1] In reflecting the flaps, free hæmorrhage is nearly always met with, especially in the case of the chief superficial trunks and the deep temporal arteries, but this is promptly and easily arrested by the use of Spencer-Wells's or Lane's forceps, which act as most useful retractors, taking up but little room while at the same time they arrest the hæmorrhage. It is always difficult, owing to the density of the tissues, to take up the vessels neatly here. It is quite permissible, especially in urgent cases, to take up the whole thickness of the flap. Owing to its vascularity it will not slough. No sutures should be inserted just at those spots where the forceps have

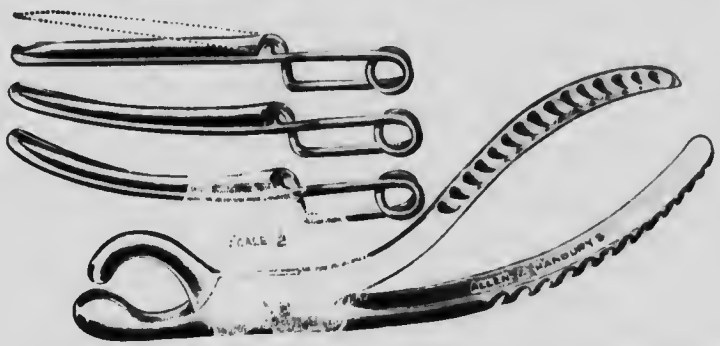


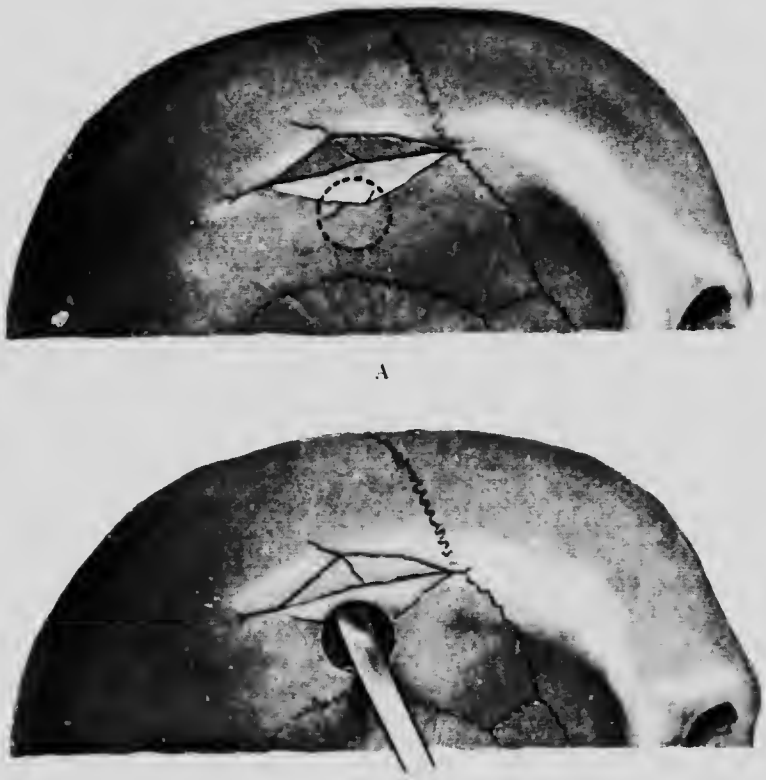
FIG. 118. Makka's clamps for control of hæmorrhage from the scalp during trephining. On the right is figured the forceps for manipulating the clamps.

been applied. Another excellent method of temporarily controlling hæmorrhage from the scalp in these cases is by the use of Makka's clamps (Fig. 118). One blade of each clamp has a sharp point which is pushed between the soft parts of the bone; the other blade is on the surface of the scalp. The vessels are thus firmly compressed. If bleeding continues from any crack in the bone which may now be found, it will only cease on the elevation of the fragment, or on the exposure of, and the dealing with any subjacent clot. The fracture being now in view, if it be found impossible to introduce an elevator, strong dressing or sequestrum-forceps, even after sawing off any projecting angle of bone, the surgeon must decide where to place his trephine. In doing so, he must choose a spot, if possible, clear of a sinus (*see* p. 252) or large branch of the middle meningeal artery (*see* p. 273),[2] and one which will at the same time support firmly the pressure needed in the working of the trephine. Thus the pin and greater part of the trephine-crown are placed on sound bone (Fig. 119), while a small part of the trephine usually overhangs a depressed fragment. But if the surgeon fears that the fragments are in contact with the dura mater, and perhaps injuring it, and that the jarring movement of the trephine coming in contact with one may be pernicious, he will so place his trephine that it rests entirely on sound bone, any intervening ridge being easily cut away.

[1] The greater thickness of the soft parts which will here form the cicatrix will, in a measure, make up for the difficulty in preserving the periosteum.

[2] If it is really needful to trephine over one of these vessels the remarks at p. 266, will show how the hæmorrhage should be met.

A spot being thus chosen, a trephine of about one inch in diameter is taken with the centre-pin protruded for about a tenth of an inch, and firmly fixed in this position, the trephine being so grasped in the hand that the index finger steadies the centre-pin screw when the bone is entered. The instrument is now firmly applied to the bone, the centre-pin being bored inwards, and as soon as the teeth feel the bone



A

B

FIG. 119.—A shows a depressed "gutter" fracture in the right parietal bone. The dotted circle indicates the disc to be removed by the trephine. B. The disc has been removed and the depressed fragments are levered into position by means of an elevator.

the trephine is worked from left to right and then from right to left, care being taken to exert equal pressure in both directions. While the first groove is being cut, the movements of the trephine must be light and quick, but without jerking, the tendency of the instrument to slip being met by steady bearing on the centre-pin, and by keeping the left forefinger at first on the bone close to the trephine.

As soon as a groove sufficient to keep the trephine steady has been cut, the pin is drawn upwards, and there fixed. The rotatory movements alternating from side to side are now continued, care being taken to bear as evenly as possible on every part of the circle, till the diploe[1]

[1] This is absent or deficient in early life and in the aged. Also, over a large part of the squamous bone and in the occipital fossæ, diploe is never met with.

(if this is present) is reached. This is known by the easier working of the instrument and by the softer sound. On the living body at least, owing to the oozing from the vascular parts around, the blood-staining of the bone-dust described as taking place at this stage is liable to be fallacious.

Throughout the operation, but especially now as the thinner table is being reached, every care must be taken to keep the circle of equal depth: (1) By pressing on the saw evenly; (2) by making it bite in equally from right to left and from left to right; (3) by remembering that, owing to the skull being spheroidal in shape, it is impossible, without the greatest care, to keep the groove of equal depth all round; (4) by bearing in mind that while the average thickness of the adult skull is one-fifth of an inch, the thickness varies so much that it is almost always greater at one part of a trephine-circle than at another.

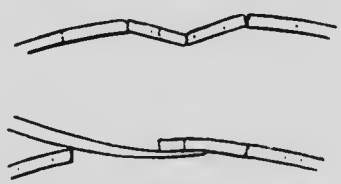


FIG. 120. A, Section of a depressed fracture. B, Elevation of the depressed fragments by means of an elevator introduced through a trephine opening.

Thus at frequent intervals the flat end of a sterilised trephine-probe must be carefully introduced at different spots, and when the circle is found to be deeper on one side (still more if it is perforated) the trephine must be slanted so that its teeth are only cutting on that part of the groove which is still shallow. When the groove has been made sufficiently deep, and careful examination finds three or four points of penetration, the bone may be removed by inserting the elevator at the deepest part of the groove and lifting up the disc of bone by carefully making a fulcrum of the sound bone on of a finger. An elevator is then gently insinuated between the depressed bone and the dura mater, and the depressed area levered into position. Any loose fragments are removed and preserved in sterilised saline solution. If profuse hæmorrhage occur on raising either the disc of bone or a depressed fragment, it will probably come either from a branch of the middle meningeal artery or from a sinus. The treatment of the former is given at p. 265: in the latter case pressure should be at once applied by means of a pledget of sterilised gauze; if this has to be left *in situ* beneath an edge of bone to control the bleeding, a ligature of sterilised silk or catgut should be fastened on to it, to secure its withdrawal in about three days' time (*see* p. 252).

In the case of a punctured fracture, a full-sized inch trephine should be applied, so as to remove the outer table around the immediate neighbourhood of the puncture, and thus expose freely the damage to the inner table.

If after removing a crown of bone more room is still required, this may be obtained either by taking out a second crown close by, and joining the two, or by the use of a Hey's saw or the forceps of De Vilbiss (*see* p. 312), or of Hoffman's forceps, or Lane's skull forceps.

Sufficient drainage must be provided in those cases which require it, *e.g.* where infection is present, or where a large cavity is left under the flap, in which fluid will collect. Any drainage-tube used should be brought through the lowest part of the flap, by puncture if needful, and stitched to the skin.

Where it has been needful to remove bone extensively the question

will arise as to the best means of diminishing the gap. In many cases the trephine-crown or bone fragments, so long as these are not too small, unite readily if they have been kept in a hot, sterile saline solution, the temperature of which has been maintained. In many cases, often when their survival is most desired, they fail to unite. They cannot be used in compound fractures, where they are perhaps infected; or in cases where the dura mater and brain have been injured and any cavity or irregular surface exists. In cases of trephining for traumatic epilepsy their replacement would be injudicious, it being here desirable to leave a safety-valve for the relief of future varying tension. Where the scalp has been extensively destroyed the surgeon may, if the patient's condition permit of it, diminish or close the gap by means of one or more pedunculated flaps.

But, as a rule, this will be left to a later stage. German surgeons, König and Müller, have advised that such flaps, for the better protection of the brain, should be raised with periosteum and the outer table, by holding the chisel horizontally. This is a severe operation, and only possible where the bone is well developed. It cannot be employed in children owing to the non-development of the diploe. Another method is the employment of grafts of decalcified bone, recommended by Senn. Here all scar tissue and the edges of the adjacent bone must be completely removed, so that the graft will fit accurately with the cavities of the diploe round the margin of the fracture. The graft must be covered with the scalp, by a pedunculated flap, if needful, and strict asepis is necessary for success.

The above remarks refer to conditions which call for immediate or primary trephining.

The following will be amongst the intermediate or secondary conditions which may suggest trephining some days or weeks after an injury to the skull, where there is no definite evidence of fracture. Long continued unconsciousness, as when this lasts over twenty-four hours, no other cause than the injury being present. Convulsions, especially if localised and associated with aphasia. Paralysis, especially if marked and occurring in adults. Dennis[1] refers to a case of a child who fell on the pavement from a third story, sustaining an indented fracture of the parietal bone.

> The compression was sufficient to produce hemiplegia of the opposite side and deep coma. Dennis so manipulated the sides of the head as to cause the indentation entirely to disappear. As soon as the bone sprang back to its normal position the child passed at once from deep coma into complete consciousness, and the hemiplegia instantly disappeared.

The possibility of a linear fracture causing a depression of the inner table has often been overlooked. Messrs. Shield and Shaw report[2] an interesting case of this kind.

> The patient, a healthy man, æt. 30, sustained a scalp wound in the left frontal region. No fracture was found, and the man was confined to bed for a short time for concussion. He was perfectly well for some weeks, but about a month after the injury he began to suffer from pain in the head, loss of memory, and sudden bursts of passion. He gradually reached a condition of dementia. There being no history of alcoholic excess or syphilis, the symptoms appeared to be directly due to the injury. Shaw trephined at the seat of injury and found a healed linear fracture with a depression of the inner table. The operation was immediately followed by a most marked improvement. The patient ultimately recovered.

[1] *Med. News*, March 21, 1903.

[2] *Lancet*, February 14, 1903.

It is especially under the thickness of the temporal muscle, itself swollen with extravasated blood, and the soft parts over it bruised and tender, and thus interfering with the accuracy of diagnosis, that the existence of a depressed fracture must be remembered, when an altered mental condition, dulness, &c., and, if on the left side, aphasia, supervene some time after an injury.

Traumatic cerebral abscess (p. 261). Suppuration between the bone and the dura mater, which is considered in the next section. Cases of hæmorrhagic pachy-meningitis, which occasionally follow on trauma and give rise to pressure symptoms which demand operative interference.

TREPHINING FOR PUS BETWEEN THE SKULL AND DURA MATER

While the mode of using the trephine here will in no way differ from that already given, a few practical remarks will be made on this most important condition.

Operative interference here, while less frequently called for, owing to the improvements of modern surgery, especially the antiseptic treatment of scalp wounds, has also been less successful than it would appear to have been a hundred years ago, when Pott drew the attention of surgeons to the need of trephining when pus was present immediately beneath the skull. For while Pott, in his day, saved five out of eight of these cases in which he trephined, surgeons of later days, when they have trephined, have been usually baffled by the co-existence of pyæmia owing to an infective osteo-myelitis and phlebitis of the veins of the diploe, or if this ominous complication be absent, by finding the collection of pus not localised between the bone and dura mater or, if so localised, combined with suppurative arachnitis also.

When it is remembered that pus does not form between the bone and dura mater without a previous stage of infective osteitis and phlebitis of the veins of the diploe, it will readily be understood how easily, if the wound be contaminated, infective osteo-myelitis and phlebitis, with the inevitable result of pyæmia, will follow.

Indications of the formation of pus between the bone and dura mater: question of trephining. There will usually be a history of injury to the head with damage of some kind to the outer table. Thus there is frequently a scalp wound exposing the pericranium, often opening this up though this may have escaped observation at the time; occasionally the bone itself is laid bare by the injury. Sometimes, however, contusion of the soft tissues and the pericranium alone may be the starting-point of a septic osteo-myelitis without any open wound. Either now or later on, the wound becomes infected. After a varying period, usually in the course of the second week after the injury (during which period definite symptoms are often absent), headache, fretfulness, nausea or vomiting are gradually followed by drowsiness, delirium, twitchings, convulsions, paralysis, coma and death.

This onrush of symptoms about the eighth or tenth day may be accompanied by evidence of pyæmia, viz. rigors followed by sweating, a jactitating temperature, progressive emaciation and affections of viscera and joints, amongst which pleuro-pneumonia is one of the most frequent and grave.

The surgeon who is watching a case of this kind, and who is also

not unmindful of what has happened and what is liable to be going on—the injury to the pericranium and bone, the osteitis and osteo-myelitis with plugging of the diploic veins, the extension to the inner table, the formation between the bone and the dura mater of lymph ready to suppurate, this deep-seated inflammation being only too ready to extend to the arachnoid and thus become a diffuse meningitis—will find it a matter of much difficulty to answer the questions: How far has the mischief gone? Is the case a hopeless one? If the intracranial collection of pus be a localized one and uncomplicated, well-marked hemiplegia and the absence of pyæmic symptoms will call hopefully for trephining. On the other hand paralysis, indistinct or complete, epileptiform convulsions, extreme irritability, and especially any evidence of involvement of nerves at the base, will all point to that form of meningitis which will show itself as a diffuse layer of pus and lymph over one side of the arachnoid.

Equally pointing to a fatal issue will be the symptoms of pyæmia already alluded to, and needing no further mention here.

What is to be done in these cases? Where the evidence of meningitis is undoubted, of some days standing, where the hemiplegia has been little marked, or where it is replaced by paraplegia, general convulsions, and other unfavourable signs, trephining is not likely to be successful.

Should evidence of co-existing pyæmia be looked upon as equally hopeless and equally negativing the use of the trephine? Every surgeon knows that, although pyæmia is usually fatal, it occasionally ends favourably. Again, in treating pyæmia resulting from periostitis and osteo-myelitis elsewhere, we are not deterred from making free incisions and exploring the bone. The right **treatment** of these cases is, of course, preventive, *i.e.* every scalp wound should be rendered aseptic and kept so from the very first, however slight it seems to be. But, as this precaution is not always taken, and is occasionally impossible, the condition of the pericranium and the bone should be explored earlier, at the very first warning of danger. Instead of treating such a case as a special result of head injury and waiting for evidence of pus between the bone and dura mater, we should deal with it as we do with osteitis and periostitis elsewhere; that is to say, that in cases of this kind where there is reason to believe that the bone has been injured, especially if there be any doubt as to the condition of the wound throughout, the surgeon should, on the very first appearance of malaise, irritability, headache, nausea, or chilliness explore the wound. Any granulations present will very likely be at a standstill. A piece of bone will probably be bare and perhaps soft, the pericranium infiltrated and separating. The whole area of bone which is affected should be explored. This is done by removing the outer table and exposing the diploe with a gouge or chisel. Wherever infiltration with pus or undue reddening is present, the diseased condition must be followed up. If necessary the bone must be freely removed with a trephine and Hoffman's forceps. The state of the dura mater must be ascertained in every case where lymph or pus is present. Free drainage must be secured by removing the whole thickness of the bone over the diseased membrane as widely as possible. Where the patient's condition admits of it and where this step is indicated by the symptoms any of the sinuses that are adjacent to the area of operation and which can be reached should be explored and, if infected, treated on the lines

given at p. 359. In any case all infective granulation tissue must be removed and free drainage must be provided. The possible co-existence of a cerebral abscess must not be forgotten (*see* p. 254).

The above depends on the fixed conviction that trephining, in careful hands and with due precautions, is not in itself a dangerous operation, and on the fact, which is beyond dispute, that, if these cases are left till hemiplegia announces the existence of intracranial pus, they will, too often, be left too long, as this waiting will give time for the onset of pyæmic infection and for the arachnoid to be involved in the inflammation.

The operation of trephining here will in no way differ from that already described. Pus welling up from the diploe, or a fœtid condition of this, is ominously suggestive of impending pyæmia. If such a condition be present, the bone should be freely removed and disinfected as far as possible; but the outlook, from the probable extension of the thrombi to the sinuses, is a very dark one. If pus be present between the bone and the dura mater, it must be thoroughly evacuated and freely drained.[1] The condition of the dura mater should always be examined, whether pus be found superficial to it or no. If it pulsate freely and be natural in appearance, nothing more need be done. If, on the other hand, it bulge into the trephine hole and does not pulsate, it should be punctured, this perhaps giving vent to a jet of purulent fluid from the arachnoid cavity. If the arachnoid is seen to be covered with lymph this is of the gravest omen. More bone must be removed or a second trephine disc removed at the most dependent part, the dura mater again opened here, and irrigation employed.

The following cases are good examples of this most dangerous condition of osteitis of the cranium and its sequelæ and complications: The first case, one of Mr. Hutchinson's, shows much arachnitis and no general pyæmic infection. The second shows both arachnitis and pyæmia combined. In both pus was present between the bone and the dura mater.

E. S., æt. 10, was admitted, July 21, into the London Hospital with extensive laceration of the scalp on the left side, laying bare the parietal bone. During the first few days he seemed to be doing well. July 26: Bone as large as a crown piece is exposed white and dry above the left ear. July 29: A strong rigor; wound not granulating. July 31: Very restless. Uses all his limbs at times, but the left ones better than the right. August 1: The skull was trephined in the middle of the exposed bone two inches above the left ear. The dura mater was covered with yellow lymph, but pulsated freely. On cutting through it about ʒj of thin purulent fluid escaped. The arachnoid was seen to be covered with lymph. August 2: There is still paralysis of the right hand. When the brain, which bulged, pulsating, into the wound was pressed back, pus in considerable quantity escaped from the arachnoid cavity. Death took place on August 3. The cone around the trephine aperture was dry and green. On the left side the arachnoid was covered with a thick deposit of purulent lymph, while on the right side it was normal. The superior longitudinal sinus contained puriform fluid. The skull at the seat of injury was discoloured over an extent almost as large as the palm of the hand; adjacent to it were other patches, greenish-yellow, and non-vascular. There were no pyæmic abscesses in any of the viscera.

E. S., æt. 40, was admitted into Guy's Hospital under Sir H. Howse on January 22, 1877, with a scalp wound four inches long, exposing the right parietal bone. The discharge became offensive and erysipelas of the scalp set in. At this time almost the entire right parietal bone was exposed owing to sloughing of the

[1] In these cases, and in fact, in any trephining cases where the discharges are infected, hot boracic fomentations, frequently changed, are preferable to dry dressings changed less frequently.

pericranium. Incisions were made where needful, drainage tubes introduced, and in a few days the erysipelas had subsided and the wound was sweet. February 11: She had a rigor for the first time. February 13: The temperature was 104; there was some paralysis of the left side of the face and the left limbs. February 15: The hemiplegia becoming more marked the skull was trephined about one inch above the right parietal eminence. Pus was found in the diploe. On removing the disc of bone, about ʒj of thick, foul, greenish pus welled up. The inner surface of the bone was rough, the dura mater, which corresponded to it, being covered with velvety granulations. As the dura mater did not pulsate it was punctured but without result. The patient became more conscious after the operation, but soon relapsed into a semi-conscious state. Convulsive seizures of all the limbs, with twitchings of both sides of the face, then set in, and continued until the patient's death on February 17. The parietal bone was in a necrotic condition for a considerable area, the diploe being green and offensive. The pus seemed to have drained from the extra-dural space, but there was suppurative arachnitis over the right hemisphere, reaching to the falx in one direction and towards the base in the other. There were numerous pyæmic abscesses in the lungs and liver.

In the following case Sir W. MacEwen[1] was more fortunate. The case was one of extra-dural suppuration with pachymeningitis, exhibiting Pott's "puffy tumour," and originating in infective bruising of the scalp and deeper tissues, but here the pachymeningitis was fortunately limited and pyæmia absent.

J. R., æt. 45, received from the shaft of a cart, a severe blow on the left side of the vertex, about an inch from the mid line. He was subsequently able to work for a week without feeling anything wrong except slight pain at the seat of injury. Later on he felt feverish, the pain, which was of a dull character, increased, and was accompanied by occasional sharp stabs over the vertex. He also had great headache and prostration. There was a distinct puffy tumour over the seat of the injury. The swelling, the patient declared, appeared three weeks after the accident and after it formed he had some relief from the pain. The primary swelling from the bruising had subsided some weeks before the puffy swelling appeared. On incision the skull was found bare, a small quantity of semi-purulent exudation bathing the bone. The diploe was filled with granulation tissue, which could be traced in small portions penetrating the bone, both through the external and almost through the internal table of the skull, which was dark in colour. Between the internal plate and the dura there was a considerable layer of freshly formed granulation tissue, bathed in purulent exudation. The patient's symptoms quickly cleared up after the operation.

TREPHINING FOR MIDDLE MENINGEAL HÆMORRHAGE

(Figs. 121, 122)

Indications. When a patient, after receiving an injury to the head, has shown some of the symptoms given below.

It is noteworthy that the injury and amount of violence vary extremely. While most frequently serious, as in falls on the head, the violence may be extremely slight, for example, a patient slipping while going downstairs and striking his head against the wall, a boy receiving a blow from a cricket ball, or a child having a trifling fall from a swing. From this the following conclusions may be drawn: (*a*) That in cases of severer violence, laceration or contusion of the brain are only too frequently complications. (*b*) Where the violence has been slighter, either no fracture may be present or, if one be present, it is often only a mere fissure and may involve the internal table only. It is a point of practical importance that the slighter the injury the less likely are the soft parts to show any damage. This has led, in some cases, to the injury being overlooked.

(1) *Interval of consciousness or lucidity.* Typically the injury to the

[1] *Pyogenic Diseases of the Brain and Spinal Cord*, p. 289.

head is followed by the symptoms of concussion: These may be but slightly marked and quickly disappear. Then, after an interval, during which symptoms may be slight or even absent, the patient gradually passes into a condition of deep coma. This interval between the concussion and the onset of compression varies, when present, from a few minutes to several hours. In about half the cases it is well marked. In a second group it is but little marked and may be easily overlooked. In a third and last set of cases this interval is never present at all owing to (1) the presence of a very large hæmorrhage, producing compression symptoms at once; (2) co-existing depression of bone; (3) co-existing injury to the brain; (4) drunkenness of the patient.

(2) *Condition of the limbs as to hemiplegia, paralysis, rigidity, &c.* Hemiplegia, though well marked in a large proportion of cases, must not be looked upon as essential, and middle meningeal hæmorrhage must not be overlooked because hemiplegia is absent, ill-marked, or replaced by some other condition of the limbs. At least the following seven conditions of the limbs may be met with in middle meningeal hæmorrhage:

(*a*) Hemiplegia present and well marked, the leg or arm, and usually both, when taken up and let go, dropping without any resistance. This condition is present in probably one-third of the cases. It is noteworthy that occasionally the hemiplegia is on the same side as that injured, the extravasation taking place on the side opposite to that struck.

(*b*) Hemiplegia present, but little marked. In these cases, which are not uncommon, the extravasation may be overlooked. They fall into at least two divisions. In one the hemiplegia is little marked throughout, due, perhaps, to some power of accommodation on the part of the brain or to the circulation remaining feeble owing to co-existing shock from the time of injury to the moment of death. In another group of cases the hemiplegia is ill-marked because of brief duration, coming on as it does in these cases towards the close, together with coma, giving but little warning and leaving but short time for interference.

When there is any doubt as to the existence or degree of hemiplegia, the following tests should be carefully made use of: whether the patient resists on the surgeon attempting to move the limbs; the power of the grasp; the result of a needle prick; whether the patient moves either of his hands, or which of them, when the cornea is carefully touched, or the cilia gently pulled.

(*c*) Hemiplegia present, but temporary. A very rare condition, produced probably by the brain being able to accommodate itself to the pressure of the effused blood.

(*d*) Monoplegia, or the paralysis more marked in one limb than the other. While a large hæmorrhage generally makes pressure upon all the motor area, von Bergmann and Kronlein point out that the opposite arm is the part affected first and most, the branches of the artery having become quite small by the time they reach the centre for the leg.

(*e*) General paralysis. Another rare condition, the existence of which may be explained by a very large clot, *e.g.* on the left side rapidly effused and making pressure through the left side of the brain, upon the right as well—or by co-existing extravasation into the brain substance itself.

(*f*) Absence of any paralysis. A very rare condition and one which is, perhaps, due to the blood effused finding its way through a fracture in the skull beneath the scalp (*see* footnote, p. 265). Another explanation may be that the clot is posterior to the motor area, of the rarer parieto-occipital and not the more frequent tempero-parietal variety.

(*g*) Limbs rigid, convulsed, or twitching. It is only too probable here that, in addition to middle meningeal extravasation, contusion or laceration of the brain substance will be found at more spots than one.

(3) *Condition of the pupils.* Whilst this may vary, there are at least three conditions which are most important.

(*a*) In an uncomplicated case of compression from middle meningeal hæmorrhage the pupil on the injured side, after an initial transitory contraction, becomes dilated and fixed, *i.e.* does not react to light. The pupil of the opposite side, which at first is normal in size and reacts to light, also becomes dilated and fixed in the later stages. When present, this condition of the pupils is a most valuable sign of the existence of compression, and also affords important information as to the side affected. Its value and explanation were first pointed out by Sir Jonathan Hutchinson.[1]

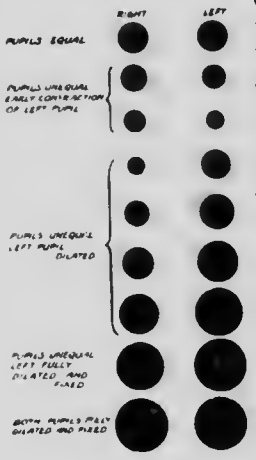


FIG. 121. Typical condition of pupils in left middle meningeal hæmorrhage.

(*b*) If the pupils are natural as regards reaction to light, the compression of the brain is probably recoverable if trephining be immediately performed. Further, it is more likely to be a case of compression of the brain only without other injury.

(*c*) If the pupils are insensitive, often at the same time dilated, the compression is probably extreme, and, while trephining is urgently called for, it is less likely that in these cases the brain will recover itself after removal of the clot.

(4) *The pulse.* This will vary according as the case is one of well-marked, uncomplicated extravasation, or complicated with contusion or laceration of the brain; and, if the concussion stage has been severe, according to the degree to which the heart has recovered from this. In well-marked uncomplicated compression the pulse will be slower than normal, *e.g.* 66, 52, or even slower, and usually full and labouring. If, later, a pulse which has been typically slow becomes very rapid it means that the final stage of paralysis of the vagus has set in and that a fatal termination is imminent.

(5) *Coma.* With regard to this the following points should be borne in mind:

(*a*) The degree of unconsciousness will vary with the size of the branch injured, and the rapidity with which the blood is effused. Where the effusion is rapid and the compression great, the coma may be as deep and complete as in apoplexy. But, in other cases, it will be found that though the coma is apparently deep, this is not really so; thus the patient may moan constantly or may move his limbs feebly when disturbed.

(*b*) The commencing coma may be taken for natural sleep or

[1] *London Hospital Reports*, 1867, vol. iv, p. 29.

drunkenness, in which condition the patient may be allowed to lie until it is too late.

(c) In a few cases the onset of the coma is deferred till late; its onset is here sudden, its course rapid, and it generally ends in death.

(6) *Respiration.* This, in well-marked cases, is often stertorous and somewhat slow. In cases where stertor has not supervened to call attention to the existence of compression, other and still graver alterations in the breathing may be present, alterations which are warnings that the end is not far off and that, in the case of intended trephining, there is no time to lose, viz. cachexy, short respirations, cyanosis, and gasping, irregular breathing, ceasing for intervals of ten or fifteen seconds and then repeated.

(7) *State of the scalp.* When the history is deficient, or when the signs of compression are not well marked, ecchymosis or contusion of the parietal and temporary regions, giving rise to a pappy or puffy feel, are of great value. This condition will be especially marked when the hæmorrhage from the middle meningeal artery is finding its way through some fissure into the tissues of the scalp.[1]

Treatment. Early trephining should be performed as follows: The scalp should be shaved widely as much bone may require removal. No anæsthetic should be given if the patient is unconscious or the respiration failing. If any be employed the greatest care must be taken on account of the risk of vomiting and aspiration-pneumonia. The head being supported on sand bags or a firm pillow, the middle meningeal area[2] on the side which is bruised, and on the side opposite to the hemiplegia, is explored by turning down a semilunar flap, the centre of which is one and a half inches behind the external angular process and one inch above the zygoma—roughly speaking, two fingers' breadth above the zygoma and about the same behind the external angular process (Fig. 122, p. 273). Kronlein distinguishes, according to the point of rupture, three hæmatomata—an anterior, fronto-temporal; middle, temporo-parietal; and posterior, or parieto-occipital. He advises trephining first at the usual place; if no hæmatoma be found here, a second perforation should be made further back, a little above and behind the ear, or, more accurately, at the inter-section of a line drawn backwards from the upper margin of the orbit with a vertical one carried up directly behind the mastoid process. Enlargement of either of these openings

[1] [illegible]re is a good specimen of this in the St. George's Hospital Museum, figured by Mr. H[illegible] in his *Surgery*, 4th ed., p. 140. It shows the parietal bone of a child, in which a ga[illegible]ssure crosses the middle meningeal artery, producing considerable extravasation insi[illegible]he skull and still more externally.

[2] L. B. Rawlings (surface markings) gives the following useful account of the surface-anatomy of the middle meningeal artery. "The middle meningeal artery enters the skull through the foramen spinosum, and divides after a short and variable course across the middle fossa into two main trunks. The seat of bifurcation usually corresponds to a point just above the centre of the zygoma. The anterior branch is not only the larger of the two, but it is also more liable to injury, since it is protected in the temporal region only by a thin osseous barrier. The danger zone in the course of this may be mapped out by taking three points. (1) One inch behind the external angular process of the frontal bone and one inch above the zygoma. (2) One and a half inches behind the external angular process and one and a half inches above the zygoma. (3) Two inches behind the external angular process and two inches above the zygoma. A line uniting these three points indicates therefore that part of the anterior branch which is most liable to injury. The anterior division of the vessel will be exposed by trephining over any of these three points, but it is generally preferable to choose the highest point, as in this way the posterior border of the great wing of the sphenoid is avoided; as an additional reason it should be added that, in the position of points 1 and 2, the artery frequently runs in an osseous canal."

will enable the surgeon to deal with a middle or parietal-temporal hæmatoma. The brisk hæmorrhage which takes place from the scalp may be controlled by the use of Spencer-Wells forceps and Lane's tissue forceps, the latter acting as retractors also; Makka's clamps may also be employed for compressing the base of the flap. The pericranium is then carefully separated, and any fissure or fracture looked for in the bone. Whether one be found or no, a disc of bone is next removed with a full-sized trephine. When this has been exposed the clot,[1] hæmorrhage may still be going on, warning of which will, perhaps, be given by the pulsation of the clot. This having been removed by a small scoop, by one of Volkmann's spoons, or better still by irrigation with sterile saline solution, the hæmorrhage may cease, or it may continue profusely, welling up from a point quite out of reach. In such cases the surgeon may, after saving his patient from the dangers of compression, have to face those of most serious hæmorrhage. In such a contingency much will depend on the accessibility of the bleeding-point, whether it is in the wall of the skull or in the foramen at the base; the following steps may be made use of after the free exposure of the interior of the cranium by the removal of sufficient bone by Hoffman's forceps (p. 312). A good light is essential, an electric head lamp being often of the greatest use.

(1) Ligature of the artery after removal of sufficient bone to expose the site of injury. (2) Crushing together with forceps the edge of the bone from which bleeding comes. (3) Underrunning the artery in the dura mater with a fine curved needle. (4) The use of Horsley's wax. This is a mixture of beeswax 7 parts, almond oil 1 part, and carbolic acid or salicylic acid 1 part. Its use is especially indicated when the artery is ruptured in the bony canal, the wax being forced into the opening with a probe. (5) Another method of checking the bleeding when the vessel is damaged in a bony canal is to plug this canal with a tiny boiled and aseptic wooden peg.[2] (6) Forcipressure by means of a pair of Spencer-Wells forceps left *in situ* for twelve hours. (7) The above means failing, which is unlikely, ligature of the external or common carotid had better be resorted to.[3] If such a step be really needful, a temporary closure of the common carotid (*q.v.*) will perhaps suffice. It is always to be remembered that local hæmostasis is greatly to be

[1] Perhaps more bone must be removed by skull forceps satisfactorily to expose the clot.

[2] This was suggested by Sir T. Smith, and used successfully by Mr. Willett and Mr. H. Marsh, at St. Bartholomew's Hospital in cases of hæmorrhage from the descending palatine artery (*Clin. Soc. Trans.*, vol. xi. p. 71.

[3] Ligature of the common carotid is justified by a successful case by Dr. Laddell (*Amer. Journ. Med. Sci.*, vol. lxxvi. p. 344), in which secondary hæmorrhage from the middle meningeal artery, three weeks after a shell wound in the temporal region, was successfully arrested by ligature of the common carotid. If the condition of the patient be very grave, ligature of the common and not the external carotid will generally be resorted to, as being more quickly done. More recently Dr. E. L. Robinson, of Guernsey (*Brit. Med. Journ.*, Dec. 31, 1904) reports a successful case with several points of interest. The patient, a woman æt. 20, had, in falling from a shop counter, struck her head against a shelf. She had walked home and there vomited blood. While telling her story to a medical man, an hour later, she suddenly became unconscious with left hemiplegia, and widely dilated right pupil. A fracture was found in the anterior third of the temporal fossa, running down to the base. The bone when trephined was very thin. Fresh arterial blood and clot welled up into the opening as soon as this was made, and as it was impossible to see the source of the bleeding, the right common carotid was tied. This was successful at once. As the patient came round from the anæsthetic it was seen that the hemiplegia had disappeared. Save for rather tardy disappearance of paralysis of the third nerve the recovery was uneventful.

preferred, and that, of the methods given above, ligature of the middle meningeal artery itself is the safest.

Dr. Shepherd, of Montreal, records[1] an instructive case of middle meningeal hæmorrhage in which ligature of the common carotid was successfully resorted to. That the hæmorrhage was not severe at first, and pressure symptoms from the slowly spreading clot were not marked until the day after the accident, is explained in Dr. Shepherd's opinion, by the fact that the rupture of the artery was low down, where the dura mater was closely attached to the base of the skull, and where it needed considerable force to separate it from the bone.

A large and very thick clot having been exposed by the removal of two trephine crowns in the line of a fissured fracture in the anterior part of the left parietal, the empty meningeal artery could be seen ramifying on the dura mater, while blood was freely welling up from below. A large piece of bone, three inches long by two inches wide, was chiselled away in the hope of reaching the bleeding point. After a large amount of clot had been removed there was furious bleeding from below. The brain and dura mater being held aside by a broad retractor it was seen that the fracture ran through the foramen spinosum, and then across the body of the sphenoid. The artery was evidently torn in the foramen. It was decided to tie the common carotid which immediately stopped the free hæmorrhage. All the blood clot having been washed out, the space at the base of the skull was packed with iodoform gauze. The patient soon recovered consciousness. Two days later as the gauze was being removed, there was a tremendous spurt of blood as the last piece came away. The wound was therefore again packed. Three days after, the patient had a rigor, a temperature of 102·5°, and paralysis of the left side and motor aphasia. These gradually disappeared and the gauze was removed without any bleeding ten days after the second plugging. The patient made an excellent recovery.

Dr. Shepherd considered that the paralysis and aphasia were due to the compression affected by the large quantity of firmly packed iodoform gauze, and not to ligature of the carotid, for these signs came on only after the second packing and were very temporary in duration. The compression would have been rendered still greater when the gauze became soaked with blood. Dr. Shepherd resorted to ligature of the common carotid instead of plugging the foramen, because this might have separated the fracture in the base of the skull. As in all operations on the head and brain, where the patient's condition is a grave one, infusion of saline fluid should be resorted to when the artery has been secured.

How far the surgeon should remain satisfied with partial removal of the clot, or proceed to remove the skull freely, and then the clot, more extensively, must depend partly on the conditions under which the operation is carried out, but chiefly on the state of the patient, the size of the clot, and whether the depression in the dura mater begins quickly to pulsate and to rise up. If these last points are in doubt, there should be no hesitation, the condition of the patient admitting it, in removing more bone, and any clot which seems firm and dense, till all cause of depression in the membrane is removed.

Prognosis. With reference to this point, the following remarks from a paper by Mr. Jacobson in the Guy's Hospital Reports, vol. xliii, may be quoted: "The chief points on which this depends are whether the middle meningeal extravasation is probably complicated with such injuries as extensive fractures and brain injury and, secondly, upon the date of trephining, and whether, at this time, the brain recovers itself quickly or not. With regard to the former, or the existence of complications, the

[1] *Brit. Med. Journ.*, 1896, vol. i, p. 905.

surgeon will, if asked to state the probable result, base his opinion on the history of the case, the severity of the violence, *e.g.* height of fall, whether any interval of lucidity has been present and, if so, for how long and how far has this been well marked, how far the symptoms of compression, well-defined hemiplegia, the failing pulse, the stertorous breathing, &c., are present or replaced by, or complicated with, those symptoms which are believed to point rather to laceration or contusion of the brain or its membranes, viz. restlessness, convulsive movements or twitchings, pulse quick and sharp, or pyrexia, which show that inflammation of the brain has probably supervened upon the injury to its substance."

The seventy cases upon which the above paper was based appeared to fall into the three following groups:

A. *The most hopeful cases for trephining.* Violence comparatively slight; laceration of the middle meningeal artery or its branches; fracture of skull, if present, slight and localized to one side, *i.e.* not implicating the base; compression present, but little or no contusion or laceration of brain. Twenty-seven cases.

B. *Less hopeful cases.* Violence greater; laceration of middle meningeal or its branches; fracture implicating middle fossa; some injury to brain, but this only trivial. Twenty cases.

C. *Cases probably hopeless from the first.* Violence very great; laceration of the middle meningeal or its branches; fracture of skull extensive; perhaps implicating several bones and sutures both in the vault and base; injury to brain very severe. Twenty-three cases.

Sub-dural hæmorrhage. This obscure and difficult subject has had much light thrown upon it by a paper by Mr. W. H. Bowen.[1] The differential diagnosis of extra-dural hæmorrhage, intracranial suppuration, uræmia, idiopathic epilepsy, cerebral hæmorrhage, and meningeal hæmorrhage is carefully considered. Mr. Bowen is inclined to rely upon (1) the long duration of lucid intervals. (2) The presence of a scalp wound, or bruise, recent or remote. (3) The presence of Hutchinson's pupil (*see* p. 264), which is however rarely present. The only treatment is early trephining. The following points of practical importance are brought out by Mr. Bowen in his paper: (*a*) No fracture may be present in these cases of sub-dural hæmorrhage. Operators who may be inclined on exploring a case to close the wound because the bones are found uninjured, should bear this in mind. (*b*) If, on opening the dura at more than one place, no clot is found and the brain bulges through, pulsating, the following possibilities must be borne in mind: (1) The diagnosis may be wrong and a cerebral abscess be present. If this is excluded, and if the passage of a curved director into the arachnoid cavity for the purpose of exploring neighbouring areas proves negative, the opposite side of the skull should be trephined and a careful search made there. (2) As in the case of middle meningeal hæmorrhage it may be a case of contre-coup. (3) Where sub-dural hæmorrhage is present, tenseness and non-pulsation of the dura mater are far more valuable than the colour of this membrane. "If colour be relied upon, two conditions at least may lead to error, one being that the compressing agent is not always blood, but may be blood and serum, or serum alone, when there will be no discoloration, notwithstanding the presence of pronounced compression; the other that a thin layer of blood over the surface of the brain, associated with severe contusion, yet incapable

[1] *Guy's Hospital Reports*, vol. lix.

of compression, may cause discoloration, and this may also appear to be present when caused by the very distended veins on the surface of the brain pressed against the membrane." (4) With regard to the removal of the clot there is nothing to be added to the account given at p. 266. (5) Haemorrhage may be difficult to stop and may recur dangerously. In such cases it is possible that a sinus has been opened by a fracture running into the base. Cerebral vessels may require ligature. (6) As to the advisability of drainage no rule can be laid down. Only when it is certain that all clot has been removed and that the field of operation is sterile, should the wound be entirely closed. The following case under the care of the late Mr. H. W. Allingham,[1] is a most interesting one, the bleeding having apparently come from a laceration of the frontal lobe. The length of the "latent" interval will be noted.

A man, æt. 40, was admitted to the Great Northern Hospital, having fallen off a tramcar while half drunk. He complained of pain in the left shoulder; there was no evidence of injury to the head. The next four days the patient was very drowsy and irritable when disturbed. There was no paralysis. A week later the patient was seized with convulsions. These began in the left side of the face, the mouth being drawn up, and the eyelids moved in clonic spasm. The muscles of the neck were next affected, and subsequently the left arm and leg. The breathing was stertorous. A large flap was turned down in the right parietal region and a disc of bone was removed over the right fissure of Rolando *i.e.* about two and a half inches behind and one and a half inches above the external angle of the orbit. The posterior branch of the middle meningeal ran across the exposed dura mater. This membrane did not pulsate, and showed a black mass beneath it; the artery being secured, the dura mater was incised and a large clot exposed. About three ounces of this having been removed chiefly by irrigation, a large cavity could be felt as far as the finger could reach; the brain appeared to be much lacerated over the frontal lobe. The patient made a good recovery.

TREPHINING AND EXPLORATION OF CEREBRAL ABSCESS DUE TO INJURY

Indications for exploring; symptoms and diagnosis of traumatic cerebral abscess. Many of these are given at somewhat fuller length in reference to that form of cerebral abscess which, as one of the results of otitis media, is discussed at p. 352. To begin with there is often the history of an injury.[2] This may have been a stab with a knife, a graze of the head with brief concussion, a fracture, especially a compound one, a blow with a stone or a glancing bullet. Occasionally an abscess may follow a trifling superficial septic injury, such as the bite of an insect, the infection reaching the brain through some of the emissary veins. Again the nasal fossæ must not be forgotten, as shown by the case mentioned at p. 461. Dr. Carson[3] mentions the case of a child where the infection, starting in a nasal catarrh the result of an injury, extended through the cribriform plate to the brain and led to an abscess which terminated fatally. Often, but not always, follows a latent period devoid of brain symptoms, which may last from a few *e.g.* four days to three or four weeks or much longer. This latent period is succeeded by brain symptoms increasing in severity and going on to

[1] *Clin. Soc. Trans.*, vol. xxii. p. 220.

[2] But the help which a history of injury gives is not always present, and this is an indication for always examining for any wound or scar, and exploring it, however unimportant it may seem to be, in these cases.

[3] *New York Med. Journ.*, April 27, 1905.

those of compression, viz. headache felt over the side injured, but not necessarily most intense at the injured spot; nausea or vomiting; some pyrexia, although the temperature usually rises slowly, if it rises above the normal at all.[1] Optic neuritis may be present.

Other symptoms are mental dulness (the answers long delayed, but intelligent when they come), a slow pulse, perhaps rigors, progressive emaciation, perhaps accompanied by vomiting. Whether local nerve symptoms *e.g.* disturbances of sensation and motion—are present must depend on the position of the abscess. If the injury has been over the motor area (Figs. 122 and 123) nerve symptoms may be clearly marked, but if over the anterior part of the frontal or temporo-sphenoidal[2] lobes, they may be entirely absent. Thus hemiplegia, a paralysis limited *e.g.* of upper limb and, later on, gradually increasing—epileptic seizures, spasms, spastic rigidity, all have been met with, but must by no means be relied upon; and even when paralysis is present it may escape observation, as when there is slight paralysis of the muscles of the lower half of the left side of the face, and some loss of power in the left hand and arm, but only temporary.[3] Here, as in otitis media, there is but one rule, and that is, that in all cases where an abscess of the brain may be present, exploration should be undertaken, and that this step should not be deferred.

For the surgeon, who is watching what he believes to be a cerebral abscess, must always remember that after a period of lateney, which may last weeks or more, acute symptoms may set in suddenly and quickly close in death.

Operation of trephining for traumatic cerebral abscess. As the fatality of cerebral abscess, if left to itself, is so high—90 to 100 per cent.—trephining is abundantly justified. The chief difficulty is, of course, hitting off the seat of the abscess, especially in cases where there are no definite nerve symptoms to guide and where the history of the part of the head injured is indefinite also.

To obviate the necessity of multiple trephining, Dr. Fenger and Dr. Lee, of Chicago, have recommended,[4] as easier and safer, exploratory puncture and aspira-

[1] On this and other points reference may be made to p. 352. Prof. Nancrede (*loc. supra cit.*, p. 95) writes thus: "I believe that an abscess involving the cerebral tissue alone will be accompanied, in most cases, by a subnormal or, at least, a normal temperature. Where a high temperature is noted, either the pus collection is a localised suppurative arachnitis limited by adhesions, or there is a meningitis in addition to the abscess."

[2] With regard to the large collection of pus found here, Dr. Yeo (*loc. supra cit.*, p. 885) quotes as follows from Huguenin (*Ziemssen's Cyclopædia*, vol. xii): "The difficulty of diagnosis is increased by the circumstance that no bands of fibres, which are direct conductors of sensibility or motion," pass through this lobe; and, therefore an abscess here "may attain a considerable size, and may cause general symptoms of compression, before any distinct symptoms of local disease arouse the suspicion of a localised affection of the brain."

[3] The value of accurately noting symptoms which, though of but brief duration, may be very important guides in treatment, is well shown by a case of Sir. W. Macewen's (*Lancet*, 1881, vol. ii, p. 582).

A boy, aged 11, was admitted into the Glasgow Royal Infirmary, two weeks after a fall upon his head, with a partially healed wound and bare bone over the left eyebrow. A week later he had a rigor. Five days later, or twenty-six days after the injury, the patient had a convulsion confined to the right side; when this had passed off, he was distinctly aphasic. The seat of the abscess now seemed to be the third left frontal convolution, and trephining was proposed. The friends, however, refused to permit this, as the patient had recovered consciousness, though they were warned that the improvement would only be temporary. Thirty hours later, the convulsions of the right side recurred, the temperature rose quickly from 101° to 104°, and the patient died before the operation could be performed. The situation of the abscess was verified after death.

[4] *Trans. Amer. Surg. Assoc.*, vol. ii, p. 78.

tion. This must be done methodically, with a needle, four inches long, set in an exploring syringe. The needle should not be too fine, and the gauge should be powerful enough to make sufficient suction, as a fine needle is readily plugged with brain substance. This may be easily taken for pus. The needle, sterilised, is pushed through a trephine-hole, straight in, in a definite direction, for half an inch or one inch; the piston is then withdrawn a little and, if no pus follows, the needle is pushed half an inch further and the piston again withdrawn. The depth to which it will be permissible finally to push the needle will, of course, vary with the position of the trephine-opening and the direction of the puncture, the surgeon being guided by the anatomy of the brain. The punctures are to be repeated at intervals of half an inch or one inch, the utmost care being taken to push the needle in straight and to avoid all lateral movements. The loss of resistance and the sensation that the point moves in a cavity are to be carefully watched for. If, after a reasonable number of punctures, no pus is withdrawn, the operator may feel convinced that none is present. An abscess in the brain is usually as large as a walnut, often much larger. More details are given at p. 357.

Puncturing healthy brain tissue with a fine, perfectly aseptic needle can do but little mischief.

The needle should be kept as a guide till the abscess-cavity is definitely opened either by inserting a pair of Lister's sinus-forceps or a sharp straight bistoury. The abscess must be thoroughly drained and made to close from the bottom.

A drainage tube should be used and should be kept in position by stitch securing it to the margin of the skin.

The following cases of traumatic cerebral abscess, in addition to those given at p. 261 and in the footnotes to p. 270, are good instances of the disease and also of its successful treatment:

A labourer, aged 60, was admitted into the Middlesex Hospital, under the care of the late Mr. J. W. Hulke, a fortnight after being struck a glancing blow on the right temple by a falling ladder, which stunned him for a few minutes and caused considerable bruise. He continued, nevertheless, to work as usual until the middle of the third day, when headache, which he had from the time of the accident, became very severe—so severe that his wife feared that he would go out of his mind. On admission the pulse was 56, and the temperature slightly below the normal. The patient's mind was unclouded. About one week later, in the night, he became insensible, and in the morning the right upper and lower limbs were found absolutely palsied as regards motion, and nearly so as regards sensation. When the arm or thigh was severely pinched, he gave scarce any sign of consciousness of it, but shrank slightly when the left limbs were pinched similarly. Two days later, spastic rigidity of the left arm supervened. A small disc of bone cut out beneath the bruised bone on the right temple appeared uninjured. The dura mater bulged up so tensely that pulsation could neither be seen nor felt; its exposed surface appeared healthy. A needle connected with an exhausting syringe was pushed through it to a depth of one and a quarter inches. A brownish turbid fluid rose up into the receiver, and continued to flow after the needle was withdrawn. The minute opening was enlarged with a scalpel, and a considerable quantity of fluid escaped. The flaps, which had been reflected, were replaced. Next morning the spastic rigidity of the left arm had gone. On the second day slight return of power was noticed in the right limbs, and before the end of a week their palsy had disappeared. For a very few days after the operation the dressing was wetted and discoloured by the fluid which continued to ooze, but the wound soon healed, and two months after the operation the patient appeared quite well.

It is interesting to note in the following case that the hemiplegia which followed the operation was only transitory. It also shows that grave symptoms may be latent for as long as five months if a skull wound remains unhealed.

A child, aged 4½, had sustained a severe compound fracture of the right frontal bone. The removal of some portions of necrosed bone led subsequently to a slight hernia cerebri. The sinus persisted, but the child seemed well in other respects until about five months after the accident, when left-sided convulsions (chiefly of the muscles of the face and arm) came on, and an alarming condition rapidly developed. The sinus was opened up and a director passed for a distance of one inch

into the right frontal lobe downwards and backwards. A free flow of fetid pus occurred, and after the cavity had been washed out with carbolic lotion (1 in 40), a drainage-tube was inserted. The latter was removed at the end of a fortnight. Left hemiplegia followed the operation, but it passed off some twenty-four hours subsequently. Recovery was rapid and complete.

TREPHINING FOR EPILEPSY AND OTHER LATER RESULTS OF A CRANIAL INJURY

This is one of the advances in cranial surgery, the results of which have not come up to the expectations formed of it. The operation—one of the most ancient in the history of surgery—after being almost abandoned for centuries, has been again taken up in recent years, with all the advantages of modern surgery, especially in those cases where, after an injury, epileptiform convulsions beginning in the leg, arm, or face are due to lesions of the corresponding parts of the motor area. This form of convulsion forms a large part of the epilepsy which bears Dr. Hughlings Jackson's name. It is to be feared that any candid inquirer, weighing fairly, unsuccessful as well as successful cases, and attaching due importance to the facts that many of the latter have been published prematurely as to final result—*i.e.* before they have been submitted to the time test—will come to the conclusion that the result of trephining for traumatic epilepsy is a disappointing one. It will be worth while to go a little into detail with regard to the grounds which lead to these conclusions:

Results of operation. Later collections of cases and (what is of paramount importance) keeping cases more carefully under after-observation, have shown that the operation for traumatic epilepsy has not come up to the expectations formed of it.[1] One of the most extensive of cases with careful analysis of results is by Graf.[2]

Graf has collected 146 cases. Of these 71 were trephined, and though the dura was incised in some of these, the brain was not incised. In the remaining 75 the operative procedure was extended to the cortex cerebri. In 56 of the latter group there was removal of spicules or fragments of bone, or incision or excision of a cyst or removal of a cicatrix, while in the remaining 19 the cortical centre was excised. Of the total number there was an operation mortality of 6·1 per cent. Fifty-three of the cases were under observation for too short a period to estimate the result of the operation. Of the remainder, 35, or 29·9 per cent. were free from recurrence at the end of six months, 22, or 15·1 per cent. were improved, while 36, or 27·6 per cent. were failures. Graf found that successful cases without recurrence at the end of three years were at the most only 6·5 per cent.

This want of success can be readily understood from a consideration of the possible pathological conditions (*see* p. 274). It is of course quite possible to remove spicules or depressed portions of bone, or to remove any cyst or mass of connective tissue. As the result of the

[1] Agnew (*Trans. Amer. Surg. Assoc.*, 1891) gives results in 57 cases operated upon at Philadelphia. Of these 4 died, 4 were cured, 4 were operated upon too recently to venture an opinion, 4 passed out of observation, 32 experienced temporary benefit, and 9 obtained no relief. Of those reported as cured 2 had been under observation for only 10 months—too short a period to be sure of a permanent cure. Dr. E. G. Mason, of New York, tabulates (*Med. News*, vol. i, 1896, p. 313) 70 cases in a paper which is especially valuable because he refuses to accept any cases as "cures" unless the patients have been under observation for three years, and have had no return of fits. Starting with this sound proviso he finds 8 cases, or 6·3 per cent, can be accepted as cures; 6 (or 4·2 per cent.) showed improvement of more than a year's duration; in 14 (20 per cent.) there was no improvement; in three cases death was due to the operation.

[2] *Arch. f. Klin. Chir.*, Bd. lvi, quoted by Oppenheim, *Textbook of Nervous Diseases*, p. 1229.

operation, however, some scarring or adhesion is certain to take place which too frequently keeps up the cerebral irritation. Still more is it useless to break down adhesions between the dura and pia or between the pia and brain, because they will inevitably re-form after the operation. Even excision of a portion of the cortex is certain to be followed by a cicatrix, which, in turn, will act as an irritant. It is usually impossible to determine the exact pathological condition present beforehand, and it must be remembered that in some cases an injury to the head may cause contusion of the brain and subsequent sclerotic changes in the cortex without any fracture or depression of the bone. In some

FIG. 122.

of these cases, even when the initial lesion or portions of the cortex are removed, the slowly established habit, created by years of excitation, will remain.[1]

The treatment of traumatic epilepsy should, to a certain extent, be preventive. All depressed fractures, however small, should be elevated, for though no symptoms may be present at the time, such injuries are apt at a later date to produce epileptic convulsions.

The surgical treatment of epilepsy is thus summed up by Professor Oppenheim:[2] (1) The operative treatment of non-traumatic true epilepsy is not justifiable. (2) The operative treatment of Jacksonian epilepsy of non-traumatic origin is admissible under certain conditions, *e.g.* if an operable cortical affection (cyst, tumour, or abscess) is probably

[1] *See* the remarks of Prof. Nancrede (*Ann. of Surg.*, 1896, vol. ii. p. 122). Also Sachs and Gerster (*Amer. Journ. Med. Sci.*, Oct. 1896). For an expression of the opinion of German surgeons *see* the proceedings of the German Surgical Congress (*Ann. of Surg.*, December 1903).

[2] *Textbook of Nervous Diseases*, p. 1229.

present. Should this not be so the prospects of a successful operation are slight. (3) Operation is indicated in cases of cortical epilepsy following injury, especially if the cicatrix practically corresponds to a motor area. If at a distance from the Rolandic area the point for trephining should be that indicated by the attack. (4) In all cases scars, spicules of bone, &c., should be removed. In many cases it is advisable also to excise the cortical centre.

But while it is authoritatively proved that the value of trephining for traumatic epilepsy has been greatly exaggerated, owing to many operations having been ill-advised, and also what is less excusable, to premature reporting of "successes," it by no means follows that this operation is to be abandoned. It is to be employed on careful and scientific lines. We should be more careful in promising success save in cases of recent date, where there has not been time for the changes to occur which, as we have seen, must render recurrence of the convulsions after a time a matter almost of certainty. In other cases it will be only honest not to hold out much hope of cure, but to explain to the patient and his friends that the operation more or less must be uncertain; that its dangers are slight in experienced hands; that while cure in the truthful sense of the word is unlikely, some relief will almost certainly be granted in the number and severity of the fits; that as to any headache, &c., from which the patient suffers, it is impossible to state what the amount of relief will be till the parts have been explored; and, having said this, we shall be wise if we leave the decision in the hands of the patient or his friends.

For as we know nothing of the actual causation of epilepsy in these cases, so we must rest uncertain as to the relief which a trephine-opening on wide lines may give. If headache or optic neuritis is present, these will be relieved. As to convulsions, we may hope that, in cases which are not of too long standing, the relief to tension may help towards recovery the impaired vitality of cells so delicately constituted as those of the brain. In other cases the opening may allow of the intracranial circulation undergoing fluctuations, to which it is inevitably exposed, without the unstable cortical centres becoming congested and irritated and prone to explosions, as would otherwise be the case.

Condition of the parts which may be met with during the operation and which may have originally caused the epilepsy. (1) *The scalp.* Shaving often reveals scars known or undiscovered. When operation was again resorted to in this disease, some years ago, it was hoped that tenderness of such scars would be a valuable guide and characteristic of cases to be benefited by operation. Thus Mr. Walsham[1] found that, of eighty-two cases, the scar or spot was sensitive, tender, or painful in forty-two. Pressure in some caused vertigo, convulsions, rigidity, or spasmodic twitchings of certain groups of muscles.[2] Larger collections of cases have shown that these instances are fewer than was hoped, the share taken in epilepsy by tender scalp scars being a small one. In eight out of the forty-two cases collected by Mr. Walsham a sinus was present leading down to bare bone.

(2) *The periosteum.* This may be found extremely thickened, and very closely adherent to the bone. Excess of vascularity may also be met with. Osteophytic deposits have not been observed.

[1] *St. Bartholomew's Hospital Reports*, 1883, vol. xix, p. 127.

[2] It is especially in those cases in which pressure on a tender scar produces convulsive movements on the same side, that the surgeon may be content with removing the scar.

(3) *The skull.* Lesions of all kinds have been present. Depressions, fractures, fissures, are common. From the inner table a spicule[1] may project inwards. With regard to these last conditions it is very noteworthy that in one of the cases collected by Mr. Walsham, though nothing was detected at the operation, a spicule was found, at the necropsy, not far from the trephine-hole.

Another point which is of great importance with regard to the indications for trephining as given by the state of the skull is this. Several cases have been recorded which prove that it is not always safe in trephining for epilepsy to rely on the position of a fracture, unless that fracture coincides very closely with the spot selected for trephining from the character of the fit. Thus, in two cases related by Dr. Starr, depressed fractures existed, epileptic attacks had developed subsequently to them, but the fit, which in both patients began in the arm, indicated disease in the middle third of the motor area, while the position of the fracture was upwards of two inches away from this spot.[2] In another case where the surgical indication or position of the fracture was put aside in favour of the medical one, or the evidence given by the fits, the latter proved to be the correct one, as on raising the button of bone a splinter from the internal table was found penetrating the dura mater and brain, though at the spot selected there was no evidence of fracture.

(4) *The membranes.* Before opening the membranes the surgeon should remember that it is at this stage that danger begins. Aseptic trephining in experienced hands entails no risk, but it is another matter when the membranes are opened and the brain itself is interfered with. The risks of hæmorrhage, sudden cessation of breathing, shock, infection, hernia cerebri, have now to be faced. Both the dura and pia mater may be found much thickened, blended with each other, and adherent to the cortex. In some cases they form respectively the outer and inner wall of a cyst.

(5) *The brain.* When pathological changes are present in the part explored, the cortex may be found compressed or indented, stained, sclerosed or softened. Cysts in the cortex, perhaps the result of old hæmorrhage, are not uncommon lesions, and are amongst the most hopeful for treatment. If removal of the cyst is impracticable incision and drainage should be employed. Any blood clot must be removed by curetting or carefully cut away. If old, it may resemble yellowish scar tissue. If the dura has been opened to get at it, the edges of this

[1] The term exostosis is sometimes applied to the depressed bone; this, when circumscribed, is easily dealt with. An allied condition rarer, and one much more difficult to deal with, is described by Dr. Echeverria (*Arch. Gen. de Med.*, 1878, t. ii, p. 533). A conical, irregular projection of bone, measuring 2 × 2½ inches, here compressed the dura mater and brain, being situated very close to the superior longitudinal sinus, just to the left of the occipital protuberance. In trephining, the crown entered into this exostosis, the removal of it proving most laborious, the operation lasting three and a half hours. The patient recovered. A case of Kochler's, of Berlin (*Deutsche Med. Woch.*, No. 46, '889), illustrates a less localised condition. A sword-cut had injured the bone, without depression. Epileptic fits followed in six weeks. About a year later trephining was successfully performed. The dura mater was adherent, the bone much thickened and covered with thorn-like processes pressing on, but not perforating, the dura. Before deciding whether any diffuse thickening of the bone is really morbid the varying thickness of the skull in different parts must be remembered. Good illustrations of a blunt spicule from the internal table are given by Dr. Williamson and Mr. Jones (*Brit. Med. Journ.*, vol. ii, 1899, p. 919).

[2] Such cases emphasise the need of sweeping a probe around the margins of the trephino-hole, so as to explore the neighbourhood thoroughly.

membrane must be drawn together with sutures, drainage being employed if needful.

Before cutting through thickened membranes, especially if adherent to the brain, the surgeon should remember the following case, which occurred in the experienced hands of Dr. Gerster himself:

> The patient, æt. 17, had been operated on twice before. The epilepsy continuing and the patient being anxious for a third operation, an attempt was made to lessen the tension caused by a scar at the site of the first operation, over the left arm-centre. Cutting through this scar, the surgeon found an enormously thickened membrane between the dura and the scalp. In the attempts to separate adhesions and cut through thickened membrane, excessive hæmorrhage occurred, which it was impossible to check for some time. The patient did not recover from the shock of the operation, and died in collapse three days later.

If nothing be found when the dura is opened, the surgeon may, before deciding to interfere with the brain itself, explore the neighbourhood of the wound within the dura with a blunt-pointed instrument, *e.g.* a curved, flexible, sterilized director. By this means a clot or cyst, which would otherwise have been missed, may be detected, and dealt with by enlarging the opening.

But even when clots and cysts may seem to have been satisfactorily dealt with, and the fits cease at once, mischief in the brain may co-exist (especially if the case be one of long standing) and lead to their recurrence (*vide infra*).

The majority of lesions of the brain will however be found to be much less amenable to treatment. How varied they are is shown by the following list enumerated by Dr. Starr:[1] "Any affection of the meninges, whether pachymeningitis or leptomeningitis, of traumatic or syphilitic or tubercular origin; or new growths upon or in the cortex of the brain; or cysts formed as the result of small circumscribed hæmorrhages, or of spots of softening from embolism or thrombosis of a cerebral artery; or circumscribed encephalitis or sclerotic patches, may act as centres of irritation in the cortex of the brain. The majority of these forms of disease, when exactly localised in a small area, appear to be traceable to traumatism, either to a blow, a fall on the head, or to a fracture with or without depression."

But it is not only the variety of the lesions of the brain which may, after an injury, produce Jacksonian epilepsy, that is worthy of careful note; it is their nature which makes the majority of cases recurrent after any operation, however skilfully performed. At first sight hæmorrhage and cysts would appear capable of being dealt with by careful curetting, drainage, &c. (*vide supra*). But going with these coarser lesions there is almost always present some meningo-encephalitis, circumscribed or diffuse. Coen,[2] van Gieson,[3] Starr (*vide supra*)—the latter especially—have shown the frequency of the occurrence of adhesions between the pia and the cortex, of a chronic degeneration of the pyramidal cells, and of an increase in neuroglia. The bearing of this on excision of the cortex will be alluded to later (*see* p. 280).

Operation. To begin with, a painful cicatrix[4] may be freely excised. This may be done with some hope that nothing further in the way of

[1] *Brain Surg.*, p. 25. [2] *Ziegler's Beitr. z. Path. Anat. u. Physiol.*, 1888, Bd. ii, s. 107.

[3] *New York Med. Record*, April 24, 1893.

[4] In one of Dr. Echeverria's cases (*loc. supra cit.*), convulsions, vertigo, &c., were cured by the removal of a small fibroma adherent to the frontal periosteum and supra-orbital nerve, Dr. Starr's opinion, on the other hand, is much less favourable: "From my

operation will be required in cases where the scar is constantly painful, tender, or hot; where it corresponds to the course of some known nerve; and in any case where the original wound lacerated, or contused, and slow in healing, and where there is any chance of a splinter of wood or metal being embedded in the scar.[1]

If it be necessary, as it usually is, to remove a crown of bone, an appropriate semilunar flap (*see* p. 309) must be reflected, with the aseptic and other precautions already given. Haemorrhage is next arrested, and the flap retracted by Spencer-Wells forceps, the pericranium being carefully turned off the bone, and its condition noted as to thickening and other evidence of old inflammation. The bone being thoroughly exposed, the surgeon must be prepared for the following conditions, viz. the line of an old fracture, necrosis (indicated by a sinus with prominent granulations), hypertrophic sclerosis, depressed fragments of the internal table, spurs, or nodules of bone. Any sequestrum will, of course, be removed. For dealing with the bone the surgeon will select out of those methods described at p. 310 the one with which he is most familiar. In trephining the surgeon will use the precautions given at p. 256, remembering that here he is especially likely to be dealing with a disc of bone of varying density at different points of its circumference.[2] It must be elevated with particular caution, as a spicule may have made its way through the dura mater and be pressing on the brain, or be in close contact with one of the sinuses.

If the first crown show nothing abnormal, a probe should be gently inserted between the bone and dura mater and carefully swept around, so as to give information of the condition of the inner surface of the surrounding bone. If the crown show changes which are, however, not localised to it, more bone must be taken away, by one of the methods described at p. 312, till all that is thickened and capable of exerting pressure on the brain and its membranes is removed.

If no change can be found in the crown removed, or in the surrounding bone, what more should be done on this occasion? If there be reason to suspect the presence of an excess of cerebro-spinal fluid or of an abscess in the brain, because the symptoms of this condition (pp. 269 and 352) are present, or because the dura mater bulges up without pulsation into the trephine-hole, the treatment should be as directed at p. 356.

Directions as to dealing with any cysts, and how far it is wise to go in attacking the thickened membranes, have been given at p. 275. These details of the operation would not be complete without some reference to the *question of excising portions of the cortex where no lesion sufficient to account for the epilepsy has been found more superficially*. This is not to be lightly undertaken. Professor Nancrede, of Michigan,[3] has with great candour recorded three cases in which he took this step;

experience I consider that true reflex epilepsy from scars in the scalp is a very rare occurrence."

[1] Dr. Johnson (*Clin. Soc. Trans.*, vol. vi, p. 35) records a case where trismus, facial neuralgia, and paralysis, with a recurrence of epilepsy (the patient, aged 44, had been free from fits for twelve years), were caused by a sharp, angular piece of flint embedded in a painful cicatrix of the cheek, the removal of which was followed by complete recovery.

[2] Free and most embarrassing haemorrhage may be met with in sawing through altered diploe traversed by large sinus like venous channels, requiring firm pressure during and after the operation, plugging with a tiny sterilised wooden peg, or crushing the bone together with forceps at the bleeding-point.

[3] *Ann. of Surg.*, 1896, vol. ii, p. 122.

in all the fits recurred, though in one case not for two and a half years, while in another "somewhat over three years" had elapsed. And this candour is the greater, as Professor Nancrede allows that formerly he thought well of this procedure. Dr. Sachs and Dr. Gerster[1] have given this a full trial, having employed it in five cases. Their experience leads them to the conclusion that, in epilepsy of long standing, the excision of cortical tissue does no good, and such excision is hereafter to be restricted to epilepsies of short duration. And again: "Since such cortical lesions are often of a microscopical character, excision should be practised even if the tissue appears to be perfectly normal at the time of operation; but the greatest caution should be exercised to make sure that the proper area is removed."

Not only may this step cause severe hæmorrhage, shock, and open the door to infection, but is impossible to see how it can do otherwise than lead to fusing of the scalp membranes and cortex in a scar which will become increasingly dense with time, and bring about "anchoring of the brain," with its grave disadvantages (*see* p. 276) and sclerosis of the cortex, leading inevitably to a recurrence of the trouble. To put it briefly, it seems certain that when taking this step the surgeon is almost sure to replace one traumatic epilepsy by another, which, supervening somewhat later, is traumatic also, but in addition, unhappily, surgical as well.[2]

What is needed is to prevent the adhesion of brain, membranes, and scalp, and at present none of the methods are reliable. Possibly transplanting a flap of scalp, bone, and membrane might succeed, but such a step is too severe to be undertaken at the close of an operation already severe and prolonged, and if deferred for some days its object would probably be defeated. The use of gold and other pliable metal plates between the dura and the skull will not prevent the formation of adhesions between the dura and the brain. A case of Dr. Gerster's proves this. Having removed a cerebral cyst, this surgeon placed a gold plate between the dura and the skull. Two years and nine months after the first operation it was necessary to perform a second, and, while the gold plate was found lying exactly as it had been introduced, the best result attained was "that the surrounding tissue had undergone fewer changes than would have been the case if the ordinary scar had formed." Other materials have been suggested by the ingenuity of American surgeons.[3]

Another objection to the removal of motor centres (except, of course, in cases where they are involved by a growth) is that this step may merely replace one inconvenience by another. It is true that in most cases the loss of power has been temporary, but in some this has not been the case. Certainly not every patient would choose to lose his

[1] *Loc. supra cit.*

[2] After mere incision of the dura or meninges, the cicatrix left will no doubt, be linear and small, and the inner surface of the skull smooth and adhesions absent, but the condition present after removal of one or more centres will be very different.

[3] Beach has used gold-foil, Abbe rubber tissue; but these substances have been proved to have disadvantages of causing formation of adhesions and scar tissue, of disintegrating of causing suppuration. Dr. L. Freeman, of Denver (*Ann. Surg.* October 1898), having tried gold-foil in a case of trephining for cerebellar tumour, and found, three months later, that "considerable new connective tissue had formed," recommends the use of egg-membrane, as being inexpensive, readily obtainable, strong in spite of its thinness, and durable, and not, in the full sense of the word, a foreign body. The above claims are based upon two experiments on animals.

epilepsy at the cost of having a right arm or leg permanently paralysed. Furthermore, it is easy to understand that in inexperienced hands permanent damage may be readily inflicted on the centres adjacent about the motor area, bringing about a condition by which one form of distress may merely be exchanged for another.

If it be decided, owing to the gravity and frequency of the attacks—especially where the condition amounts to the patient being practically in what is a status epilepticus—their limitation to one or two centres, the absence of any other extra-cerebral cause, and perhaps also the failure of a previous operation, to remove one of the motor centres, this should be accurately localised by electricity. To trust to measurements of the skull is not enough. Sufficient of the motor area having been exposed, the dura-arachnoid is opened and all hæmorrhage is arrested. By means of two aseptic platinum electrodes, different parts of the motor area are examined, the results most carefully noted, and when that spot is reached which causes motion in that particular part of the body first affected in the fit, that particular spot, and that only, should be excised (Keen). The limits having been determined, any large veins which enter the field of operation are first tied with fine sterilized catgut passed under them by Sir V. Horsley's needle-director. The area of the centre is then marked out by a sharp knife held vertically to the surface and penetrating to the white matter. The centre is then excised by a sharp knife or scissors going to the same depth, about three millimetres, or a quarter of an inch. Hæmorrhage is best arrested by ligature of any bleeding-points if possible, hot aseptic lotions, or compression with gauze wrung out of hot lotion, or sterilised adrenalin chloride. The cautery should never be resorted to if it can possibly be avoided. It introduces sepsis and suppuration, and may lead to a hernia cerebri. It prevents the surgeon bringing together the flaps of dura mater over the excised centre. Drainage will usually be required on account of the oozing.

After the removal of the centre, to make sure that this has been effectual, it will be well to again make use of the electric test (Keen).

The strictest aseptic precautions should be taken before and during the operation; sufficient drainage should be provided and, in bringing the wound together, the drainage-tube must not be pressed upon or closed. Great care must be taken to keep the wound sterile later on, infection leading to infective softening and hernia of the brain. Only if it has been needful to remove much bone should any of this be preserved and replaced, with the precautions given at p. 258.[1]

In cases where during the operation there has been any escape of cerebro-spinal fluid, the dressings will soon need to be repacked or changed.

Causes of failure after trephining for traumatic epilepsy. These may be summed up as follows:

[1] Prof. Kocher, of Bern (*La Sem. Méd.*, April 12, 1899, p. 121), is of opinion that not only should the bone disc not be replaced, but that the dura mater itself should be widely excised. He holds that one of the chief causes of epilepsy consists in an exaggeration, local or general, of the intracranial pressure. He believes that, in a number of cases of excision of cerebral centres, except in those where the excision has been sufficiently complete to bring about a definite paralysis, the success should be attributed rather to the opening of the dura mater, which establishes a sort of safety-valve susceptible of regulating the intracranial pressure.

Kocher would, therefore, only put back the disc where a very definite lesion, such as an exostosis or growth, has been removed; in all others the skull should be left open.

(1) *Not hitting off the right spot.* A bony spicule, undetected at the operation, has been found, at the necropsy, not far from the trephine-hole. To meet this contingency, or to find a clot, it has been advised to sweep a probe or wire-loop carefully round the vicinity of the trephine-opening.

(2) A general and diffuse thickening of the bone round the site of injury.

(3) Membranes too much thickened and too adherent to the cortex to admit of their being safely detached.

(4) Owing to the long continuance or to the amount of the irritation, the brain may be permanently affected. Thus, in Dr. Gunn's words already quoted (*see* p. 250), there are cases of depressed fracture in which "the constant irritation has begotten a permanent impression upon the brain and nervous system which remains after the offending point of bone has been removed." The grosser and more localised the lesion the more speedy will be the relief. As long as the fits are diminished in number and severity, the prognosis is still hopeful. The fits may be very slow in disappearing.

(5) While marked relief has been given in some cases of violent temper, delusions, and melancholia, whether associated or not with local epilepsy, the same rule holds with the former as with the latter, *i.e.* if the interval between the injury and trephining has been a long one, the cure is very likely to be imperfect.

(6) *Neglect of after-treatment, both medical and surgical, but chiefly the former.* Professor Nancrede's words[1] are worthy of remembrance: "The operation, indeed, removes the most important cause of the epilepsy, but only one cause. The disturbed circulation in the nervous centres, and the excessive mobility of the nervous system, can only disappear with time; and if all other sources of peripheral irritation are not most carefully guarded against, the patient may be slightly, if at all, benefited, whereas judicious after-treatment will sometimes relieve an apparent operative failure." Judicious after-treatment should especially refer to alcohol, exposure to the sun, overheated small rooms, and, generally speaking, the patient should lead a healthy life.

(7) *Trephining for fits not belonging to traumatic epilepsy in character.* There is no doubt that the glamour of a new operation and "the chance of finding something" have led to this operation being performed in unsuitable cases, which have not been published. It cannot be too strongly laid down that no operation is justifiable in other epilepsies save the Jacksonian, of which so many are traumatic in origin. That is to say, that in ordinary idiopathic epilepsy the conditions justifying operation must be of the very rarest. They would be something of this kind: Epilepsy with intense local headache; epilepsy in which, after the general convulsions, paralysis or paresis of any group of muscles follows. Those who trephine an idiopathic epilepsy because it is impossible always to exclude traumatism in idiopathic cases, or because there is a bare possibility that a hæmorrhage, the origin of irritation, may be met with on the surface of the brain, are likely to meet with disappointment.

(8) An infected condition of the wound, almost invariably occurring during the operation, and bringing about (*a*) meningitis: (*b*) hernia cerebri: (*c*) cerebral abscess.

(9) Shock.

[1] *Int. r. Enc. Surg.*, vol. v, p. 102.

Finally, in cases of honest doubt, and in those where a well-considered operation has failed, the interference of the surgeon will be justified by the fact that traumatic epilepsy tends to grow worse, and is little affected by medical treatment. In the words of Echeverria,[1] once declared, traumatic epilepsy, due to injury to the head, leads to early insanity or to feebleness of intellect.

OPERATIVE INTERFERENCE IN THE CASE OF FOREIGN BODIES IN THE BRAIN

Under the above heading such bodies as bullets, knife-points, &c., are included. Depressed and isolated fragments of bone may come within the meaning of foreign bodies, but have already been considered (*see* p. 252).

A. *Bullets.* The following questions will suggest themselves when a surgeon is called to a case of bullet wound of the skull:

(1) *Has the bullet penetrated the skull at all?*

(2) *It may have passed between the bone and the dura mater, without penetrating the latter, and reached a spot quite out of sight.* Probably in most hands a second application of the trephine, if needful, at some distance from the wound, so as to extract the bullet there, would be preferable to attempts at removing it from the original wound.

(3) *Has the ball split into two or more pieces?* Balls elongated as well as round are liable to split when impinging on sharp angles of bone. Thus, when the ball splits upon the outer table, part may pass beneath the scalp, while the rest may drive on before it some of the internal table, causing pressure on the dura mater, or even reach the brain.

(4) *Has the bullet penetrated the brain?* If so, where does it lie?

(5) *Ought any exploration to be performed at once* and if so, how far is the surgeon to go?

If the last question be answered in the affirmative, an answer will be given to most of the others.

While, owing to the rarity of gunshot injuries of the head in civil practice in this country, it is very difficult to give a dogmatic answer, the following reasons are in favour of exploring in all cases in which it is clear that the injury is not going to be quickly fatal:

(*a*) The fact that only by exploring will the surgeon be able to answer the question certain to be put to him by the friends, whether the brain is injured or no?

(*b*) Whether the bullet has split, whether the internal table is shattered and, if so, how far it resembles a punctured[1] fracture, are points which alone can be cleared up by trephining.

(*c*) Disinfection of the wound and good drainage are almost hopeless unless this be opened up and explored by trephining if needful.

The following case is not only a good instance of the kind of gunshot injury to the head which may be met with in civil practice, but it shows how slight may be the injury which actually originates the fatal mischief. It was brought before the Clinical Society[2] by Mr. Lucas:

The patient, aged 21, had shot himself with a small revolver. "Almost in the centre of his forehead were two small circular holes, with slightly inverted edges. The surrounding skin was raised into a rounded prominence. There was some bleeding from the nose as well as from the wounds. On turning back flaps, a

[1] *Loc. supra cit.*, p. 277.

[2] *Trans.*, vol. xii, p. 5.

blackened cavity was opened beneath the skin, formed by the expansion of the powder after it had penetrated the integument. At the bottom of this cavity, a somewhat cruciform aperture was seen in the bone, and lying upon the internal table were two flattened bullets. The internal table was driven back so as to give the appearance of a sinus, in which the bullets were lying loose; and at the time we were under the impression that the man had very large frontal sinuses, which had been opened by the bullets. After removing numerous fragments belonging to the external table and diploe, the splintered internal table forming the posterior wall of the cavity was also removed.

This came away in large, sharp-edged, angular fragments, two of which were grooved by the longitudinal sinus. When the internal table had been removed, the dura mater was seen at the bottom of the wound and pulsating. The membrane was entire except at one spot, where there was a small aperture just such as might be made by stabbing the point of a penknife into a sheet of paper. But for that small puncture it is not improbable that he would have recovered. Infective meningitis came on in about forty-eight hours, followed by death early on the sixth day.

If the surgeon decides to explore the wound he does so with the intention of rendering the wound as sterile as possible, removing all dirt, hair, and splinters in the cortex, if accessible, without making the condition of the patient worse than it already is. He will have warned the friends that removal of the bullet may be found impracticable on this occasion owing to the patient's condition. We will suppose that no cerebral symptoms are present, either focal ones to guide him, or such grave ones as coma, stertor, paralysis of the sphincters, which would lead him to stay his hand. Lastly, the injury is not of that destructive character, so shattering the skull and ploughing up the brain, especially in a direction towards the basal ganglia, as is certain to prove quickly fatal.

Localisation. This can be accurately ascertained by a radiographic examination. Surgeon-General Stevenson[1] thus sums up the question of localisation:

It is not the bullet so much as the fragments of bone driven in which will cause infection. This is borne out by the military experience in South Africa. Here also while suppuration was rare after bullet injuries, it was the rule in wounds due to fragments of shell. "All exploring instruments, electrical and other, for the detection of lodged missiles may nowadays be set aside as out of date, and dependence placed entirely on the use of X-rays for this purpose. By their means, using Mackenzie Davidson's cross-thread localiser, the exact position of any foreign body within the tissue can be ascertained to a millimetre, or stereoscopic photographs may be taken which will afford means of sufficiently exact estimation of the position of an object as large as a bullet to warrant the surgeon in operating for its removal without more accurate localisation. When using this method, small pieces of wire should be fastened on to the skin above and below the bullet, so that its relative position to known points on the skin may be shown in the stereoscope, and thus a clear indication obtained for the operative procedure to be carried out. Before proceeding to localise the bullet, or to skiagraph it stereoscopically, its general position should be ascertained by means of the fluorescent screen or by a single skiagraph so that part of the limb or body in which it is situated may be placed in the proper position over the photographic plate while these methods are being carried out."

Mr. E. W. H. Shenton, Surgical Radiographer to Guy's Hospital, writes as follows: "It is possible by means of the Rontgen Rays to estimate the size of and to exactly locate bullets or other bodies which have become lodged in the cranial cavity. The simplest method, perhaps, is that where two radiograms are taken—one in an antero-posterior direction, and the other in the lateral. Another system, and a far more accurate one, is that now in common use at Guy's Hospital. It is a system whereby the exact distance from any given point may be found, and the principle upon which it is based as follows: When an image is being viewed upon the screen and the tube moved, the shadows of the various parts of the object viewed will move upon the screen at different rates according to their distance from the screen; that is, the nearer to the screen the less their shadows will travel in a

[1] *Report on Surgical Cases noted in the South African War.*

given time. Quite superficial objects, those almost touching the screen, will hardly move at all. By a suitable mechanism exact measurements are easily obtained and, in all cases where the foreign body can be seen upon the screen, this can be accomplished without the employment of any photographic process. If considered desirable in the case of bullets in the head, a skull may be taken and a bullet arranged in it, by the aid of the measurements obtained, to correspond in situation to the original bullet. Such a device will prove of great value to the surgeon at an operation for the removal of the foreign body. When exact localisation has been obtained, radiography can go no further, unless the practice of operating with the rays to hand is adopted. By such a method the surgeon is enabled to see the position of the foreign body from time to time, and any metal instrument he may be using. Until tubes of greater power are forthcoming this method cannot be advised for cases of bullet in the head."

Though probes should not be used for localising the position of the bullet unless it is very superficially situated, they are of use in identifying it when its position has been determined by a radiographic examination. Some blunt instrument should be employed, such as Nelaton's, which is provided with a rounded porcelain knob at its extremity.

Treatment. This may be considered under two headings. (1) The opening up of the wound for the purpose of removing fragments of bone and bruised tissues, and for cleaning the wound and providing drainage. (2) The removal of the bullet. This may be immediate or late and will depend on the condition of the patient and the situation of the bullet.

The following remarks by Mr. G. H. Makins[1] are of twofold interest, first from their recent date and their bearing on the effect of modern small projectiles of high velocity and, secondly, from the wide practical experience and weight with which the writer speaks.

"Operative interference is necessary in every case in which recovery is judged possible. The injuries are, without exception, of the nature of punctured wounds of the skull, and the ordinary rule of surgery should under no circumstances be deviated from. An expectant attitude, although it often appears immediately satisfactory, exposes the patient to future risks which are incalculable. . . . Cases of a general character,[2] or in which the base has been directly fractured other than in the frontal region, are seldom suitable for operation, since surgical skill is in these of no avail; but in all others an exploration is indicated. I use the word 'exploration,' since what may be called the formal operation of trephining is seldom necessary except in the case of the small openings due to wounds received from a very long range of fire; in all others there is no difficulty in making such enlargement of the bone opening as is necessary with Hoffmann's forceps.

"The scalp should be first shaved and cleansed; if for any reason an operation is impossible, this procedure at least should be carried out, with a view to ensuring as far as possible, future asepsis, infection in head injuries being almost the only danger to be feared. The scalp having been cleaned with all care, a flap is raised, of which the bullet opening forms the central point, and the wound explored. In slight cases the entry wound is the one of chief importance, and the exit may be simply cleansed and dressed. The flap having been raised, if the wound be a small perforation, a half-inch trephine crown may be taken from one side; but it is rare for the opening to be so small that the tip of a pair of Hoffman's forceps cannot be inserted. The trephine is more often useful in cases of non-penetrating gutter fractures where space is needed for exploration, and the elevation or removal of fragments of the inner table. Loose fragments may have to be removed from beneath the scalp, but the important ones are those within the cranium. These may either be of some size, or fine comminuted splinters of either table, often at as

[1] *Surgical Experiences in South Africa*, 1899-1900.

[2] Under this heading are included extensive sagittal tracts passing deeply through the brain, and vertical wounds passing from base to vertex or vice versâ, in the posterior two-thirds of the skull. For their production the retention of a considerable degree of velocity on the part of the bullet was always necessary, and the results were consequently both extensive and severe.

great a distance as two inches or more from the surface. The cavity must be thoroughly explored and all splinters removed. I have seen more than fifty extracted in one case of open gutter fracture. The brain pulp and clot should then be gently removed or washed away, and the wound closed without drainage. Fragments of bone, as a rule, are better not replaced, but complete suture of the skin flap is always advisable in view of the great importance of primary union, and the fact that a drainage opening exists at the original wound of entry, and that the wound is readily reopened to its whole extent, should such a step become desirable.

"The detection of fragments is most satisfactorily done with the finger, and in all but simple punctures the opening should be large enough to allow thoroughly effective digital exploration. The determination of the amount of brain pulp which should be removed is somewhat more difficult; all that washes away readily should be removed, and its place is usually taken up by blood.

"Few fractures of the base are suitable for operative treatment; the only ones I saw were those of direct fractures of the roof of the orbit or nose, produced by bullets passing across the orbits. Here the advisability of interfering with the injured eye led to opening of the orbit, and sometimes exposed the fracture.

"As to the most satisfactory time for the performance of these operations . . . in head injuries the advantages of early interference were more evident than in any other region. This depended on the fact that, as in civil practice, the scalp is one of the most dangerous regions as far as the auto-infection of the wound is concerned, and one of the most difficult to cleanse except by thorough shaving." With regard to the treatment of retained bullets which are stated to have been distinctly rare, Mr. Makins advises that the operation should not be undertaken until "the patient can be placed under the best conditions which can be secured. . . . Such operations need the infliction of an additional wound, require great delicacy, and may be very prolonged in performance." Earlier interference is only indicated where the bullet has tried to escape or secondary symptoms develop pointing to irritation.

Operation. A. *The position of the bullet has not been determined, either on account of the condition of the patient or the radiographic examination may have been inconclusive.* While the head is being shaved and preparations for the operation made, the surgeon will take note of any superficial lesions, such as blackening of the skin, burning, the presence of grains of powder, and the original characters of the external wound, both for medico-legal purposes and for future guidance, all these lesions being soon liable to alteration. It is rare, supposing the patient to have recovered consciousness, that any localising symptoms are present, which can point to the lodgment of the bullet in a definite part of the cortex, *e.g.* the motor or the speech area.[1] In a few cases, as soon as the whole head is shaved, the surgeon may gain evidence of the position of the bullet by finding on the opposite side of the skull a contusion of the scalp, an elevation of the bone, or even a tender spot, beneath which, after incision, some fine fissures may be detected (Phelps).[2] The surgeon, having raised an appropriate flap, enlarges the wound in the skull with Hoffmann's forceps and removes any dirt, soft parts which will certainly die, and superficially lying splinters. In order thoroughly to remove any powder, dirt, or lead splashes from the external wound in the skull, even after this has been enlarged with Hoffmann's or other forceps (*see* p. 342), it may be needful to resort to rubbing with sterilised gauze, or even to use the gouge. The wound in the dura should be sufficiently enlarged to give exit to any blood or cerebral debris. If uninjured, or very slightly injured, the bullet having been deflected, the dura should be most carefully examined

[1] Any such lesions, which may be noted immediately, are due to the passage of the bullet; if occurring later on they will mark certain secondary morbid conditions.

[2] *See* "Traumatic Injuries of the Brain and its Membranes," by Dr. Phelps, of New York, p. 343.

before it is taken for granted that the parts beneath have not been implicated. If this membrane, though uninjured, is bulging, it is always to be opened. Fragments of bone accessible within the cortex should, after the wound has been enlarged, be sought for with a probe or even with the finger and, when found, removed with dressing forceps or a small scoop. The bullet may be discovered in the course of these manipulations but, unless it is soon met with, its extraction should be postponed to a future operation when its exact position has been localised. The opening in the dura should be sufficiently large to give exit to any blood or cerebral debris. If irrigation of the bullet-track is practised, with the view of removing infected clots or sloughs, it will be well to plug round the opening in the skull with strips of gauze lest the fluid carry infected particles into the arachnoid or sub-arachnoid spaces. Dr. Phelps is of opinion that drainage tubes are to be employed with much reserve, and only in cases where there is great and widespread damage to the central regions of the brain. If used at all, drainage-tubes should be withdrawn and abandoned at a very early period, usually on the second day.

The following objections to the employment of drainage tubes must be remembered: (1) That they are irritant foreign bodies. (2) That they are likely to become filled with clot, and thus act as plugs rather than as drains. (3) That they are media for the deep implantation of infective elements when the surface is no longer sterile.

If the surgeon fails to find the bullet he will, in the majority of cases, do well to wait for an improved condition of his patient and careful localisation by the use of the Röntgen rays. If already localised he must consider whether the state of the patient justifies further interference. While profound unconsciousness and deepening coma or a marked condition of shock contra-indicate any prolonged operation, it will be better if the site of the bullet is known with anything like certainty, to remove it at once, and so minimize as much as possible the risks of infection. Before inflicting this additional injury and running the risk of causing, perhaps, further severe loss of blood from incisions in scalp, dura mater, and brain, the surgeon will, accordingly, take into careful consideration the condition and vitality of his patient.

B. *The removal of the bullet.* Whether this is done at the same time as the cleaning of the wound or later, when the condition of the patient has improved, it may be effected through the original wound or by counter-trephining. The advisability of the latter operation will depend upon the position of the bullet. The course of the projectile within the skull is often very erratic, as it may be deflected by coming into contact either with the dura, or with some bony prominence. A radiographic examination may therefore show it to be in an easily accessible position at some distance from the wound of entry. It will now be necessary to consider those cases where, after careful exploration, the patient has been saved from the risks of infection, but though the bullet has not been found the wound has healed. The question then arises as to whether the bullet should be removed or allowed to remain. Where headache or any local symptoms are present, we will say two or three months after the injury, the course to follow is clear, especially when a radiographic examination clearly localises the bullet. But it is not so easy to give an answer in those cases where, after healing of the wound, cerebral symptoms are absent, or extremely slight, and perhaps

the Röntgen rays are unable clearly to define the position of the bullet. On the one hand, any honest surgeon knows that by operating he may, in spite of all his care, expose his patient to dangers greater perhaps than those entailed by leaving the bullet alone. On the other hand, the evidence is strong that if a large number of cases of recovery without removal of the bullet were accurately watched for long periods, many would be found to be cases of incomplete recovery.

The evil results of allowing a foreign body to remain in the brain are usually manifested sooner or later, even as long as fifteen years after the injury. Inflammation, slow or rapid, sometimes involving large portions of the brain tissue, or yellow softening, is apt to be set up around the foreign substance, either spontaneously, or from the most trivial exciting causes. The usual termination is cerebral abscess, this condition having been found in fifty-three cases in which a necropsy was performed. Apoplexy is an occasional cause of death, as is pressure of the foreign body on the venous trunks, inducing ventricular effusion and consequent compression of the cranial nerves. The probable explanation of those cases in which no symptoms have been present for long periods, but in which death has rapidly followed upon the sudden development of brain symptoms, is that quoted by Wharton from Flourens. This observer found that bullets introduced into different portions of the upper parts of the hemispheres and the cerebellum gradually penetrated the brain substance, ultimately reaching the basis cra, ii. the bullet tracks healing after them. "There is probably no authenticated case of recent Anglo-American record in which a bullet left in the brain substance has failed to work mischief, nor has the mischief been often long procrastinated. There have been occasional instances in which it has remained harmless for a number of years in the cranial cavity, but the brain has not been penetrated. The fact that epilepsy has developed so late as fifteen years after injury must make even apparently exceptional cases doubtful."[1]

The following detailed case by Mr. W. Sheen, of Cardiff,[2] which is an instance of removal of the bullet by counter-trephining at a second operation, will be found extremely instructive:

The patient, a man æt. 23, had been struck by a revolver bullet about 2 cm. to the left of the mid-frontal line, and the same distance above the supra-orbital arch. Owing to the depth of the bullet, about 12 cm. from the point of entrance, it was not considered advisable to extract it at first. Ten weeks later there were still attacks of left parietal and frontal headache, some motor aphasia, and weakness in the right leg. The position had been localised with the Röntgen rays by Dr. Martin, whose remarks are quoted below, at a depth of 6·5 cm. from the lateral surface o. the head. A flap was turned down behind the left ear, and a one-inch disc removed above and behind the meatus. This opening was enlarged downwards and forwards, the dura mater opened, and the bullet searched for "by entering a probe 3·5 cm. above the meatus, and 2·5 cm. behind the intermeatal line, and passing it in the horizontal plane of the head to a depth of 6·5 cm. The bullet not being felt, Hedley's telephone probe was passed in the same line, and after feeling a moment a rather doubtful tap was felt. The probe was withdrawn, and a pair of ordinary dressing forceps passed in felt the bullet, which bobbed about in an elusive way, suggesting the possibility of its being in a cavity." At the second attempt the bullet was removed, with a little brain substance adhering. The length of forceps introduced measured 6·5 cm. from the skull surface. As there was considerable increase of intracranial tension, some of the brain substance had to be removed before the dura could be closed. The disc of bone was replaced and the

[1] "Traumatic Injuries of the Brain and its Membranes."

[2] *Lancet*, vol. ii, 1904, p. 825.

wound closed without c dinage. The after-progress was uneventful, but there was still some weakness in the right arm and leg and dimness of vision in the right eye. About five months after the operation the patient resumed work as a stoker, and is believed to have continued it since.

Such cases as the above are the ones likely to be met with in civil practice. In a case like this, revolver bullets, with comparatively low velocity, inflict damage largely limited to their track. On the other hand, as pointed out by Mr. Makins,[1] a high velocity bullet of the modern small arm type not only fissures the skull extensively, but as it rushes into the brain, scatters waves of destruction in different directions. The exact course of the bullet, as in Mr. Sheen's case, above the ventricles and basal ganglia, helps also to determine the result. With regard to the justifiability of the operation, all will agree with Mr. Sheen's remarks: "The man was nearly free from symptoms and apparently on the road to complete recovery. There were, however, certain symptoms, viz. intermittent headache, pain on moving the head, and at least one severe attack of headache, with temporary remission of symptoms. Then one realises that the heavy bullet may change its position; its being felt as if in a cavity at the second operation supports this possibility."

The remarks of Dr. W. Martin on the result of the radiographic examination are of equal interest:

"When the question of removing the bullet was brought forward, radiograms were taken laterally and antero-posteriorly, and localisation was effected by the double impression on the single plate, and the Mackenzie-Davidson cross thread localiser. By these means it was found that the depth of the bullet from the plate was 6·9 cm. About ·5 cm. was allowed for scalp, &c., intervening between the plate and the external surface of the skull, so that it was calculated that the centre of the bullet approached on the horizontal plane of the head from a point 3·5 cm. above the left meatus, and 2·5 cm. behind the interneatal line, would be found at a depth of 6·4 cm. This distance was checked by the antero-posterior view, which placed the centre of the bullet between 6·4 and 6·5 cm. Stereoscopic views were also obtained the night before the operation. Such views, however, for foreign bodies lying deep in the cranial cavity do not give a very clear idea of the exact depth, owing to the absence of intervening landmarks, in the same way that distances at sea are so difficult to estimate."

A number of interesting cases of bullet wounds of the skull are recorded by Surgeon-General Stephenson in the Report on Surgical Cases noted in the South African War. In the following case complete recovery is stated to have resulted, though the time the patient was under observation after the operation is decidedly short. The bullet appears to have been in a very inaccessible position.

Trooper M., Canadian Contingent, admitted 13 General Hospital April 5, 1902, with small scab over frontal bone due to gunshot wound. No brain symptoms—seemed perfectly well. Wound probed, probe passed into skull; dry gauze dressing. Six days after temperature rose and brain symptoms appeared; restless; quite unaccountable for his actions. Next day trephined; spicules of bone removed; dura found lacerated; drained. On the seventeenth day brain symptoms again appeared, and he was explored the day following. Pus under scalp above right ear evacuated; it was found to be issuing from a fracture here, from abscess in the brain three inches deep; trephined, and abscess drained. Completely recovered in two months; invalided; X-rays showed bullet at base of brain. The man returned to Canada September 4, 1902, from Royal Victoria Hospital, Netley. (Civil Surgeon Malcolm.)

B. Other foreign bodies besides bullets which may penetrate the

[1] *Loc. supra cit.*, p. 248.

brain are *knife-points*. These, with their tendency to form cerebral abscess, have already been alluded to.

C. *Another class* of foreign body which may be met with by the surgeon in civil practice is shown in the following case of Mr. Couper's:

A house painter fell twelve feet from a ladder, impaling the right side of his skull on the spike of an iron palisade. When brought into hospital there was a clean cut wound three quarters of an inch long immediately under the right ear, partly overlapped by its lobule. In this the end of a large rough piece of metal, corresponding to a freshly broken spike, could be felt, and its direction could be inferred to be upwards, inwards and a little forwards from the outer wound, which was situated half an inch under the external meatus between the mastoid process and the ramus of the jaw. There was some bleeding from the ear, but no facial or other paralysis. The patient was put under chloroform, and Mr. Couper succeeded, after much forcible wrenching, in extracting the iron. During these efforts about three ounces of blood oozed from the wound; the hæmorrhage ceased as soon as the iron was out, but a small quantity of semi-fluid brain substance then escaped. Right facial paralysis came on two days after the injury, then delirium, restlessness, and on the seventh day left hemiplegia, followed by convulsive attacks affecting the right limbs and the right half of the face. Two days later, or nine days after the accident, the patient died. At the necropsy the surface of the right hemisphere showed well-marked sub-arachnoid meningitis. The posterior part of the right middle cerebral lobe had been deeply wounded: the brain substance at this spot softened and streaked with pus, elsewhere was healthy. The spike had entered just under the apex of the mastoid process, traversed the internal ear, and driven several irregular masses of petrous bone through the dura mater.

In a similar case the careful use of chisel or gouge would loosen the foreign body, while opening up of the wound would facilitate drainage and cleansing the parts damaged, including the brain itself and its membranes.

[1] *London Hospital Reports*, vol. ii; *Hutchinson's Clinical Surg.*, vol. i. p. 91, pl. xvii.

CHAPTER XV

CEREBRAL LOCALISATION IN REFERENCE TO OPERATIONS. OPERATIONS FOR TUMOUR OF THE BRAIN

Motor Area. The motor area, or that part of the cortex in which lesions cause paralysis on the opposite side of the body, lies beneath the anterior half of the parietal bone. It is situated immediately in front of the fissure of Rolando, occupying the precentral convolution. Formerly it was thought that the motor area extended behind the fissure of Rolando into the post-central convolution. It is now recognised that the latter convolution is concerned with muscular and tactile sense.

Speaking succinctly, but perhaps with sufficient accuracy for practical purposes, paralysis or convulsions limited to one lower extremity mean that the lesion is situated in the upper third of the opposite motor area and will call for removal of bone in this situation; paralysis of the arm points to a lesion in the middle third of the area; while paralysis of the face indicates a lesion of the lower third. The centre for speech lies (on the left side) a little below and in front of the latter area and is situated in the first frontal convolution. Where lesions are combined a more or less extensive removal of bone over the corresponding areas will be called for.

It will be seen that a simple method of marking out the fissure of Rolando is of great importance to the surgeon. This may be fairly accurately marked out as follows: Draw a line between the root of the nose (nasion) and the external occipital protuberance (inion): bisect this line and take a point half an inch behind its centre. This will give the upper extremity of the fissure, *i.e.* where it meets the mesial longitudinal fissure of the brain. From this point a line, four inches in length, is drawn downwards and forwards making an angle of 67·5° with the first line. This angle, which is three quarters of a right angle, is easily measured. The second line indicates the fissure of Rolando, so that the motor area is just in front of it.

Sir R. Godlee, in the classical case mentioned on p. 293 used the following simple method of marking out this fissure. A very similar method was employed by Mr. Makins and the late Mr. Anderson.

(1) A line was drawn between the nasion and the inion as described above.

(2) At a right angle to this a second line was drawn vertically downwards through the front of the external auditory meatus.

(3) Parallel to the last another line was drawn vertically upwards at the level of the posterior border of the mastoid process, reaching the first or longitudinal line (1) about two inches behind the second.

(4) From the junction of lines 1 and 3, one was drawn diagonally downwards, reaching the second about two inches above the external auditory meatus. This corresponds to the direction of the fissure of Rolando.

With regard to all surface markings of the cerebral convolutions it may here be pointed out that the eminences and sutures of the skull, and the relations of the sulci and convolutions beneath to the cranial surface are liable to variations.

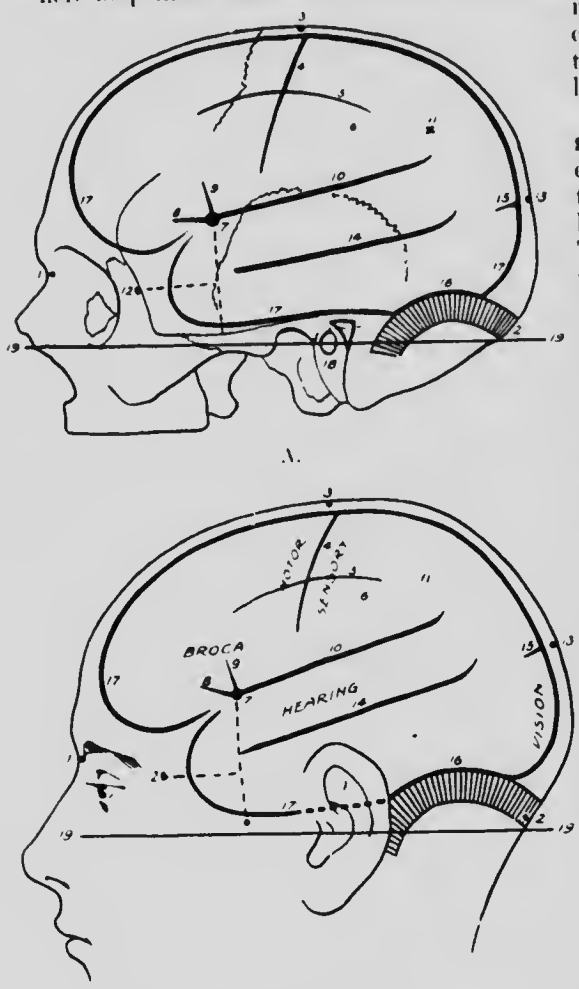


Fig. 123 A. Showing relations of chief cerebral sulci to surface of skull. B. Showing chief sulci and their relations to surface of head.

1. The nasion. 2. The inion. 3. Mid point between nasion and inion. 4. Fissure of Rolando. 5. Superior temporal crest. 6. Inferior temporal crest. 7. Sylvian point. 8, 9, 10. The three limbs of the Sylvian fissure. 11. The parietal eminence. 12. The malar tubercle. 13. The lambda. 14. First temporo-sphenoidal sulcus. 15. External parieto-occipital sulcus. 16. Lateral sinus. 17. Level of the base of the cerebrum. 18. External auditory meatus. 19. Reid's base line.

Position of the chief sutures (Fig. 123). The coronal suture, the anterior limit of the parietal bone, may thus be traced. The point where it leaves the sagittal suture, the bregma, may be found by drawing a line from a point just in front of the external auditory meatus straight upwards to the vertex; from this point the coronal suture runs downwards and forwards, speaking roughly, to the middle of the zygomatic arch, or more exactly, to join the temporal part of the great wing of the sphenoid, which it meets an inch and a half above the middle of the zygoma, and not quite an inch behind the external angular process of the frontal bone.

Under this suture lie the posterior extremities of the three frontal convolutions, for the frontal lobe lies not only under the frontal bone, but extends backwards under the anterior part of the parietal, the fissure of Rolando, which forms the anterior boundary of the frontal lobe, lying from one and a half to two inches behind the coronal suture.

The occipito-parietal or lambdoid suture, the posterior limit of the parietal bone, will be marked out by a line which starts two and a half inches above the external occipital protuberance, and runs forwards and downwards to its termination, which is on a

level with the zygoma, an inch and a quarter behind the meatus. As the occipital lobe is not limited to the upper portion of the occipital bone, but extends forwards under cover of the posterior part of the parietal, the parieto-occipital fissure lies about three-quarters of an inch in front of the apex of the lambdoid suture. But this varies a good deal according to the ossification of the tabular part of the occipital.

The squamous suture is not easy to mark out, owing to the irregularity of its curve. Its highest point is usually an inch and three-quarters above the zygoma.

The Sylvian fissure, which separates the temporo-sphenoidal lobe from the parietal, passes obliquely upwards and backwards across this suture near its middle, the temporo-sphenoidal lobe lying beneath the lower part of the parietal as well as under the squamous and the great wing of the sphenoid.

To mark out the fissure of Sylvius it is necessary to find first of all the Sylvian point, which represents the site of divergence of the three limbs of the fissure. This point is situated an inch and a quarter behind the external angular process of the frontal and an inch and a half above the zygoma. "The main posterior horizontal limb of the Sylvian fissure passes backwards and upwards from this point to a point situated three quarters of an inch below the most prominent part of the parietal bone. The vertical limb is directed upwards for about three-quarters of an inch, whilst the anterior horizontal limb passes forwards for about the same distance."[1]

The following practical points are given by Prof. Naucrede, following M. Lucas-Championnière.[2]

(1) Monoplegia, or spasms limited to one limb, or a portion of one limb, indicate limited lesions. If the lower limb be affected the upper portion of the ascending parietal convolution (Fig. 121) is involved. Bone must therefore be removed over the upper part of the motor area.

(2) With paralysis of the arm and leg, the lesion probably involves the upper two-thirds of the area with possibly the paracentral lobule on the mesial aspect of the hemisphere. The trephine should thus be placed at the upper part of the area, and the opening enlarged upwards or downwards as required.

(3) Paralysis of the upper extremity alone probably indicates a lesion at the middle third of the ascending frontal convolution, and the trephine should be applied in front of the middle third of the fissure of Rolando.

(4) Paralysis of the lower part of the face points to a lesion in the lower third of the motor area.

(5) In simple aphasia a disc of bone should be removed lower down still, in front of and below the lower extremity of the fissure of Rolando.

(6) In most cases more than one centre is affected, and consequently a considerable extent of bone may require removal. Lesions which irritate a localised area of the cortex, *e.g.* a spicule of bone, a meningeal hæmorrhage, a localised meningitis, or a growth, produce spasms in the corresponding groups of muscles on the opposite side of the body which are supplied by the cortical centres irritated (Jacksonian epilepsy). The irritation may involve adjacent centres, causing widespread and even general convulsions. Lesions which destroy any area of the cortex produce paralysis on the opposite side of the body corresponding to the

[1] Rawlings, "Surface Markings." [2] *Intern. Encycl. Surg.*, vol. v, p. 90.

position and extent of the area destroyed. A few special cortical centres must be remembered. Broca's convolution, in the posterior extremity of the left inferior frontal convolution, corresponds to a point three fingers' breadth vertically above the middle of the zygomatic arch. This centre governs the muscular movements concerned in speech, and lesions of it cause "motor aphasia." The auditory-speech, or word-hearing area, the function of which is the perception of spoken words, lies in the middle of the first temporo-sphenoidal convolution. Lesions here produce "word deafness," the patient being unable to understand spoken words. The visual speech or word-seeing centre, by which written words are

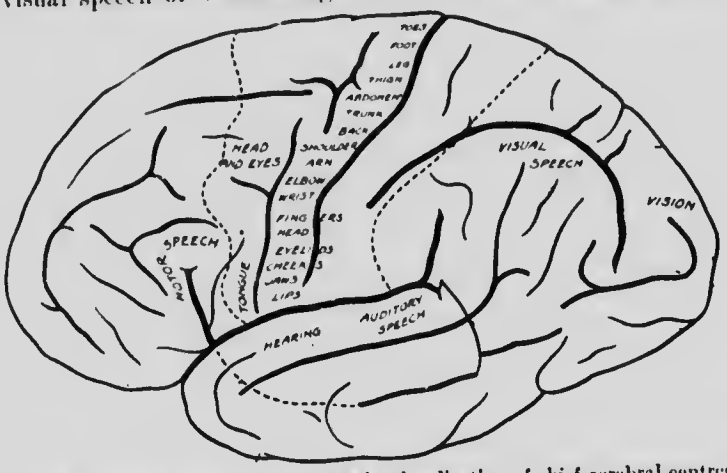


FIG. 124. Outer surface of brain, showing localisation of chief cerebral centres.

appreciated, lies in the angular gyrus at a point higher up and behind the last (Fig. 124). If this centre be destroyed power to read words is lost. All the above are situated on the left side in right-handed patients.

The cortical centres for vision lie near the calcarine fissure on the inner aspect of the occipital lobes, below the level of the parieto-occipital fissure (Fig. 124). Each is a half-vision centre and receives fibres from the same side of each retina. Lesions of one centre produce "homonymous hemianopsia" or inability to see objects situated on the side opposite to the lesion.

PRACTICAL VALUE OF CEREBRAL LOCALISATION

A few instances will be given under the following headings: (*a*) In head injuries; (*b*) In brain growths.

(*a*) *Cerebral Localisation in the Diagnosis and Treatment of Injuries to the Head.* (For examples *see also* pp. 301–308.) A typical case in which localisation may help the surgeon in trephining, would be one in which the injury is limited to the cranium, and is followed immediately by paralysis. Secondary or late paralysis may be the result of later inflammatory processes.

M. Lucas-Championnière [1] gives this interesting case:

A man was found in the street with slight paralysis of the right arm, but with perfect sensibility. There was a small superficial cut half an inch long over the left parietal eminence. Five or six days later the patient became stupid and unable to

[1] *La Trépanation guidée par les Localisations cérébrales*, p. 107.

swallow, and convulsions,[1] increasing in violence and involving all the body save the right forearm and hand, set in. Suspecting a fracture of the inner table, M. Lucas-Championnière trephined at the site of the wound, and found a fine fissure just in front of this; there was a slight depression of the fragments, which were wedged tightly together. After the operation the convulsions ceased and a good recovery took place, with use of the right arm. The fracture was proved by measurements to be over the middle and lower part of the fissure of Rolando, considerably in front of the scalp wound.

The following is a case of traumatic aphasia successfully treated by removing blood clot from the interior of the cerebrum.[2]

The patient had been struck on the head with a penknife six days before admission. At that time he had difficulty in speaking correctly, which had increased somewhat, and pain in the left side of the head, but no paralysis or loss of sensation. A small scar was found over the left squamous bone two inches from the external angle of the orbit and three-quarters of an inch above the zygoma. Both forms of aphasia (motor and sensory word-blindness) were to a certain extent present. Five days later the scar was explored, and a wound of the squamous bone, in size and shape likely to have been produced by a small penknife, found, and cut out in a trephine disc. The knife had penetrated the dura and brain, the large posterior branch of the middle meningeal just escaping. The dura being opened, a sims forceps was gently passed along the brain wound, and on separating the blades a blood clot presented, and was gradually extruded by brain pressure. More clot was then washed away by a stream of weak perchloride lotion. A drainage-tube was inserted. On the evening of the same day the aphasia was much improved. Next morning the patient was again more aphasic, and it was found that the tube had become blocked. On freeing it, much fluid with broken-down clot escaped, and the power of speech improved. The patient recovered uninterruptedly, regaining completely his power of writing, reading and speaking. Sir C. Ball believed that the knife had penetrated the superior temporo-sphenoidal gyrus, traversed the Sylvian fissure, and probably injured Broca's convolution.

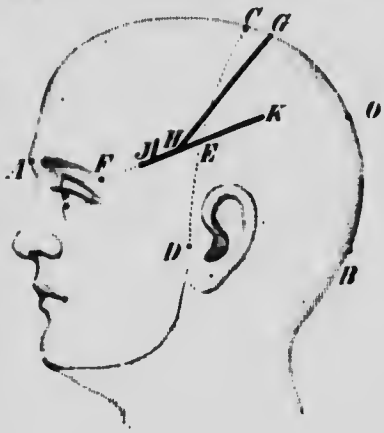


FIG. 125.

(b) Cerebral Localisation in the Diagnosis and Removal of Cerebral Growths.

The following case, trephined by Sir R. Godlee for Dr. Hughes Bennett in 1884,[3] is of great interest, partly because it was one of the first cases of removal of a tumour from the brain in this country, and also on account of the completeness of the details and the accuracy of his reasoning.

A man, aged twenty-five, had four years before suffered from slight concussion from a blow on the left side of the head. A year later there first set in twitchings in the left side of the mouth and tongue, paroxysmal and irregular in occurrence. Some months after fits began, with loss of consciousness and general convulsions. This condition lasted two and a half years; and six months before admission, twitchings of the left hand, followed shortly by weakness of the left fingers, hand and forearm, were noticed. For three months these had prevented his using his tools. During this last period there had been twitchings of the left leg, which had also been getting weak. There was nothing abnormal in the skull or scalp. Vision was normal, but optic neuritis was present on both sides, most marked on the right. Hearing was less acute in the right ear. There was now complete paralysis of the left fingers, thumb and hand, the elbow movements were very

[1] Convulsions in themselves are only an indication for interference when they are localised and persist, and especially if they alternate with paralysis of the same muscles.

[2] Sir C. B. Ball, *Trans. Roy. Acad. of Med., Ireland*, vol. vi, p. 155.

[3] *Med. Chir. Trans.*, vol. lxviii, p. 244.

limited, those of the shoulder impaired. There was no rigidity or wasting of muscles. The toes of the left leg did not clear the ground in walking. There was persistent vomiting and retching, with attacks of lancinating headache, rendering life intolerable. Large doses of the iodides were fruitless.

An operation being decided on, the motor area and the fissure of Rolando were mapped out. Theoretically, in order to hit the middle of the fissure of Rolando, the centre of the trephine should have been placed about half an inch behind the diagonal line and about an inch and a half from the median longitudinal line. As, however, there was a tender spot on the scalp two inches anterior to this, the first trephine opening was made between the two. The dura mater was normal; after a crucial incision was made in it, the brain was thought to bulge abnormally, and to be rather more yellow than usual. A second disc was removed with the trephine, overlapping the first, external to and slightly in front of it, and the angles of bone were rounded off with a gouge. These two openings were then joined by one posterior to them, so that an aperture measuring two inches by an inch and three-quarters was made. The dura mater was opened and a surface of brain exposed nearly equal in size to that of the skull-opening. Occupying most of this space and crossing it obliquely from above and behind, downwards and forwards, was a convolution, into the centre of which an incision was made. From an eighth to a quarter of an inch below the surface lay a transparent, lobulated, solid tumour, thinly encapsuled but quite isolated from the surrounding brain substance. The incision into the cortex being prolonged, the sides of the growth were easily separated by a steel spatula. The superficial surface of the growth being thus isolated, this portion was removed with the finger. As part now broke away, the deeper part was enucleated with a sharp spoon, the scraping being continued till apparently only healthy brain matter remained. The cavity, about the size of a pigeon's egg, filled up with blood, and sponge pressure failing, the hæmorrhage was eventually checked by the electro cautery. A drainage tube was inserted beneath the dura mater, which elsewhere was drawn together by sutures. The skin wound was closed and an antiseptic dressing applied.

The wound was not dressed till the third day, when the scalp near the wound was somewhat œdematous. The next day wet boracic dressings were applied, but a hernia cerebri as large as half an orange was protruding through the lips of the wound. There were no twitchings of limbs or face, no headache. The patient was bright and cheerful, with a good appetite. The hernia cerebri, however, increased, and on the eighth day, having reached the size of half a cricket ball, was snipped away with scissors, the parts removed consisting chiefly of granular matter and clot, with, apparently, little true cerebral structure. The hernia cerebri again increased somewhat, but all seemed to be doing well, when, on the twenty-first day, a rigor occurred, headache and vomiting followed, then restlessness, sleeplessness, and gradual sinking about four weeks after the operation.

At the autopsy extensive arachnitis was found. The parietal area appeared to have fallen in; in its centre, and occupying the position of the fissure of Rolando, was the wound in the brain. The destruction of the cerebral cortex involved nearly all the ascending parietal convolution, the upper part of the ascending frontal, and the anterior third of the supramarginal gyrus. The extent of softening was not great, but it was difficult to tell this accurately, as the brain had undergone the process of hardening. The growth was a glioma, of the size of a walnut.

In the comments on the case, most interesting remarks are grouped under the following heads: (1) diagnosis, (2) surgical treatment, (3) clinical phenomena after the operation, (4) revelations of the necropsy physiologically and pathologically considered.

These will repay most careful perusal; only the chief points can be given here.

(1) **Diagnosis.** A brain growth on the right side was diagnosed in this case on the following grounds: slow progress, uncontrollable vomiting, violent pains, double optic neuritis.

It was thought to occupy the cortex because certain motor tracts were implicated in definite order, because paralysis was present without loss of sensibility, and above all because of certain paroxysmal seizures of local convulsions occurring without loss of consciousness, eminently suggestive of irritation of the grey matter.

In this case there was complete paralysis of the fingers and hand, with inability to pronate and supinate the forearm; there was partial paresis of the movements of the elbow, and weakness of those of the shoulder joint. There was also slight paresis of the leg and one side of the face. Accompanying all these there were paroxysmal convulsions in all these regions, occurring either singly or in definite order one after the other. These phenomena were to be accounted for by an extensive but not absolutely complete destruction of the motor centres of the fingers, hand, and forearm, with slight encroachment on and irritation of those of the face, upper arm, and leg. A very definite localisation was thus permitted, and the tumour was pronounced to have occupied the whole thickness of the middle two-fourths of the ascending parietal convolution, and a portion of the adjoining upper half of the ascending frontal convolution. The growth was proved to be limited by the fact that the centres of the leg above, of the face and tongue below, of sight behind, and of the movement of the eyeballs in front, were not seriously involved. As to the probable nature of the tumour, the age of the patient, the absence of syphilis, and the slow progress, suggested glioma.

(2) **The Operation.** One convolution only being exposed during the operation, there was at the time some question as to whether it was the ascending frontal or parietal. This doubt arose from the circumstance that in the attempt to approach the tender spot the theoretical position had been slightly departed from. After death, however, it was apparent that the convolution which had been incised was that in which from the first the disease had been diagnosed to exist, viz. the ascending parietal. There was no external appearance of disease about this part except that it seemed swollen, less glossy, and less vascular than natural. An incision into it showed the morbid growth to be immediately under the surface, and almost completely involving the entire thickness of the cortex.

It may be questioned whether it was advisable to arrest the haemorrhage from the interior of the wound by means of the galvano-cautery, as the bleeding was not severe and would no doubt have become arrested by natural means. The use of this instrument appears to have brought about the sloughing which was the cause of the inflammation and consequent hernia cerebri. It was remarkable that the discharge continued for so long to be so copious and so watery, as to suggest the idea of its being cerebro-spinal fluid.[1]

(3) **Clinical Phenomena following the Operation.** The patient lost his headache, vomitings, and violent twitchings in the limbs; even the double optic neuritis markedly diminished. The only change which followed the operation was completion of the paresis of the upper extremity, evidently due to the unavoidable destruction of the remaining arm-centres in the removal of the tumour. Coincident also with the formation of the hernia cerebri came fresh symptoms, in the shape of paresis of the left leg and partial anæsthesia of one half of the body. These were probably due to the effects of simple pressure, and possibly to the subsequent secondary softening of the conducting fibres caused by it.

(4) **Revelations of the Necropsy.** The brain was, practically, everywhere healthy except over the area injured by the operation and in the

[1] It was not conclusively shown at the necropsy if the lateral ventricle had been opened.

membranes in the immediate neighbourhood. The meningitis was due to irritating matter from the interior of the wound flowing downwards between the layers of the arachnoid, and accumulating at the base of the brain. The local inflammation of the wound had opened out the parts, and separated the adhesions so as to allow the discharge to make its way into the cranial cavity, but not till three weeks after the operation.

The following case, quoted from a paper by Dr. Risien Russel, read before the British Medical Association in 1907,[1] is an example of a case in which the position of the tumour could be ascertained with practical certainty, and in which it was successfully removed by operation.

M. B., a woman aged 40, complained of increasing weakness of the right foot of two months' duration. She next noticed twitchings of the right toes in attacks which lasted for a minute or two and which occurred once or twice in the twenty-four hours. These clonic movements and the motor weakness gradually ascended the limb, until six weeks after the commencement of her illness they culminated in a Jacksonian fit, which, commencing in the foot, subsequently involved the right arm and face, without loss of consciousness. A similar fit occurred three days later. Seven weeks from the onset of the illness she began to notice progressive loss of power in the right upper limb. She had been entirely free from headache, and at no time did she become aphasic. When she came under observation there was hemiparesis of the right side; the face was only slightly affected, the arm much more so, and the leg most of all. Indeed, no movement of the ankle or toes was possible. A diagnosis of a tumour in the leg area of the left motor region was made. Sir Victor Horsley operated, with the result that a tumour the size of a walnut was removed from about half an inch beneath the cortex of the leg area. As an immediate effect of the operation there was marked increase of the hemiplegia, but the paralysis subsequently improved so that before the patient left the hospital, seven weeks after her operation, feeble movements could be made in the right toes and at the ankle, in which parts no movements had been possible before the operation.

QUESTIONS ARISING BEFORE OPERATION ON A CEREBRAL GROWTH

The chief of these are: (A) The existence of a growth; (B) The site of the growth; (C) The depth of the growth; (D) Is it single or multiple? (E) Its nature; (F) The conditions which justify operative interference and the probable results of this step.

The above points, and the five first especially, must be decided with the help of a physician; and it is to be hoped that in future physicians will invoke, at least, the opinion of the surgeon at an early stage of the disease. In too many cases of cerebral growth the operation has only been resorted to as a forlorn hope, a fact which is always to be considered when the mortality from operation in these cases is estimated. Information with regard to questions (A) to (D) will be obtained by referring to some standard work on medicine. The surgical aspect and treatment of these cases necessitate the discussion here of questions (E) and (F) at some length.

(E) **The nature of the growth.** Before dealing with growths of the brain itself it will be necessary to allude to those springing from the dura mater (*see also* p. 245).

Prof. Keen[2] published a case of fibroma weighing over three ounces, attached to the dura mater, which he removed successfully in a patient aged 27 in 1887. The growth dated probably from an injury in childhood. It caused epilepsy, aphasia,

[1] See *Brit. Med. Journ.*, 1907, vol. ii, p. 1122. This paper and the discussion which followed contain much useful information as to the localisation of cerebral tumours, and of its practical value as regards operative treatment.

[2] *Amer. Journ. Med. Sci.*, 1888.

complete hemiplegia, intense neuralgia, deafness, and great impairment of vision. After the operation, save for the eye and ear symptoms, all the others had passed away except slowness of speech and the epilepsy, and the last was much improved. In the same periodical for 1896 (vol. cxii. p. 563), Prof. Keen gives the state of this patient nine years after the operation: "Eyesight still imperfect. Epileptiform attacks recur now at intervals of about a year. Patient still very nervous and unable to do any work."

Sir W. Macewen[1] has published a case in which a growth of the dura mater caused irritative lesions of the left frontal lobe. The patient was restored to perfect health after the operation, and died eight years later of Bright's disease.

In the above-mentioned case the growth was limited to the dura. A detailed account of a case in which a growth originating in the dura involved the cortex of the brain is recorded by Dr. Bremer and Dr. Carson, of St. Louis.[2]

The growth was an endothelioma. Owing to the characteristic spread of the paralysis from one, the shoulder centre, to the others of the upper extremity, the diagnosis of growth in the brain was made, though headache, vertigo, nausea and optic neuritis were absent. At the operation alarming hæmorrhage took place during the removal of the bone owing to the immense size of some branches of the posterior meningeal vein. This was checked by packing while the opening was enlarged. The dura was dark, covered with large vessels, and did not pulsate. It was adherent to a growth beneath, which, though friable, was easily lifted from its bed between the dura and the apparently healthy brain. The patient died on the twelfth day with pyrexia and delirium. At the necropsy a portion of the growth was found to have escaped removal, and the microscope showed that the surface of the brain was itself invaded.

It will now be necessary to consider growths of the brain itself. Almost every form of neoplasm may be found within the cranial cavity. The most common forms are sarcoma, glioma, tuberculous tumour, syphilitic tumour, endothelioma, and cysts. Less common are fibroma and osteoma, while rarer forms are hydatid cysts, psammoma, lipoma, large aneurysms of the arteries at the base of the brain, and tumours of the pituitary body. Some help as to the varieties of growth most likely to be met with, and the relative frequency of each, will be gained from the following table.[3] The interval since the publication of this paper may make it appear out of date. Owing to the care with which it was drawn up, and the sound pathological basis on which it rests, this is not so. The paper remains one of great value and is still quoted and relied upon by different authorities. It will be noticed that Dr. W. Hale White's conclusion that 10 per cent. of the cerebral growths collected by him could certainly have been operated on is distinctly higher than is shown to be the case now in the light of the experience of twenty years later.

Of one hundred cases of cerebral growth the proportions were as follows:

Tubercle	45
Glioma	21
Glio-sarcoma	2
Sarcoma	10
Carcinoma	5
Lymphoma	1
Myxoma	1
Cyst	4
Gumma	5
Doubtful	3
	100

[1] *Lancet*, August 11, 1888, p. 304. [2] *Amer. Journ. Med. Sci.*, February 1895.
[3] Dr. W. Hale White, *Guy's Hospital Reports*, 1886.

Of the forty-five cases of tubercle, the cerebrum was affected in twenty-two, the cerebellum in twenty cases. The growth was multiple in nineteen, and single in twenty-four cases. In all the forty-five cases one or more other structures than the brain were affected. Dr. W. Hale White concludes that not more than three tuberculous cases were likely to be benefited by operation, and even in these the other organs were tuberculous.

Of the twenty-four cases of glioma, of ten only could it be said that they were not infiltrating. The cerebrum was the seat of the disease in thirteen cases, the cerebellum in four. In one case there were multiple gliomata in the brain, and in two others there were growths in other parts of the body.

Of the ten cases of sarcomata several affected the dura mater in inaccessible positions; of the five cases which attacked the brain only, one alone could have been removed with any prospect of success. Of the remaining growths none of the carcinomata or glio-sarcomata were amenable to treatment. Of the four cases of cyst one could certainly, and another possibly, have been operated upon; the myxoma was, and the lymphoma was not, amenable to operation; and of the three doubtful cases, two could have been operated upon. Dr. W. Hale White's summing up is as follows: "Thus we see that out of one hundred cases of tumour of the brain, ten might certainly have been operated upon, and four additional ones might possibly have been; so that in 10 per cent. of our cases we can hold out some hope of operative relief to our patients, provided that a correct diagnosis of the position of the growth be made, even so late as shortly before their death, whilst, of course, earlier in their histories many others might have been operated upon with a good prospect of success."

The following are the conclusions of another physician of great clinical and pathological experience—Dr. Byrom Bramwell, well known as an authority on this subject, the conclusions having been given at a debate on Intracranial Surgery, at the Medico-Chirurgical Society of Edinburgh.[1] Dr. Bramwell considered that the cases in which intracranial tumours can be successfully removed by the surgeon are rare, a consideration of the conditions present making it easy to understand why this must necessarily be the case. (1) In a certain but very small number of cases an intracranial tumour is not characterised by any symptoms during life which enable a positive diagnosis to be arrived at. (2) In some of the cases of intracranial tumour in which the symptoms *e.g.* headache, vomiting, giddiness, and double optic neuritis—distinctly show the presence of an intracranial tumour, there are no localising symptoms which enable the physician to determine in what part of the cranial cavity the tumour is situated. These cases constitute a not inconsiderable proportion of the whole. It is by no means uncommon to meet with large tumours in the temporo-sphenoidal and frontal[2] lobes, the "silent areas" of the brain, which are unattended

[1] *Trans.*, vol. xiii, 1894, p. 180.

[2] There is increasing evidence to show that the frontal lobes can no longer be regarded as "silent areas" as has hitherto been the case. Sir D. Ferrier (Allbutt and Rolleston's *System of Medicine*, vol. viii, p. 50) comes to the following conclusions with regard to the frontal lobe:

(i) Lesions of the frontal lobe may be said to be not infrequently latent.

(ii) On the other hand, in some cases, especially if the lesion is bilateral, and even in the case of lesions which are not calculated to cause pressure or disturbance of the brain in general, there may be mental symptoms of which the chief characteristics are failure

with any very definite and characteristic localising symptoms. The occipital lobe was formerly also thought to be a silent area, but it is now known that lesions in this situation produce homonymous hemianopsia, a most important localising symptom (p. 292). (3) In a few cases, in which there are localising symptoms, these give an erroneous impression as to the position of the tumour.

In support of this statement an instructive case is given in which, in a syphilitic patient, the local pain and tenderness and the localised character of the spasms, which commenced in the left big toe, clearly indicated that the tumour would in all probability be found in the cortex in the region of the foot-centre. The necropsy showed a glioma involving the right optic thalamus, the growth having encroached upon the posterior division of the internal capsule and apparently implicated the fibres to the left leg.

(4) In many of the cases in which the exact position of the tumour is clearly demonstrated, successful operative procedure is impossible or uncalled for. Thus, (*a*) in addition to tumours situated at the base, the basal ganglia, &c., Dr. Bramwell is inclined to include under this head a large proportion of tumours situated in the cerebellum, and for these reasons: The surgeon can hardly hope successfully to remove tumours which involve the middle lobe of the cerebellum. Tumours which are situated in the lateral lobes are with difficulty reached, and the operation required for their removal is a dangerous one: the surgeon has to work in a very narrow space, and there is a risk of wounding the large venous sinuses, the medulla, the pons, &c. Further, it is often an extremely difficult or impossible thing to determine, during life, in which lobe of the cerebellum the tumour is situated. (*b*) In many cases the tumour is so extensive and infiltrates such a large area of brain tissue that its complete removal is impossible. (*c*) In others the tumour is multiple. (*d*) In others it is malignant and of a secondary nature. (*e*) In some the cerebral tumour is complicated by associated lesions in other organs which contra-indicate any operative interference. Thus, in not a few cases of tuberculous growth of the cerebellum the lungs are also affected, and in some syphilitic cases the vessels either of the brain or other parts of the body are so extensively diseased that an operation is very hazardous. (*f*) Speaking of syphilitic tumours, Dr. Bramwell, while admitting the good results obtained by very active drug treatment, was disposed to think that in many of the syphilitic cases in which the gumma is large and of some standing cases in which a cicatrix must necessarily remain on the surface of the brain—operative procedure is advisable after the acute symptoms have subsided under the vigorous use of specific remedies, as the termination of many of these cases (the

of memory, lethetude, apathetic indifferent or tendency to sleep, vague restlessness, and inability to concentrate attention, or a silly jocularity.

(iii) The regional diagnosis of lesion of the frontal lobe is rendered more probable if, in addition to the psychical symptoms, there occur convulsive or paralytic symptoms, monoplegic or hemiplegic, on the opposite side of the body. These symptoms are indicative of extension of the lesion backward into the Rolandic area.

(iv) The diagnosis of lesions of the frontal lobe may be made with still greater certainty if, in addition to the symptoms enumerated under paragraphs (ii) and (iii), there are signs of pressure in the anterior fossa; consisting in protrusion or displacement of the eyeball, with perhaps unilateral loss of vision, anosmia, and paralysis of one or other of the oculomotor nerves.

(v) The diagnosis is confirmed if, in addition to some, or a combination of several, of the above-mentioned symptoms, there is pain on deep pressure on the frontal bone. This local pain may, however, be entirely absent if the lesion be subcortical, and is especially to be found in cases of tumour causing tension or irritation of the dura mater.

patients ultimately becoming useless members of society, or insane) is so deplorable.[1]

The above conclusions of Dr. Byrom Bramwell were based on an analysis of eighty-two cases of intracranial tumour which he had seen during life and which he had examined post-mortem. In seventy-seven out of the eighty-two operative interference for removal of the tumour was contra-indicated. Of the five remaining cases he considered that in two the success of an operation would have been extremely doubtful; in the remaining three an operation might, he thought, have probably been attended with success.

But, while believing that there are comparatively few cases in which the surgeon can hope successfully to remove[2] an intracranial growth, Dr. Byrom Bramwell would very strongly advocate trephining as a palliative measure[3] in many of these cases. "Thus in not a few, the headache is intense, and it has been conclusively shown that in some of these cases sudden death takes place, apparently as a result of the pain and resulting inhibition of the heart, a point to which Dr. Hughlings Jackson has directed attention. Again, in other cases in which the intracranial pressure is greatly increased, the patient dies either suddenly in an epileptic fit, or gradually as a result of failure of the respiration. Further, it must be remembered that in a large proportion of the cases of intracranial tumour the optic neuritis is intense, and that in not a few of them the optic neuritis, if allowed to continue, passes on to optic atrophy, and produces more or less, and it may be complete, blindness. Now, it has been conclusively shown that in some cases in which the operation of trephining has been performed both for tumour and abscess, the optic neuritis has speedily disappeared, in consequence, I believe, of the sudden relief of the increased intracranial pressure."

It will thus be seen, in many cases, in spite of the aid derived from localisation, that the operation must be exploratory. The surgeon will, however, so plan the operation that in the event of the impossibility of the removal of the growth, he can proceed to the palliative operation of decompression for the relief of symptoms.

These are the opinions of two well-known physicians in this country on the percentage of cerebral growths suitable for operation. To turn

[1] While admitting the force of this opinion it is to be feared that if surgeons follow Dr. Bramwell's advice they will sometimes find, if they publish the results of their cases after carefully watching them, that they have merely substituted one cicatrix for another (p. 273).

[2] Dr. W. J. Taylor has published an account (*Ann. of Surg.*, 1912, vol. lvi., p. 55) on the end results of 63 cases of operative treatment of cerebral tumour which have been under his personal care or observation extending over a period of twenty-five years. Of the 63 cases 1 lived for twenty years, 2 for about six years, while all the others died within three years of the operation. In 30 of the cases the tumour was localised and was found at the operation: in 14 of these the tumour was completely removed, in 9 it was partly removed, while in the remaining 8 cysts were opened and drained. Six of the cases were tumours of the dura mater: of these 3 died within a few hours of hæmorrhage, one was alive five months after and was then lost sight of, another died with a recurrence after 108 days, while the other lived for twenty years. Eight of the cases were simple cysts of which 6 recovered from the operation and 1 was alive five and a half years after. The operation mortality was very heavy, 6 of the patients died in the first five days, and 13 in the first ten days, giving an operation mortality of 19 per cent. Dr. Taylor describes these end results as "very bad indeed." In many of the 33 cases in which the tumour was not found, decompression was successful in relieving the symptoms for a variable time. A paper by v. Eiselsberg (*Wien. Klin. Woch.*, 1912, p. 17), in which 100 cases are analysed, may also be referred to. The operation ie two stages is recommended.

[3] Palliative measures are again referred to at p. 318.

elsewhere, Oppenheim analysed twenty-three cases observed by himself and verified by necropsy. Only one could have been removed by operation. Von Bergmann puts the percentage of suitable cases as at most 6 to 7 per cent., and, with very few exceptions, would limit the operation to growths of the motor region and to those parts of the brain adjoining it. Having spoken in general terms of intracranial growths, it will now be necessary to consider, from a surgeon's point of view, the varieties most frequently calling for operation. These are the tuberculous, the gliomata and sarcomata, gummata, and cysts.

Tuberculous Tumours. As a rule these should only be attacked when there is good reason to believe that the growths are primary and single. The frequency with which they are multiple and present as well as elsewhere is alluded to above (p. 298). But where a tuberculous growth is threatening to cause blindness, severe headache, constant vomiting, &c., it should be explored, and removed if possible.

Sir V. Horsley [1] expressed himself as strongly in favour of operation. Where a trial of medical treatment for four months, fails, such tuberculous nodules are probably densely fibrous with caseous centres. Age, no doubt, has an important effect here. Thus, in a child, owing to the yielding skull, the presence of a tuberculous mass may be long unsuspected.

Ransohoff, of Cincinnati, whose personal experience is considerable, as he has operated on eight cases of cerebral growths, reports his two successes with very instructive comments.[2] The nature of the growth in the first case is not stated. The second case, stated to have been a solitary tuberculous deposit, was operated on in two stages.

At the first operation an opening three and a half inches long and three inches wide was made. When three days later the dura, which pulsated feebly, was opened no growth was found. The patient was now placed in the sitting position—local anæsthesia being now employed—a step which caused the brain to recede and allow of palpation far beyond the limits of the cranial opening. The growth was found half an inch below the surface in the ascending frontal convolution, and was easily removed. Three and a half months after the operation the patient had had no convulsions, but a decided weakness of the flexors of the thumb, index and middle fingers remained. In this case the general symptoms of brain growths (headache, choked discs, and optic neuritis) were absent, the symptoms being altogether focal. This is explained by the fact that when the growth was removed it displaced 12 grammes of water, a pressure to which the brain accommodates itself. With the development of symptoms of intracranial pressure the value of focal symptoms decreases. This explains the frequency of failure to find a growth when seemingly unmistakable localising symptoms are present.

Ransohoff points out that in two-stage operations the second one can be done satisfactorily under local anæsthesia. If it be needful to cut away more bone, chloroform must be administered. He thinks that adoption of the two-stage method will diminish the very high mortality. This, due chiefly to shock and hæmorrhage, is stated by Haas, from an examination of 122 operations for removal of growths, to be as high as 61 per cent. Ransohoff believes that tuberculous deposits in the brain are twice as common as any other tumours.

He quotes from a paper by Preyer, who [3] collected the cases operated on up to that time, sixteen in number; Ransohoff's case and one of Heidenhain made eighteen. Three died from the operation; six survived several months, two several years; one of Czerny's lived four years and two months, one of Sir V. Horsley's seven years

[1] *Brit. Med. Journ.*, 1893, vol. ii, p. 1365.
[2] *Journ. Amer. Med. Assn.*, October 11, 1902.
[3] *Rev. Med. de la Suisse*, May and June 1900.

and eight months, dying then of tuberculous disease of the spine; one operated on by Kronlein was believed to be alive, six years after operation.

Von Bergmann some years ago opposed operations on tuberculous deposits in the brain on the grounds, chiefly, of the risk of setting up tuberculous meningitis and the great difficulties of enucleating such a deposit here, compared with one in the skin or bones. He "has reported twelve cases of cerebral tuberculosis treated operatively. In seven of these the central convolutions were affected; in four the cerebellum. In one, in addition to disseminated tuberculosis of the pia, there was an affection of the parietal lobe. Of the seven cases with affection of the motor region three were cured, two died from the effects of the operation, and two from an extension of the tuberculosis. The five cases of affection of the cerebellum all terminated fatally, three immediately after the operation. In eight cases the tubercles were not completely removed, and in each case death rapidly ensued."

Caseating foci in the cerebellum, owing to their comparative frequency, need especial allusion. The very high mortality of Von Bergmann's results—himself one of the chief pioneers on cerebral surery—and the cases alluded to below make it extremely doubtful if it is justifiable to continue attacks on tuberculous deposits in this situation (p. 322).

Sir V. Horsley [1] has removed a tuberculous growth from the right lobe of the cerebellum.

Death took place nineteen hours later, the patient having only partially recovered consciousness. Generalised chronic tubercle was found in the viscera. The operation was here performed as a last resource.

Mr. Bennett May [2] removed a similar growth from the right lobe of the cerebellum of a child.

The extreme bulging of the dura mater gave evidence of great intracranial pressure. The cortex appeared quite healthy, but at one spot palpation gave an ill-defined feeling of hardness. This spot being incised, the finger detected a hard mass nearly an inch below the surface. This was dug out with the handle of a small teaspoon. It was larger than a pigeon's egg, hard and horny outside and caseating in the centre. The haemorrhage was trifling, but the patient sank from shock a few hours later. No necropsy was permitted.

Mr. Waterhouse [3] mentions with helpful candour three cases in which he had operated upon tuberculous tumours of the brain. In none was the tumour single. Two cases died within forty-eight hours of the operation, while in the third partial recovery for four months ensued, followed by death, due to another tuberculous growth.

Gliomata and Sarcomata. As several cases are referred to, some fully, in these pages, and as the important questions of appearance and infiltration are dealt with in the section on "Operations on the Brain" (p. 321), I shall only refer to one more instance of these growths. It will be found reported by Dr. C. K. Mills; [4] the following epitome is given in the *British Medical Journal*, Jan. 24, 1903, p. 13. It contains two special points of interest: (1) the use, successfully, of the Röntgen rays, as a means of diagnosis, and (2) the means adapted for meeting the hæmorrhage.

The patient, a girl aged 21, had had symptoms for three years, and presented all the classical phenomena—optic neuritis, headache, vomiting, &c., together with left hemiparesis. Skiagraphy showed an abnormal shadow of about three inches in diameter and irregular in outline, lying directly upon the Rolandic area. Over its anterior portion the middle meningeal and its branches ran, and the inner table of the skull was seen to be disorganised over the region of the growth. The central fissure having been localised, the cranium was opened by Stellwagen's trephine

[1] *Brit. Med. Journ.*, April 1887.
[2] *Lancet*, April 16, 1887.
[3] *Brit. Med. Journ.*, October 1, 1898, p. 968
[4] *Phila. Med. Journ.*, September 27, 1902.

(Fig. 135), but the haemorrhage was so severe that the wound had to be packed, and further steps postponed. The patient rallied well, and at the second operation owing to the severe haemorrhage before, both common carotids were clamped by Crile's method.[1] An encapsuled ovoid growth, three inches in length, which proved to be a spindle-cell sarcoma, was discovered and removed with hardly any bleeding. The patient died in a few hours from post-operative shock.

Gummata. Some have expressed the opinion that here surgical interference is uncalled for. While no one will operate on a gumma of the brain till a sufficient trial has been given to mercury and potassium iodide,[2] or possibly an injection of salvarsan, there is no doubt whatever that a syphilitic lesion may reach a stage here, *e.g.* from its density, as elsewhere, in which it has quite got beyond the reach of specific remedies. Such a lesion, if localisable and to be got at, should be attacked, because, if left alone, it will go on causing trouble indefinitely, and further the compression and wasting of adjacent nerve tissue which it will set up will in time become irreparable. On this point the remarks of Dr. Byrom Bramwell (p. 299) bear strongly.

Sir V. Horsley, who is of opinion[3] that cerebral gummata are not really cured by drugs, would certainly limit the trial of drugs to two months. He holds that gummata are here incurable, because there is always a certain degree of pachymeningitis around them, and that this is inevitably progressive.

One of the most interesting instances of operation in these cases is one of Sir W. Macewen's.[4]

In a woman, aged 25, there was left-sided motor monoplegia of arm and leg, preceded by muscular twitchings and tingling sensations, without loss of sensation, due to syphilis, which resisted prolonged treatment. A cortical lesion of the right motor area, in the upper half of the ascending frontal and parietal convolutions, with probable involvement of the paracentral lobule, was diagnosed. A crown of bone over an inch in diameter, with its anterior border reaching to a point about half an inch behind the auriculo-bregmatic line, and its upper margin reaching to within half an inch from the centre of the superior longitudinal sinus, was removed. Its inner surface showed osteophytes. The dura mater was thickened and rough. Crucial flaps of this being reflected, a yellowish opaque effusion covered the brain, obscuring the convolutions and bridging the fissure of Rolando. This was very friable and came away in minute portions. Towards the upper part of the opening the brain offered resistance on palpation. This sensation proceeded from the interior of the brain, in the direction of the paracentral lobule, a layer of brain tissue intervening between this more resistant structure and the finger. An incision being made through the upper part of the ascending parietal towards this firm structure, about two drachms of grumous fluid escaped. The resistance now disappeared, and cerebral pulsation was for the first time feebly perceptible. The patient made a good recovery, and regained sufficient power over the left side to enable her to walk two miles, and to do her household work.

Mr. Waterhouse[5] mentioned an interesting case of intracranial gumma, in which, in spite of the administration of potassium iodide and mercury for four weeks, and then potassium iodide in doses of 30 gr. t.d. for a further period of five weeks, the symptoms steadily increased. The patient became hemiplegic, then comatose. A large gumma was

[1] This is described, together with other methods of temporary closure of the common carotids, *q.v.*

[2] The American method of pushing this drug in large doses at frequent intervals, in milk (*Arch. of Medicine*, New York, October 1884), is especially applicable here. A warning is needed now. Whether this drug be used for gummata or in uncertain cases, its lowering effects must always be remembered. Some days should always be allowed to elapse between the discontinuing of the drug and the operation, otherwise the shock of a severe operation will be needlessly increased.

[3] *Brit. Med. Journ.*, 1893, vol. ii, p. 1365.

[4] *Lancet*, May 23, 1885.

[5] *Loc. supra. cit.*

removed "from the left area of Rolando." Recovery was rapid and complete.

A case of gumma and localised meningitis of the motor region successfully operated upon will be found reported by Dr. C. K. Mills.[1]

The patient, aged 27, had been twice previously treated with success by large doses of potassium iodide. On his third admission the prominent symptoms were extreme pain in the left parietal region, frequent spasmodic seizures of right upper and, later, of right lower limb and right side of face. When the bone-flap was turned back—Stellwagen's trephine was used—the dura was adherent to the skull over a considerable portion of the bone-flap which had to be pulled away from the membrane. The latter was, in places, four or five times thicker than normal. The dura, pia and arachnoid were adherent to each other and to an oblong flat mass, which corresponded almost exactly in its dimensions to the shadow furnished by the Röntgen rays. As it was impossible to dissect the membranes from the mass beneath, it was decided to remove them altogether. This was done with but little disturbance of the brain tissue. To replace the removed dura, advantage was taken of a suggestion by Prof. Keen, and an incision made in the scalp outside of the line of the main opening. The scalp was turned back, and a piece of the pericranium dissected loose and inserted into the opening left by removal of the dura. This piece of pericranium was turned upside down, so that the osteogenetic surface would be away from the brain and not next to it. The last note of this case, four weeks after the operation, runs as follows: "The patient had made a perfect surgical recovery; his headache and epilepsy have disappeared."

Cysts. There are three separate conditions under which these tumours especially occur. (i) One is in the cerebellum, particularly in childhood, and affords the only hopeful outlook for operations at this early age. Sir James Goodhart[2] says that cysts, "although not common, should be kept in mind. I must have seen some five or six cases, and one can never see a fatal ending in such as these without regretting that surgery was not allowed to attempt a cure." (ii) Cysts may also occur after injury over the motor area, as in the following case:[3]

A man, aged 22, had epileptiform convulsions, each lasting from two to three minutes, with an average of over one hundred in twenty-four hours. The convulsions were limited to the tongue, right facial muscles, and platysma. When they subsided the parts remained paralysed. Consciousness was retained. Eight years previously he received an injury to the head, after which his right arm became weak, though he was able to work. It was clear that an irritating focal lesion existed, centred to the base of the ascending convolutions, causing a Jacksonian epilepsy. At the operation, in the lower part of the ascending frontal a cyst about the size of a filbert was found, situated partly in the cortical and partly in the white substance of the brain, surrounded by a narrow zone of encephalitis. In manipulating the medullary substance during the removal of the cyst, the patient while under chloroform had a convulsion similar to those prior to the operation. The convulsion ceased with the removal of the cyst, and he never had another. The wound healed firmly under one dressing, the paralysis of the facial muscles soon disappeared, and the patient has since been constantly at work. The power of the right arm has also increased. Possibly the cyst might have caused, indirectly, slight pressure on, or had set up inhibitory action of, the middle part of the ascending frontal.

Allusion has already been made (p. 275) to the difficulty which is sometimes met with in securing the obliteration of these cysts, and the need, here, of frequently prolonged drainage. (iii) While the two forms of cysts mentioned above are those most frequently met with, the surgeon must be prepared to meet with a third in which the cyst is associated with a new growth. Such a case has been reported by Mr. Ballance.[4]

[1] *Phila. Med. Journ.*, November 29, 1902.
[2] *Diseases of Children.*
[3] Macewen, *Brit. Med. Journ.*, August 11, 1890.
[4] *Trans. Med. Chir. Soc.*, March 1896.

A boy, aged 11, had, six months before admission, received a severe blow on the head. Fits, commencing with twitching of the right angle of the mouth, were followed by paralysis of the right side of the face, and right extremities. November 1890. The lower part of the left motor area having been exposed, a large subcortical cyst, lying under apparently normal brain tissue, was found and evacuated. February 1891. As the symptoms returned, a tube was passed into the cyst, in order to drain it continuously. The symptoms then in most part disappeared, and the boy remained in fairly good health until January 1893, when his condition rather suddenly became exceedingly grave. At a third operation a growth three ounces in weight was removed from between the dura and the left motor cortex. The boy left the hospital quite well save for a slight right hemiplegia, June 1893. He was readmitted in September 1893 in an almost moribund condition, and died a few hours after another attempt to relieve the symptoms of pressure. At the necropsy an enormous growth was found in the left cerebral hemisphere.

If it is right to say that cerebral surgery has not done as much as was expected of it fifteen years ago, and that surgeons no longer attack cerebral growths with the enthusiasm and frequency of that time, this proves that the enthusiasm was not based on careful and reliable reasoning, that operations for cerebral growths were performed without sufficient discrimination, and that the risks inseparable from this path in surgery were under-estimated—surgeons forgetting that while aseptic surgery had removed certain risks, others, especially shock and collapse, remained inseparable from the peculiar vitality of the part attacked. Any candid surgeon, acquainted with the history and progress of his profession, will allow that in two directions the progress of modern surgery has been less brilliant than might have been expected when its other triumphs are considered. The two referred to are: removal of cerebral growths compared with the other advances of cranial surgery, the surgery of the intra-thoracic viscera. The explanation of this is not far to seek. It lies in the fact, to which due weight has not been attached, that all the organs here concerned are peculiarly vital structures, and that, however great advances may be made, this fact will remain unchanged.

Reference to the discussion on the "Treatment of Intracranial Tumours," introduced by Sir D. Ferrier in a speech of great ability,[1] in which he put the question of operation in the most favourable light possible, will support the above conclusions. Sir D. Ferrier mentioned, briefly, two cases in which the patients had survived the operation two years or more. Two surgeons only took part in the discussion, and two more successful cases of removal of cerebral growths were mentioned, but so briefly as to be of little value.

Dr. Byrom Bramwell, the president of the section before which the paper was read, stated that his "experience in regard to the success of operative procedure differed notably from that of Prof. Ferrier, for in none of his fourteen cases in which an operation had been performed had a tumour been successfully removed by the surgeon. The additional experience of the past few years had entirely confirmed the conclusions which he had published in the *Edinburgh Medical Journal* four years ago." Speaking of the proportion of operable cerebral tumours, Sir D. Ferrier considered it a fair estimate to say that only 7 per cent. of cerebral tumours are capable of being surgically dealt with. As to the recent statistics of the results of operation, he considered that when cases were collected from all sources, and therefore containing many factors not strictly comparable with each other—of which one, the personal equation of the operator, is exceedingly variable—such a collection of cases gave 13 per

[1] *Brit. Med. Journ.*, October 1, 1898.

cent. of complete recoveries, *i.e.* the patients were alive at least a year, and in some cases several years, after the operation. Turning to the cases at the National Hospital for the Paralysed and Epileptic, where the operations were performed by Sir Victor Horsley and Mr. Ballance, men of special skill in this branch of surgery, Sir D. Ferrier pointed out that the cases operated on gave a percentage of 16·6 of complete recovery.

Two well-known authorities on growths of the brain, Dr. Beevor and Mr. Ballance, thus reply to the question, "What do patients suffering from tumours of the brain gain from surgery?"[1] "It appears to us that in the several following ways enormous benefit may be given by operation:

"(1) The complete removal of a tumour, as in Sir V. Horsley's case, of a small tuberculous mass occupying the cortex in the region corresponding to movements of the thumb.

"This patient, a man aged 20, suffered from frequent local fits, beginning in the thumb and forefinger, and from headache. From these symptoms he was completely relieved by removal of the tumour and part of the cortex.[2]

"(2) Partial removal of the tumour, as was probably done in the case on which the paper was founded.

"The operation on this patient relieved her of headache, vomiting, double optic neuritis, and from the greater part of her paralysis. The mental condition, which was very much deteriorated, was restored, the patient regaining her former cheerful condition.

"(3) The drainage of a cavity in a cerebral glioma or sarcoma which cannot be removed. This is well illustrated by a case under the care of Sir W. Gowers and Mr. Ballance.

"The patient, aged 11, suffered from headache, vomiting, double optic neuritis, fits beginning in the thumb and followed by hemiplegia, and was practically relieved of all his symptoms, including moral deterioration (stealing), by this procedure. He lived for three years.

"(4) The removal of bone and incision of the dura mater. The benefit resulting from this operation is well shown by a case which was under the care of Dr. Buzzard and Mr. Ballance.

"A woman, aged 41, was admitted with symptoms pointing to tumour of the internal capsule, viz. hemianæsthesia, nearly complete hemiplegia, double optic neuritis with failing sight, and severe headache with agonising paroxysms. In one of these paroxysms she became comatose, and was evidently dying, it was thought, from hæmorrhage into the tumour. The above operation was at once performed, and the relief of the urgent symptoms was immediate; and in a month's time the report states that there was no headache, vomiting, or optic neuritis, and some return of power and sensation had already occurred, with improvement of sight and restored mental condition.

"(5) Removal of a considerable area of bone without opening the dura mater is, we believe, considered by some to be adequate to relieve the classical symptoms of tumour. It is true that the dura, bulging through the opening in the skull, indicates that there is a relief of pressure, but what we have to deal with is tension within a practically inelastic membrane, and the intra-dural space can hardly be materially increased while the dura is intact, and the opening in the skull is comparatively small. The sac of the dura cannot be distended to its full extent while the cranium is intact, and so when bone is removed its foldings are flattened out. A considerable fall in pressure can only be obtained by taking away a large area of bone, and in tumour cases when this is done the dura still bulges

[1] *Brit. Med. Journ.*, 1895, vol. i, p. 8. [2] *Brit. Med. Journ.*, 1887.

under much increased pressure. As we have known of no case in which the removal of bone alone has relieved the pressure symptoms, we should advise that the dura should always be opened; another reason of great import being that the cortex might be involved without any of the typical signs being present. . . .

"(6) We would conclude this paper with the question, 'How soon should one of the preceding operations be performed?' When the type symptoms are present, it is quite certain that no delay is desirable after a fair trial has been given to antisyphilitic remedies, and we should limit this time to six weeks or two months.[1] The main difficulty arises when the symptoms are not typical; and it is to be borne in mind that large slowly-growing tumours may be present without any symptoms which are unequivocal. As an instance of this a case may be referred to which was under the case of Sir V. Horsley and Dr. Beevor. The patient had occasional fits beginning in the corner of the mouth, with unconsciousness, six years before other symptoms arose which justified operation, and then the tumour was found to be so situated that it could not be removed without producing aphasia. It would be easy to mention other cases illustrating the same point. In any case where the typical signs of tumour are absent, and where the fits always begin with the same localised warning, and are attended with loss of consciousness, the question is, 'Are these fits due to idiopathic epilepsy, or are they due to a tumour?' And we should say that no operation is advisable, other signs of tumour being absent, unless the paralysis which follows the fits is permanent—that is, not recovered from in the course of a few days—or unless the fits occur very frequently. While it is impossible to lay down absolute rules for the treatment of these cases, it would appear that occasional fits, beginning locally, followed by loss of consciousness, and attended only by headache, would not justify an operation; but that any other combination of the type symptoms—headache, purposeless vomiting, optic neuritis, especially with failing sight, localised fits, and permanent paralysis—would render surgical operation advisable."

We come now to the last of the questions which arise before an operation on a growth of the brain: (F) The conditions which justify operative interference, and the probable results of this step. These may be summed up as follows:

(1) That as the most benign growths have proved ultimately fatal, operations are justifiable under certain conditions. But (2) for the removal of the growth the site of the growth must be known. At present, if localisation be impossible, only a palliative operation should be attempted. The cases collected for Von Bergmann show this clearly. In one group, 116 cases, an accurate diagnosis was possible; in all the growth was removed, and in only 7 per cent. was the operation fatal. In the second group, 257 cases, the diagnosis was imperfect, and 50 per cent. died as a direct result of the operation. At present growths of the motor area are the ones which most clearly justify attacks. Operations for the removal of growths of the cerebellum, except in the case of cysts, are rarely likely to be successful (pp. 275, 304).

(3) The growths which are most favourable for operation are fibromata, encapsuled sarcomata, and gummata. (4) The operation should be undertaken at an earlier stage than has hitherto been the case, before the patient is weakened by headache, vomiting, a long course of potassium

[1] Sir V. Horsley, *Brit. Med. Journ.*, 1893.

iodide, &c. (5) As a large opening in the skull is absolutely necessary, the operation should usually be performed in two stages.[1] (6) Palliative trephinings have been shown to be thoroughly justified (pp. 300, 306). This step, if not deferred till too late, may be trusted to remove for a time the headache and vomiting, to arrest the optic neuritis which will go on to blindness, and to diminish, but probably not to arrest entirely, the epileptiform convulsions. The following case recorded by Sir A. Pearce Gould, shows that where a growth has been localised, but has not been found, and where its complete removal has not been possible, the symptoms have been materially relieved by the relief given to the pressure.

The patient, aged 41, had, six weeks before, suffered from severe headache without vomiting, followed by aphasia, right facial paralysis, and stupor deepening into coma (February 7, 1897). A two-inch trephine was used over the left face centre. When the dura mater, which bulged into the wound without pulsating, was divided the brain bulged still more. Puncture of this with a director in two or three directions proved negative. Four days after the operation the brain had receded below the trephine opening, over which the scalp had been replaced; three days later the patient was quite conscious and had lost his headache, paralysis, twitchings and apkasia. He was able to resume work in four months, but it was noted that six epileptiform fits had occurred: otherwise the health was good. The patient was able to earn his living as a market gardener, though still liable to epileptic fits, during one of which he was drowned in 1903. There was no necropsy. It will be noted that, in this case, in addition to the trephining, the dura mater was opened.

Sir D. Ferrier advised, if no guide to the site of the trephining be present, that the palliative opening be made freely over the occipital or frontal region. A free opening may lead to the appearance of a hernia cerebri; this must be treated by careful pressure and the strictest asepsis: of the other palliative measures, drainage of the lateral ventricles and lumbar puncture, it must suffice to say that our knowledge is, at present, scanty. As to the actual results, even in the cases where the growth has been successfully removed, complete recovery is the exception. The life of the patient is prolonged, and the pressure symptoms, headache, &c., are cured, but the epileptiform seizures are only diminished, though often markedly so. Much the same may be said of the paralysis in many cases.

OPERATIVE PROCEDURES ON THE BRAIN, CHIEFLY FOR THE REMOVAL OR THE PALLIATIVE TREATMENT OF GROWTHS

Preparation of the patient. The day before the operation the patient's head is shaved and thoroughly cleansed according to one of the methods described on p. 15. The patient has the usual purgative administered the evening before, followed by an enema on the morning of the operation. Any course of iodides or bromides should be suspended for at least a week before the operation.

Marking out the position of the lesion and the flap. Great attention must be paid to the exact localisation, and this step should not be left until just before the operation. Dr. C. K. Mills, a well-known American neurologist, whose papers are always practical and lucid, emphasises the following from an experience of twenty-two cases in which operations were performed for new growths. "A mistake of less than one inch in locating the fissure of Rolando or the height of the horizontal branch of the Sylvian

[1] Dr. Howard Lilienthal has published a paper (*Ann. Surg.*, 1910, vol. li, p. 30) on "Operations in two stages" in which the advantages of this procedure in a number of other conditions, in addition to intracranial disease, are insisted upon.

fissure, may add considerably to the uncertainties and difficulties in an attempt at removal by making the opening so as to only partially include the neoplasm. Not only the limits but as nearly as possible the direction of the osteoplastic flap should be marked out, as well as the extent and direction of its base line, so that no loss of five or ten minutes takes place in attempts to localise it with chances that not even then is it in the best position or direction."

The procedure advised by Dr. Mills, when it is intended to remove a growth limited to the motor area, is first of all to mark out the Sylvian point together with the stem and posterior horizontal branch of that fissure. The area supposed to include the underlying tumour is then exactly mapped out, and, finally, the base line of the flap which the surgeon is to make should also be indicated. The spot for the insertion of the Stellwagen trephine, the instrument employed by Dr. Mills (*see* p. 318), is next determined. As the arm of this trephine can be extended so as to give a radius of nearly two inches, the point selected for the pin should be about half an inch in front of the Rolandic fissure, at about its middle or a very little below this point. It is now known that the motor area is in front of the fissure of Rolando, and the circle outlined by the arm of the trephine, when the pin is placed in the position just stated, would be such as to include a little more than the motor region forwards and backwards, while it would nearly uncover it towards the median line and also in the direction of the Sylvian fissure. When the position for the pin and the extremities of the base line have been determined by careful measurement, they are marked on the scalp by small incisions.[1]

At the time of operation it is then only necessary for the pin to be inserted in the proper position in the scalp, and for the knife to be inserted at one end of the base line and swept around the circle until it reaches the other end. No time is then lost in determining the direction and length of this line.

Anæsthetic. If not contra-indicated, a hypodermic injection of a quarter of a grain of morphia[2] is given and then chloroform is administered. The object of giving the morphia is twofold: in the first place, it allows of the performance of a prolonged operation without the necessity of giving a large amount of chloroform, the amount actually used in an operation lasting two hours being very small.

The second reason is perhaps the more important: that this drug causes well-marked contraction of the arterioles of the central nervous system, and that consequently an incision into the brain is accompanied by very little oozing if the patient be under its influence.

Removal of bone and exposure of the brain. It will be taken for granted that for the present, at all events, operations for removal of

[1] Or by nitrate of silver. A solution of silver nitrate (30 gr. to the ounce) is painted along the lines and allowed to dry. It is then brushed over lightly with a solution of pyrogallic acid (5 gr. to the ounce). The stain thus produced is not washed away when the scalp is subsequently sterilised.

[2] In one case, a child of 4, one-twentieth of a grain was found amply sufficient. The advisability of a preliminary injection of morphia has been a good deal disputed. Sir F. W. Hewitt in his most careful work on anæsthetics, p. 422, says: "The use of morphine before chloroform has been found to be advantageous in cerebral surgery, there being less vascularity of the brain and its membranes with this mixed narcosis than with chloroform alone. But as many of the patients requiring these operations may be at the time of the administration in a state of torpor or semi-coma, or may during the operation display symptoms of shock or respiratory depression, considerable discretion must be exercised in applying the method. Many surgeons, indeed, who at one time used this mixture narcosis, have now abandoned it in these operations."

growths of the brain will generally be performed in two stages: (*a*) Removal of the bone. (*b*) incision of the membranes and the brain with removal of the growth, an interval of a few days intervening between the two operations.

Sir V. Horsley, to whom as a pioneer at once most skilful and scientific we owe so much, having turned down the flap which bears his name and which obviated the risk of a hernia cerebri inseparable from the old crucial incision, removed the necessary amount of bone with a large trephine followed by the use of powerful bone forceps or saw. The objections to this procedure are: (*a*) For removal of a growth, and still more for the palliative operation of "decompression" a large amount of bone requires removal: (*b*) If a large amount of bone is taken away, the resulting gap in the cranial wall may itself be the cause of considerable trouble. To obviate these objections the osteoplastic method of resection of the skull may be employed. This method, introduced by Wagner as long ago as 1889, has increasingly gained ground in recent years. Prof. Kronlein thus strongly advocates its use.[1]

> The old opinion still holds that the power of regeneration in the convex bones of the skull following loss of substance is small, and that consequently defects of any extent are only filled with connective tissue and not with bone. In certain cases such defects have recently been observed to close through regeneration of bone. These are, however, conspicuous exceptions, and as such they only confirm the rule. Experience shows that the connective tissue scar, which usually closes small defects of the cranial bones, may be so firm and dense as to lead one to believe that a production of new bone has taken place. The conditions are entirely different in the case of more extensive defects of the skull which are only covered by skin and scar tissue. Such patients are not only extraordinarily vulnerable as regards any violence affecting the skull, but their infirmity frequently manifests itself in an entirely different manner. This is very clearly shown by an observation recently communicated by König. König's patient had an extensive traumatic defect in the left parietal region. He manifested a degree of weak-mindedness bordering on idiocy, and suffered from epileptiform attacks. All these severe disturbances, which König very correctly, no doubt, referred to the displacement and distortion at the surface of the brain in the region of the defect, disappeared as soon as he successfully brought about bony closure of the defect. Based upon such experiences, it is altogether justifiable to demand that extensive and permanent defects of bones should be avoided from the beginning in cases of operations upon the brain.

We must not, however, attach too much importance to a single case, and it is by no means certain that where a large amount of bone has been removed and the healing of the wound has run an aseptic and rapid course that the defect left and the resulting scar are of the weak and perilous nature implied by Prof. Kronlein. Anyone of large hospital experience is familiar with cases where, after a comminuted compound fracture of the skull, the patient comes from time to time with a thinly covered pulsating scar, for the renewal of some artificial covering. But owing to the widely different conditions under which the two scars have formed there is no comparison between the state of such a scar and that resulting from a wide removal of bone with strict attention to the rules of modern surgery. This is certainly true of the removal of bone in the temporal fossa. Mr. J. Hutchinson, jun., whose experience and success in the removal of the gasserian ganglion by the temporal route is well known, writes[2] that the large aperture left by trephining and bone forceps

[1] Von Bergmann's *Syst. of Pract. Surgery*, *Amer. Trans.*, vol. i, p. 330.

[2] *The Surgical Treatment of Facial Neuralgia*, 1905, p. 91; Sir F. Treves's *Manual of Operative Surgery*, vol. i, p. 225.

"becomes so completely filled up with bone in a year or two that it can no longer be detected." Till recently the objections to the osteoplastic method were valid ones (1) that unless performed by complicated instruments not always at hand and involving special experience in technique the method was a prolonged one, especially in thick and compact skulls, save in specially experienced hands, and (2) if performed by the very simple mallet and chisel it entailed what has appeared to many to be an unnecessary violence and, perhaps, for there can scarcely be any proof here one way or the other, a harmful degree of concussion of the brain.

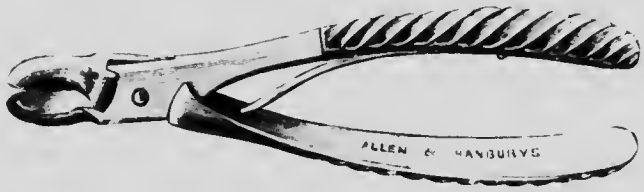
Now, however, Wagner's method has been so simplified, as will be seen below, that the above objections are no longer valid. The course to be taken is, however, an open one. On the one hand if the surgeon prefers it, especially in his earlier cases, he is entirely justified in using the simpler method. Time and further experience alone will show whether [illegible] vocates of the osteoplastic flap and this only have been premature [illegible] claim that this method is essential for sound surgery. Before [illegible] in some detail with the different ways of removal of the skull a few words must be said about the hæmorrhage. This in large incisions of the scalp must always be free; in some cases it has been so profuse as to add gravely to the perils of the patient. The simplest methods of meeting are described at p. 255. Makka's clamps (Fig. 118), if available, may be used, or a fairly large drainage-tube sterilized and split longitudinally may be carried once round the forehead above the root of the nose and the ears and below the occipital protuberance and secured over a pad of gauze. There is no need to clamp the tubing very tightly, a step which is further objectionable from the risk which it entails of causing sloughing of soft parts in a prolonged operation. It must be remembered that the above step cannot always be relied upon to arrest the hæmorrhage from the scalp.[1] If it fail, the surgeon must, if not intending to employ the osteoplastic method, raise the flap rapidly, including the periosteum, and seize each bleeding vessel, including the whole thickness of the scalp, with Spencer-Wells forceps. As soon as the flap is partly raised an assistant can compress its edge between his fingers, relaxing his pressure over different parts of this in turn, as the operator takes up the vessels.

We will now suppose that the surgeon who is not employing the osteoplastic method has turned down his flap, wrapped this in sterile gauze, arrested the bleeding, and removed the tubing. In order to remove the bone freely—and a cramped opening is certain to defeat the object of the operation—the following courses are open to him:

(1) He may make a large opening with a one or two-inch trephine in the centre of the area to be removed, and then complete the removal with bone forceps such as those of Hoffmann (Fig. 126). This is, however,

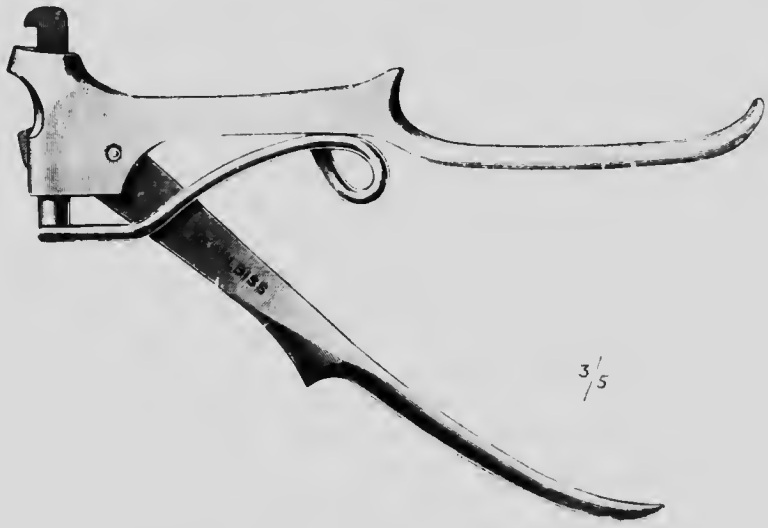
[1] Thus in a case of removal of a small spindle cell, encapsuled sarcoma of the brain and dura mater, in which the skull wall was hypertrophied and the diploe obliterated, reported by Dr. J. E. Owens, of Chicago (*Ann. of Surg.*, May 1905, p. 695), "in spite of the fact that the head was encircled by an elastic band hæmorrhage persisted even after a number of artery forceps had been employed. These, as well as digital compression here and there, were not sufficient to completely arrest the bleeding." After partial formation of an osteoplastic flap the completion of the operation had to be deferred owing to the alarming prostration of the patient, chiefly from loss of blood. The operation was completed about a week later, and then the hæmorrhage from the scalp was so free as to be only arrested by loosening the flap at the pedicle for the purpose of enclosing the latter in an elastic ligature. The patient recovered.

always a very slow process, increasing greatly the amount of anæsthetic necessary; in thick or sclerosed skulls Hoffmann's forceps may prove in-



1415 $\frac{1}{2}$ Sc.
A.

1414 $\frac{2}{3}$ Sc.
B.



C.

Fig. 126. Three useful skull-cutting forceps. A. Hoffmann's. B. Lane's. C. De Vilbiss.

adequate, and it is well to be provided with a pair of powerful forceps such as those figured above or Lane's fulcrum cutting forceps (Fig. 126).

(2) A quicker method is to make four small trephine openings at the

angles of the area to be removed, and then to join these by the forceps shown in Fig. 126, or by the forceps of De Vilbiss (Fig. 126), or by a Gigli's saw as described below.[1] If the hæmorrhage on division of the bone, now or with an osteoplastic flap, is severe—and this has been perilously the case on several occasions—the following ways of controlling the hæmorrhage suggest themselves, *e.g.*, pressure with sterile gauze wrung out of hot sterile saline solution, or out of sterile adrenalin solution (1 in 1000); the application of Horsley's wax; crushing the cut edge of the bone with strong forceps—too much force must not be used or fresh channels are opened; the use of sterile wooden pegs; these failing, temporary compression of one or both carotids may be tried.

The bone being removed, the surgeon decides by the pulse and condition of his patient, the urgency of the case, and the report of the anæsthetist, whether he shall complete the operation or defer this to a later stage. In all doubtful cases this will be the wiser course. It was advocated some years ago by Sir W. Macewen and Sir V. Horsley, and their advice is now largely followed. It is no exaggeration to say that if it had been taken oftener the mortality of this operation would not have been so high. The step, as pointed out by Sir W. Macewen, not only diminishes shock, but also, if the dura be opened, by soldering the membranes at the margin of the exposed brain, shuts off the subdural space and so prevents the escape of blood into it. The objections must not be forgotten, viz., the double anæsthetic, the two operations, and the difficulty of keeping the wound aseptic. If the above course is taken, all hæmorrhage is finally arrested, the flap is replaced, a few sutures inserted, and the usual dressings applied.

The osteoplastic flap. The first point to consider is the position of the flap. If localising symptoms are present, and the removal of the tumour is considered feasible, the flap will naturally be cut so as to expose freely the site of the tumour. In those cases where the tumour cannot be localised, or where, though its situation is known, its removal is considered to be impossible and the operation is undertaken solely with the object of relieving symptoms, its situation must be carefully planned so as to minimise the chance of any untoward results, such as paralysis, following the operation. Many surgeons prefer to make a flap the centre of which is just above the ear. Others prefer one of the "silent" areas such as the frontal. Dr. Hudson (*vide infra*) advises the occipital region in these cases as less likely to cause damage, as he maintains that the brain can project in a backward direction without interfering with these centres.

The following are among the many methods which may be actually employed.

(1) The mallet and chisel and their disadvantages have been already mentioned (p. 311).

Doyen's guarded chisel or guarded saw may be used (Fig. 127).

A large horse-shoe shaped incision must first of all be made through the soft parts down to the bone. This flap is not dissected free and turned down, but by means of an elevator the soft parts are turned to one side so as to expose the bone throughout the line of the incision. The bone is then divided by one of the following methods:

[1] Trephines and other instruments worked by an electric motor or surgical engine require much skill and care in avoiding injury to the dura mater. Their use is described on p. 316.

(2) Four small perforations may be made by means of a small trephine at the angles of the flap. These holes are then joined (Fig. 134) by the De Vilbiss forceps, by Hey's saw, or by means of a Gigli's saw (*vide infra*).

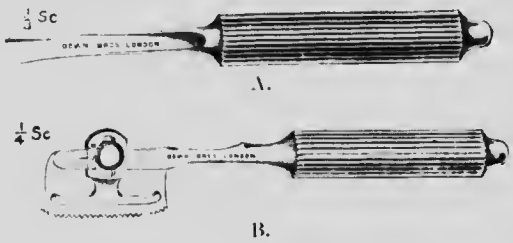


Fig. 127. A. Doyen's guarded chisel.
B. Doyen's guarded saw.

(3) The openings in the bone may be made with Doyen's perforator and burrs (Figs. 130, 131). These small openings are then joined by one of the methods mentioned above.

Marion, of Paris, having tried nearly all the different methods of craniectomy, has come to the conclusion that much the most rapid is that by means of Gigli's saw.[1] M. Marion employs Doyen's instruments for perforating the skull and uses a modification of the introducing director usually sold with Gigli's saw. A small trephine may be used instead of Doyen's perforator. As to the introducer, the whalebone guide usually sold will not stand boiling and tends to fray and perish. A flexible strip of copper and a loop of silver wire will supply all the needs of an introducer.

Fig. 128. Gigli's thread-saw.

The flap of soft parts having been outlined by incision and the periosteum separated for about a quarter of an inch (Fig. 130), four or more orifices, according to the size of the bony flap to be raised, are made with M. Doyen's instruments. "The perforator is first fitted on, and the bone is perforated down to the inner table very rapidly. Owing to the triangular shape of the perforator, with an almost blunt extremity, one can scarcely injure the dura mater if care is taken when the inner table is reached. As the deeper layers are arrived at the centre of the perforation becomes depressible. A characteristic sensation indicates that the skull is actually perforated. A burr (Fig. 131) being next substituted for the perforator—the burr should be sufficiently large, from 12 to 15 mm. in diameter—each orifice is enlarged until its dimensions, superficial and deep, are almost the same. The orifices are now joined by the saw. This is introduced by passing the director (Fig. 133) from one orifice to the next (Fig. 132), a step rendered easy by the elasticity of the director, and by giving a slight curve to its extremity. The saw is then passed along the groove, and if there be any difficulty in doing this a thread or a piece of fine silver wire is first attached to the saw and drawn through." The

[1] *Arch. Gén. de Méd.*, 26, 1904, p. 1025.

director is held in position by an assistant to protect the dura mater. The first two holes are then joined by the saw. " The sawing is effected easily and rapidly (Fig. 134) if care is taken that the two ends of the saw are not held at too acute an angle, and the two hands and the angles of the saw kept in the same place. Further, the section of the bone should not be made perpendicular to its surface but a little obliquely from without inwards. When all the circumference of the flap has been thus treated, the saw is slipped down to the base of the flap, and this is partly sawn through, a step which greatly facilitates its fracture."

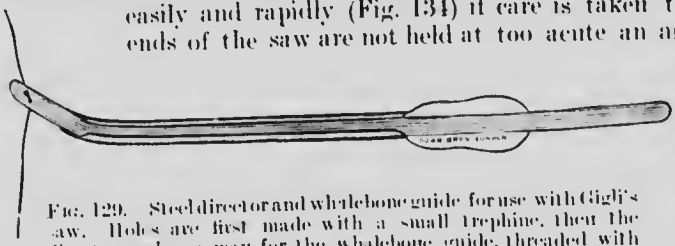


Fig. 129. Steel director and whalebone guide for use with Gigli's saw. Holes are first made with a small trephine, then the director makes a way for the whalebone guide, threaded with silk. The guide is withdrawn, leaving the silk *in situ*; the silk afterwards assists in the passage of the Gigli's saw.

The following advantages are claimed by M. Marion for this method. (1) Only one special instrument, Gigli's saw, is required. Unless a small trephine is used Doyen's instruments will also have to be added. (2) It is rapid and gentle. M. Marion claims that as large a flap as can be desired can be raised in less than five minutes. The vibrations of any electrical apparatus are avoided and the need of any installation dispensed with. (3) The surface of the section is very clean and permits of the most exact readjustment of the flap. (4) There is no danger of wounding the dura mater. (5) By this means it is easy to saw through the base of the flap in

Fig. 130. The outline of the osteoplastic flap having been marked out by incising the soft parts and slightly separating the periosteum, five openings in the cranium are being completed with M. Doyen's burr. (Marion.)

part,[1] a step which, if not indispensable, greatly facilitates the regularity of the line of fracture, a point which is not without importance in the readjustment of the flap. The only objection to the method is a small one. A saw may break, especially when used at too acute an angle or when the hands are worked in different planes. Several should always be at hand.

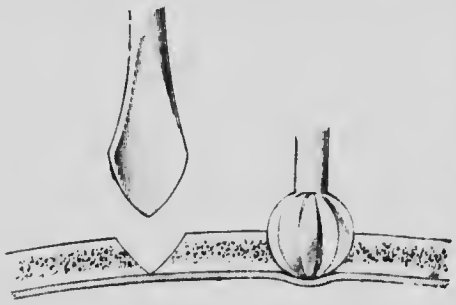


Fig. 131. M. Doyen's perforator and burr. (Marion.)

(4) The bone may be divided by means of electrically driven burrs or saws. This method is both powerful and rapid. A large bone flap can be cut in a few minutes. There is usually less trouble from bleeding from the bone. The chief disadvantage is that the dura mater is imperfectly protected.

(5) **Stellwagen's Trephine** (Fig. 135). This instrument, which combines the knife and trephine, is intended, while worked by hand, to supply, in great measure, the speed of craniectomy by the help of the electro-

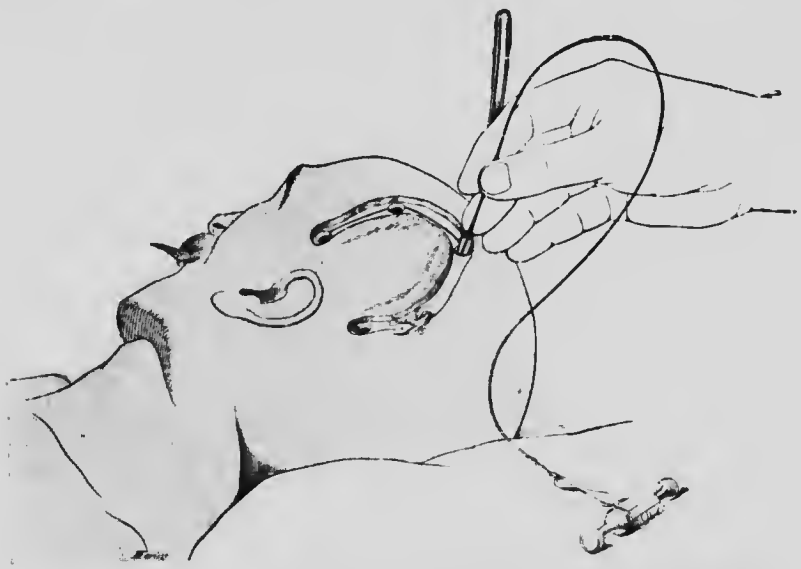


Fig. 132. The cranium having been cut through up to the third opening, Gigli's saw is being passed from the third to the fourth opening with the aid of M. Marion's guide. (Marion.)

motor. As in the case of all new inventions it has been promptly and largely tested by American surgeons, some of whom, but not all, speak very highly of it.

[1] This method may be adopted, whatever method may have been employed to cut the flap. The base of the flap may also be partly divided by De Vilbiss forceps or by the chisel: Gigli's saw is, however, simplest and most satisfactory. If the flap is forced back without partial division of its base serious fracture of the skull may result.

Advantages of Stellwagen's trephine. A large opening is rapidly made. From accounts of American cases the time varied according to experience with the instrument, from thirty to eight minutes. It does away with the risky jarring inseparable from the use of mallet and chisel.[1] It makes the osteoplastic flap so accurately that the reunion is quick and certain.

One possible difficulty is that, when the flap is large, that it may be difficult to catch all the vessels that are divided as quickly as is desirable.

Fig. 133. M. Marion's guide for Gigli's saw. (Marion.)

This may be avoided by carrying the knife to a certain distance, the vessels are then secured, and the knife is next carried round another portion of the circle and so on.

(6) Dr. Hudson[2] has described a new operation for decompression.

A large osteoplastic flap is made on the posterior aspect of the skull over the occipital lobes of the cerebrum so as to allow of the expansion of the brain in a

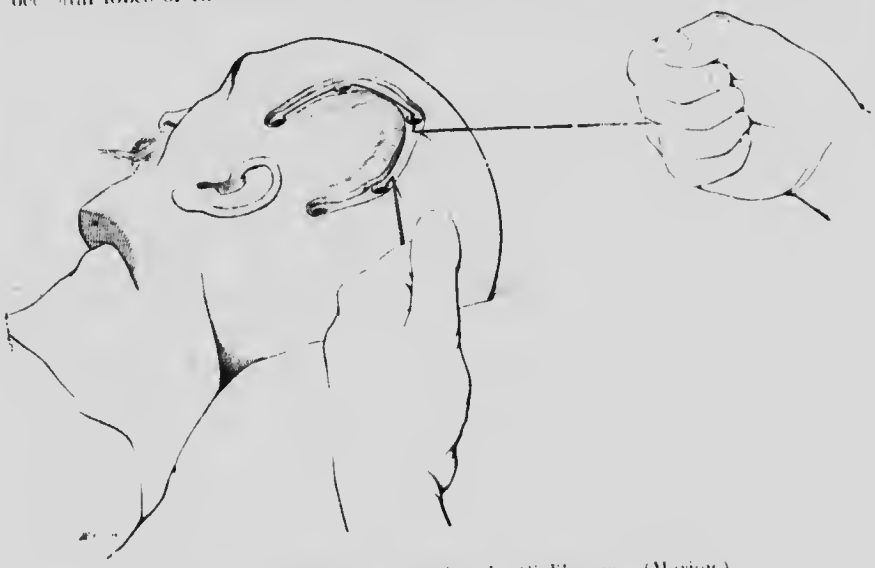


Fig. 134. Division of the cranium by Gigli's saw. (Marion.)

backward direction. By means of special forceps designed by Dr. Hudson, the bone is cut with a bevelled edge so as to allow of exact reposition. The flap is replaced and kept in position by loosely twisted silver wires. As the tumour grows and the intra-cranial pressure increases, the wire loops untwist and the bone is displaced backwards. Should this not occur, a little cocaine may be injected and the bone is given a lift by a sharp-pointed stylet.

[1] It is interesting to note that Prof. Keen has opened the skull with a chisel and mallet in 150 cases, and that he has yet to see the first instance of mischief from this method.

[2] *Ann. of Surg.*, 1912, vol. lv. p. 744.

Cushing's Operation for Decompression (Fig. 136). Cushing insists on the importance of preserving the temporal muscle in the formation of an artificial hernia cerebri. He turns down a large flap on the lateral aspect of the skull, consisting of the soft parts down to the temporal fascia. When this flap has been turned down, the temporal muscle is divided parallel to its fibres, and the periosteum is exposed by retracting the edges. The periosteum is then separated and divided and the requisite amount of bone removed, preferably by a trephine and skull-cutting forceps. The divided temporal muscle is then, when the compression has been relieved, brought together by a few sutures. Cushing finds that in this way an enormous hernia cerebri may develop without subsequent ill effects. When the tumour cannot be localised, or if it should be of such a character as to render removal impossible, this operation is often remarkably successful in relieving the distressing symptoms.

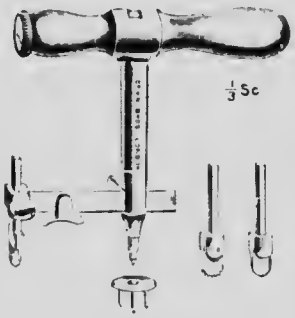


FIG. 135. Stellwagen's trephine with saw and knife blades. The latter are used to incise the scalp. The arm can be adjusted to describe a circle of from 2¼ to 4½ inches in diameter.

Second Stage of the Operation. This is undertaken after an interval of five to seven days or more. If no more bone requires removal, and this should have been rendered unnecessary by the careful preliminary localisation advised on p. 309, local anæsthesia, as recommended by Dr. Ransohoff, may be tried if a second general anæsthetic is thought undesirable. The sutures are removed and the flap turned down and wrapped in sterilised gauze. The next step is the opening of the dura mater. This stage is absolutely necessary for the relief of symptoms. If decompression alone is aimed at the dura should first be incised in the line of the vessels, a second incision being subsequently made at right angles to the first. The four pointed flaps thus formed are dissected up close to the margin of the bone and are then cut away. If it is thought that the removal of the tumour is possible, the dura is not cut away but a flap is turned down so as to expose the surface of the brain. Prof. Kocher advises that, when the convex border of the bony flap is situated near the middle line of the head, that the dural flap may be inverted, *i.e.*, the base being placed upwards and the convexity downwards. He further points out that it is desirable that the line of incision in the dura should not coincide with the edge of the divided bone. The dura mater is best opened first by incision with a scalpel and then by blunt-pointed curved scissors, great care being taken not to wound the parts beneath. The main branches of the middle meningeal are best secured by underrunning them with fine catgut by means of a small fully-curved needle before they are divided. The dura mater should be raised with much gentleness, as if any adhesions are torn, very free venous hæmorrhage may result.[1]

[1] Any of the dura mater which is adherent to the growth is usually much altered. In a recent case, the membrane will simply be highly vascular. In advanced cases it may be yellowish, and in some instances, on separating it from the growth beneath it is found to be of a dirty reddish colour. In all cases where it is adherent the dura mater must be freely excised, if possible.

Treatment of the Brain. If this, after incision of the dura mater bulges very prominently into the wound, it indicates pathological intracranial tension, and probably a growth.

C. H. Frazier,[1] calling attention to the fact that this bulging of the brain may be one of the most embarrassing features of cerebral operations, distinguishes between "initial" bulging, that which follows immediately on reflecting the dura and is due to the increased tension caused by a growth, and "consecutive" bulging caused by the œdema set up in normal brain tissue by the exploratory manipulations. This far exceeds

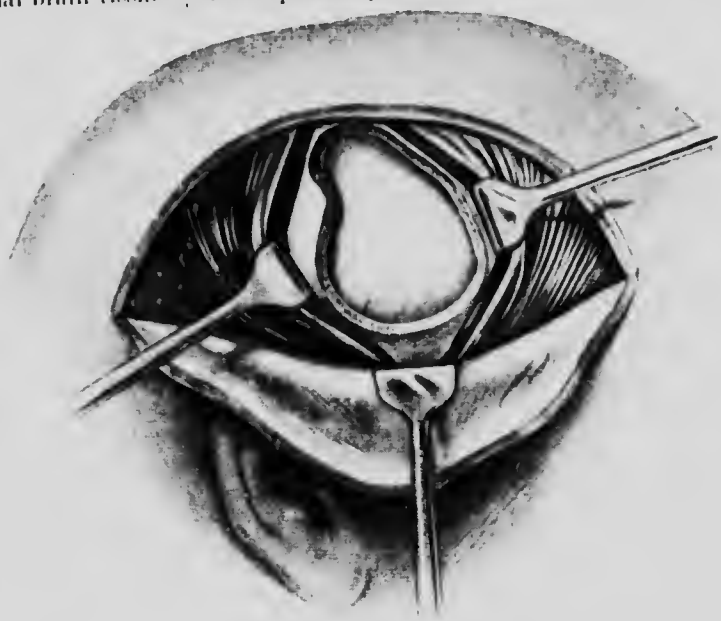


FIG. 136. Cushing's operation of sub-temporal decompression.

the "initial" form, and, as it is most embarrassing, exploration should be as expeditious as possible.[2] Alterations in the density of the brain must next be observed, but it must be remembered that the softer cerebral growths situated beneath the cortex are scarcely to be detected, save by exploratory incision; with tuberculous nodules it is different. A needle is of very little value in exploring for a growth. A tumour too soft to be detected by the finger will not be recognised by a needle: serious hæmorrhage may follow its use. Careful search with one of the instruments shown in Fig. 137, or digital palpation and the insertion of

[1] *Amer. Journ. Med. Sci.*, Feb. 1904.

[2] In some cases where there is abundant evidence of increased intracranial tension a growth may be present, but out of range of the operation. This is especially likely to be the case where "false" localising symptoms are present. Thus, in a case in which Dr. Weir (*Ann. of Surg.*, June 1887) trephined over the upper part of the right fissure of Rolando for spasms in the left limbs and loss of power in the left leg, no growth was found. Death took place ten weeks later, a [illegible] a spindle-celled sarcoma, apparently originating in the pia mater, was found springing [illegible] on the lower surface of the left cerebellar lobe, displacing the medulla forwards to the right, and invading the fourth ventricle. In such a case the best course to pursue would be to complete the operation for decompression.

the finger-tip under the margin of the bony opening are preferable. The removal of a growth is best effected by one of Sir Victor Horsley's combined spatulæ and directors shown in Fig. 137. If a sarcoma be encapsuled it may be shelled out by one of these aided by the finger.

Hæmorrhage. In removing a portion of the brain, or a growth, the bleeding which has been so much dreaded will usually cease if the wound be packed for a few minutes with strips of sterilised gauze. The value of a preliminary injection of morphine has already been alluded to. Other methods for arresting hæmorrhage are irrigation with sterile saline solution at a temperature of 110° to 120°, fine catgut ligatures tied without jerking and not too tightly; or if these fail the use of adrenalin solution (1 in 1000). Should the bleeding be otherwise uncontrollable it may be necessary to leave the gauze packing *in situ*, the end of the strip being brought out at one end of the lower angles of the wound. Sir V. Horsley has invented a combination of fine dissector and small aneurysm needle well adapted to facilitate underrunning and ligature of the vessels of the pia mater. If any bleeding vessel is not well within reach, the opening must be enlarged to get at it. When other methods fail—and careful plugging and firm pressure with firm bandages over the dressings has failed more than once—small Spencer-Wells forceps may be left on for thirty-six or forty-eight hours; but the patient must be carefully watched, lest his restlessness cause the friable tissues to give way, or inflict damage on the brain. The treatment of hæmorrhage from the meningeal or diploic vessels, or from any of the large venous sinuses, has been given at p. 266.

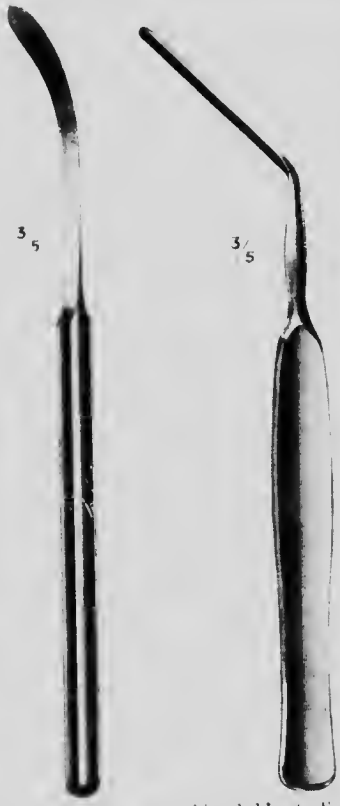


FIG. 137. Combined blunt dissectors and spatulæ used by Sir V. Horsley. They are equally adapted for the protection of the dura mater under the saw, or for the separation of a growth from the surrounding brain. They also act as flat probes in testing the depth of trephine holes.

Incision of the Brain. The cuts in the cortex must be made exactly vertical to the surface. If possible, portions of each centre should always be left, so that the cortical representation of the particular group of movements may never be totally destroyed. A portion of brain removed does not leave, as might have been supposed, a permanent gap with vertical sides, for, in a very short time, the corona radiata forming the floor of the pit bulges almost to a level with the surrounding cortex.

Difficulty in detecting the growth.[1] This may arise from several causes (1) The want of distinctness in the growth—in other words, its

[1] These remarks refer to gliomata.

close resemblance to normal brain substance.[1] A glioma may have the appearance of hypertrophied convolutions. (2) The growth may be overlaid by normal brain tissue. (3) By change in the growth viz., hæmorrhage from its thin-walled vessels, and later on, secondary changes in the clot. These conditions may be very puzzling.

Difficulty in isolating the growth. (1) This may be due to the absence of a capsule, and thus to the infiltration of surrounding parts. This is of especial importance in the case of gliomata. A capsule would occasionally appear to have been present. Thus in Dr. Bennett and Sir R. J. Godlee's case the glioma was found to be "thinly encapsuled, but quite isolated from the surrounding brain substance." Not so, however, is it in many other cases. Indeed, the chief pathologists speak decisively on this point. Dr. Fagge thus wrote: "The substance of a glioma is always continuous with that of the surrounding cerebral tissue, for there is never a capsule as with some sarcomata.[2] Indeed, it often assumes the form of the part in which it grows, so that one might imagine the corpus striatum or the thalamus or some particular convolution, to have become swollen to three or four times its usual size." Sir J. Bland Sutton[3] writes: "Virchow pointed out that . . . a glioma is situated near the surface of the cerebral cortex it appears like a colossal convolution."

Sir D. Ferrier[4] says on this point: "It is unfortunately the case that a large proportion of the tumours which invade the brain are of an infiltrating character, and apt to recur in spite of apparently the most complete extirpation. One can scarcely hope for a cure, therefore, under such conditions; but, nevertheless, there are many cases in which extirpation of such tumours has, for a time at least, rescued the patient from impending coma and death, and restored him for a time to clearness of intellect and a fair degree of comfort." A little later on we are advised that, "It is, on the whole, better not to attempt to remove a tumour which proves to be a soft infiltrating one without distinct demarcation from the healthy brain substance."

The benefits to be obtained from partial removal of a cerebral tumour are at present doubtful. Sir V. Horsley[5] mentions several cases where partial removal was followed by considerable improvement; while Dr. Byrom Bramwell regards this as a very doubtful step. On the one hand partial removal may cause very serious hæmorrhage when the patient is ill fitted to stand this. On the other hand the tension may be so great—the initial and consecutive bulging already spoken of—that unless some of the growth be removed it may be impossible to draw the edges of the dura mater together. Further, Mr. Ballance's case mentioned at p. 306 shows how long life may be prolonged after incomplete removal.

(2) Another source of doubt in telling when a glioma not encapsuled has been isolated, arises from the fact that, as pointed out by Dr. Fagge, these growths, in common with all the less circumscribed forms of cerebral tumours, are apt to set up morbid changes in their immediate vicinity, usually of the nature of softening, partly inflammatory, partly œdematous.

[1] A glioma may be of a pinkish red colour, or it may look so exactly like the normal brain substance that a microscope is required to demonstrate its presence. (*Fagge's Medicine*, vol. i. p. 523.)

[2] The glioma is distinguished by having no capsule, but merging indefinitely into the tissue around. (Wilks and Moxon, *Path. Anat.* p. 239.)

[3] *Tumours Innocent and Malignant*, p. 174.

[4] *Brit. Med. Journ.*, 1887, vol. ii, p. 966.

[5] *Ibid.* 1906, vol. ii, p. 411.

If a cyst be found it should be completely removed, if possible. If this be not feasible, all the more superficial part should be cut away, and the cavity packed with sterilised gauze.

Operation for Tumours of the Cerebellum. Unusual difficulties always attend these operations owing to the limited space, the numerous sinuses, and the proximity of the medulla and its centres. It must also be remembered that though it is often easy to diagnose a tumour in the cerebellum, it is often impossible to exactly localise it. Indeed, not infrequently it is not possible to be sure in which side of the cerebellum it is situated. Bone must therefore be freely removed so as to allow of a thorough exploration.

An incision [1] should be made commencing just behind one mastoid process, and then curving a short distance above the superior curved line to terminate in the corresponding position behind the opposite mastoid process. There will be free bleeding which must be checked in one of the ways already described. The periosteum is then incised and together with the muscles attached to the occipital, is detached with the help of an elevator and the flap thus formed is turned down. The bone is best removed by making an opening with a large trephine and then to enlarge this by means of some convenient form of bone-cutting forceps. The cerebellum may also be exposed by making two trephine openings as near the mid-line as possible and then cutting away the intervening bone. The external occipital protuberance should always be preserved on account of the torcula herophili which lies beneath it. The lateral sinus should, however, be exposed on each side of this. Bone may be removed downwards to within one inch of the foramen magnum. An osteoplastic flap is unnecessary here owing to the thickness of the flap of soft parts. If, at this stage, the patient's condition continue good, the operation should be completed; otherwise it is well to defer this for some days. When sufficient bone has been removed the cerebellum is freely exposed by turning down a flap of dura mater. The occipital sinus is secured and ligatured above and below.

If a growth is present the cerebellum will now bulge prominently into the wound. If the growth is in a lateral lobe it should be sought for and removed as recommended in the case of the cerebrum.

If on the other hand there is reason to suspect the presence of growth at the cerebello-pontine angle, a favourite site, the subsequent steps are far more difficult. The shortest route to the cerebello-pontine angle is along a line parallel to the petrous part of the temporal bone. Provided the opening in the bone is extended as far outwards as possible, one may after retracting the cerebellum inwards obtain a view not only of the seventh and eighth nerves as they enter the internal auditory meatus, but also of the sensory root of the fifth nerve at the apex of the petrous. It is, however, extremely doubtful if a growth in this situation can be safely removed considering its surroundings.

The need of the greatest care in all manipulations of the cerebellum, especially near its centre, is inculcated, owing to the risk of bruising the medulla and pons.

Owing to the increased tension it will probably be impossible to displace the cerebellum sufficiently with a retractor to expose the growth. Either the ventricle must be punctured or part of one cerebellar hemisphere removed. Dr. Frazier considers puncture of the ventricles so often fatal

[1] Harvey Cushing suggests a T-shaped incision for exposing the cerebellum.

as to be unjustifiable.[1] On the other hand, removal of a large part of one cerebellar hemisphere has given marked relief in several cases, though no growth was found. Thus blindness, headache, vertigo have all been greatly relieved. The following case, mentioned by Dr. R. W. Murray in the *Medical Chronicle*, June 1905, is a good instance of the way in which the situation of a growth, though producing well-marked symptoms, may cause insuperable difficulties in its removal.

A woman had suffered from occipital headache, vomiting, failing sight, and tendency to fall to the left side. On the removal of the brain at the necropsy, the left half of the cerebellum appeared normal. It was only after making sections and a careful examination that a small growth was found in the left amygdala. It was a mixed cell sarcoma of the pia mater of the cerebellum and the choroidal plexus of the fourth ventricle.

Closure of the Wound. All bleeding having been stopped, the cut dura mater is sutured with fine catgut. If the brain bulges much while the dura is being sutured, it should be depressed with a spatula, while the edges are, if possible, quickly brought together by a continuous suture. If necessary a flap of pericranium may be employed. Room must be left for drainage, and the flap adjusted with salmon-gut sutures. Sir V. Horsley removes the drainage tube which is to be inserted at the most dependent part of the incision (as the patient lies in bed), at the end of twenty-four hours, and makes firm but gentle pressure over the centre of the flap. The tube serves to drain the steady oozing of blood and serum from the cut surfaces, which takes place during the first day, and its removal at the end of this time is advised, in order to allow of a certain amount of tension from wound exudation to occur within the cavity; this tension not interfering with primary union if kept within proper bounds, while it secures pressure on the brain which tends to extrude, and serves, when the wound is finally healed, to separate the skin flap from the brain beneath by a cushion of soft connective tissue. If, after the removal of the tube, there is much pain and throbbing in the wound, and the union threatens to break down, the edges must be sufficiently separated with a probe, gently used, in the track of the drainage tube and another drain inserted.

Nothing has been said about the replacement of the bone in those cases where the osteoplastic method has not been employed, as the operation will often be done in two stages, and, thus, the bone will not have survived the interval. As has been said before, exact evidence is required as to how far large gaps eventually become closed and to what extent artificial protection is needed.

Needless to say every precaution for meeting and treating shock, both during and after the operation, must be taken (*see* p. 29). In these cases it is a mistake to wait for shock and to treat it: shock should be expected as a matter of course, not waited for.

Excision of Cortex Centres for Epilepsy. This matter has been referred to at p. 279. Though cases have been published in which some relief has followed this operation,[2] it is now recognised that the relief is only of a temporary nature. It is now generally regarded, that with the exception of suitable cases of traumatic epilepsy (*q.v.*), epilepsy is unlikely to be benefited by operative treatment. The following words of Sir W. Macewen, though spoken many years ago, have still an important bearing

[1] An authoritative account of the surgical aspects of growths of the cerebellum has been given by Dr. C. H. Frazier (*New York Med. Journ.*, February 11, 1905.

[2] *See* Prof. Keen, *Amer. Journ. Med. Sci.*, October and November 1888.

on this subject. "Can the motor area be removed in large pieces with immunity from serious consequences? If this region be of such psychical importance to movement, and destructive cortical lesions in it are followed by secondary degeneration of the motor tracts, then excision of these areas will necessarily induce permanent paralysis, late rigidity, and ultimate structural contracture. The removal of large wedges from the brain, especially in the motor area, will produce serious effects upon the brain as a whole, causing during cicatrisation a dragging and displacement of the neighbouring parts, with final anchoring of the cerebrum to the cicatrix." [1]

Causes of difficulty in cerebral operations and of their not doing well. Most of these have been fully alluded to.

(1) *The anæsthetic may not be well taken* (pp. 248, 309). The possibility of employing local anæsthesia in the second stage of the operation has been pointed out at p. 318.

(2) *Hæmorrhage* (p. 320). This has already been discussed. Dr. Ransohoff [2] records a case in which the hæmorrhage met with during the removal of the bone proved actually fatal.

"An osteoplastic resection had been commenced and about one inch of the bone cut through when profuse bleeding occurred, which was not arrested by plugging with Horsley's wax. The bone was rapidly removed with a trephine and bone forceps in order to get at the source of the hæmorrhage, but death took place just as the dura was reached. A glio-sarcoma, the size of a small peach, not adherent to the dura was found just under the trephine opening. The diploic veins in the neighbourhood of the opening were much enlarged. There had been no unusual bleeding from the scalp. Raising the patient into the upright position was of no avail, and there was no time for ligature of the carotid."

In two cases the hæmorrhage has occurred some little time after the operation, and has then been due to the vomiting after the anæsthetic.

(3, 4 and 5) Difficulties in sufficiently exposing the area occupied by the growth, in detecting, and in isolating it.

(6) *Shock*. Many of the causes of this are sufficiently obvious. One may be mentioned which has not been already discussed, *i.e.* the interference with subjacent parts of the brain, or the opening of a lateral ventricle in the removal of a deep-lying growth.

(7) *Œdema of the lungs*. This is especially likely after prolonged operations, where it has been necessary to give ether, and in cases where, for some time before the operation, the patient has been practically bedridden, and the functions at a very low ebb.

(8) *Hernia Cerebri*. This may occur in two ways: (*a*) Immediately, during the operation, in a case where there is much evidence of intracranial pressure, and where it has not been possible to remove the cause. Thus, in a case of Dr. Pilcher's, the projecting cerebral mass was so great in volume and so tense that there was no possibility of returning

[1] "Anchoring of the brain and some of its consequences.—When injury has been inflicted on the surface of the cerebrum, followed by plastic effusion and cicatricial formation, the superficial substance is apt to become soldered to the membranes when these remain intact, which may in turn be fixed to the skull, or, in the event of their detachment, the brain may become directly adherent to the bone. Thus the surface of the brain becomes anchored to the rigid cranial wall. It has no longer the free play within its water bed to expand and contract according to the varying state of the circulation. Each variation produces a dragging of the brain at the spot, and through it the whole hemisphere is affected. Any sudden physical effort pulls on the brain, producing a slight shock, just as if the cerebrum had received a blow. Vertigo results. Following upon this, the grey matter of the cortex, immediately surrounding the cicatrix, by the incessant movement is apt to become unstable and produce fits. Some cases of traumatic epilepsy are thus caused."

[2] *Trans. Amer. Surg. Assoc.*, 1903.

it within the cranial cavity. It was, accordingly, sliced down to the level of the bone.[1] (*b*) Later on it may point to unrelieved tension. (*c*) In other and more numerous cases a later hernia cerebri indicates infective changes, or may be the result of softening of the brain.

(9) Impossibility of complete removal.

(10) The liability of patients, with increased intracranial pressure due to the presence of a growth, to sudden and unexpected death, has already been mentioned.

Sir D. Ferrier[2] gives two instances in which sudden death occurred. In one, a growth the size of a hen's egg was found at the necropsy, under the cortex in the area of Rolando; while in the other the symptoms pointed to a growth in the upper part of the same area.

(11) Septicæmia and allied conditions.

(12) Reappearance of the growth.

CRANIECTOMY FOR MICROCEPHALUS, IDIOCY, ETC.

Lannelongue's suggestion of invoking the aid of surgery in the treatment of imbecility[3] aroused much interest, and in the immediately succeeding years a large number of cases were submitted to craniectomy, with a view of either removing some morbid condition or relieving pressure on the brain, or in some way stimulating its development. Like some other advances of modern surgery, it has not been based on the sound foundation of pathology or common sense. The disease is probably primarily due to defective cerebral development, the early ossification of the sutures being secondary to this. These hopeless pathological conditions, the poor vitality of the patients, and their unfitness for severe surgical operations, render the results, as might have been expected, very unsatisfactory.

It is first necessary to consider what *pathological conditions are likely to be met with and how far they are remediable*. These appear to be: (i) *Microcephalus*, whether due to premature closure of the cranial sutures (Virchow), or secondary to maldevelopment of the brain (Broca). In the following conditions the brain is at fault, with or without marked microcephalus, and sclerosis and atrophy are met with in a varying degree in nearly all. (ii) *Porencephalus*. By this is meant a localised atrophy, leaving a cavity in either cerebral hemisphere, which may be deep enough to open into a lateral ventricle. (iii) *Maldevelopment and atrophy of the minute structure of the cortex* of the hemispheres, without any gross defects. (iv) *Meningo-encephalitis*, leading to thickening of the meninges and atrophy of the cortex. (v) *Cysts*, perhaps containing blood (*q.v.*). (vi) *Hæmorrhages* into or on the surface of the brain. (vii) *Hydrocephalus*. This last will be separately considered. It is obvious, first, that many of the above are only to be recognised by exploration, and that most of them, if found, are hopeless of improvement. Thus it is clear that where sclerosis and atrophy are present to a marked degree, in cases of porencephalus, where one entire hemisphere is converted into a cystic cavity surrounded by shrunken brain tissue and thickened arachnoid, interference will be futile. In the latter it may be fatal by the shock that will follow on the withdrawal of a relatively large amount of cerebro-spinal fluid.

Dr. J. Griffiths, of Cambridge,[4] showed that the skulls of microcephalic idiots may be classified in the following groups: (*a*) The skull is of normal shape and outline, but small, ill-developed, and ill-filled. There is no premature synostosis of the sutures. (*b*) The skull is not only small, but deformed from unequal growth. Whether this deformity is due to primary disease of the bones or to premature synostosis of several of the

[1] *Ann. of Surg.*, March 1889. [2] *Brit. Med. Journ.*, October 1, 1898, p. 965.
[3] *Bull. de l'Acad. des Sciences*, 1890, and *Union Medicale*, t. i, 1890, p. [illegible].
[4] *Proc. Med. Chir. Soc.*, March 8, 1898.

sutures, or whether it is due to disease as well as defective growth of the brain, is still an open question. As in one form of microcephaly the brain itself is generally defective in the power of growth, its development having been arrested at an early period of embryonic life, and as in the other there is, in addition to arrested development, disease of the brain substance, and as the existence of cases of microcephaly in which premature synostosis has been able to impede or dwarf the growth of a normal brain is, as yet, quite hypothetical, craniectomy can be productive of no permanent good, the original fault being in the cerebrum and not in the skull.

In recommending operative steps the wise surgeon will be careful not to be too sanguine, remembering the nature of many of the conditions which he may meet with, and the impossibility of improving some of them. Furthermore it must be remembered that here, as in trephining for epilepsy, cases have been reported much too soon to be looked upon as successes.

The second point is, that we are here dealing with very vital parts in patients of poor vitality, and that, unless the surgeon is careful not to attempt too much, death from shock will be a very present danger. Thirdly, many fatal cases have not been published, and we do not know what the mortality of this operation really is.

Before leaving the question of the advisability of operative interference in microcephaly the conclusions of Prof. Keen, of Philadelphia, may be quoted—conclusions which are most valuable on account of his long experience in operative surgery, and especially from his well-known skill in operations on the head and brain. Prof. Keen performed craniectomy in eighteen cases of microcephaly, the youngest patient being eighteen months and the eldest seven and a half years old. In five cases the operation was fatal; in six cases slight improvement followed; in seven none at all. Prof. Keen's conclusions are as follows: No good can be expected from the operation in cases with average-sized heads, nor in those cases with extreme microcephaly, nor when the patient is over seven years old. In one case a restless, mischievous idiot was transformed into a "quiet, sleepful child"; but the improvement, when there is any, is usually slight. Much depends upon special education after the operation. In some cases of moderate microcephaly the operation is justifiable, and in a small number a slight improvement will follow; but in the majority there will be no result, good or bad; while in a definite proportion (15 per cent.) "the operation will happily be followed by death."[1]

Dr. J. Chalmers Da Costa adds the weight of his opinion to the above.

"Microcephalus is not the result of premature sutural ossification. A microcephalic brain is not a more or less normal brain of very small size, the idiocy resulting from the smallness of the parts present, but is always an abnormal and undeveloped and, in many cases, a diseased brain. If a strip of bone is removed from the skull, new normal brain cells will not be produced. Parts that are entirely absent cannot be created, and powers that do not exist cannot be called into being. The reported improvement, if continuous, is not due to the operation, but to proper instruction and care. The proper treatment for microcephalus is educational, hygienic and disciplinary."[2]

This writer puts the mortality as "nearer 15 than 2 per cent. as alleged."

Operation. We will consider first a case in which there is marked microcephalus, in which, perhaps, premature ossification is the cause of the trouble. The operation should always be of the nature of a linear

[1] *Journal of Nervous and Mental Diseases*, February 1898.

[2] *Ibid.* June 1904.

craniectomy, completed as speedily as possible. Every precaution should be taken against shock, and if the hæmorrhage has been severe it may be necessary to resort to infusion of saline fluid. Lannelongue [1] operated in his first case as follows: Having made an incision through the scalp and pericranium just to the left of the sagittal suture, a small circle of bone was removed with a trephine, a finger's breadth from the suture; from this as a starting-point, a narrow strip of bone was cut out parallel with and to the left of the sagittal suture, extending from the coronal to the lambdoid suture. The periosteum was not replaced. Sir V. Horsley removes the periosteum over the bone to be excised. This last step he effects by making parallel saw-cuts backwards and forwards from the trephine opening, and then removing the bone between the saw-cuts with bone forceps such as those of De Vilbiss. In some cases in addition to the removal of bone parallel to the sagittal suture, a second narrow strip has been removed over the corresponding fissure of Rolando. The dura mater is not incised and the greatest care must be taken to avoid injury to it during the operation. Dr. Griffiths [2] and others have established artificial lambdoid sutures, operating at intervals, first on one side of the skull and then on the other. Numerous other incisions have been employed for the craniectomy, among which may be mentioned an elliptical or H-shaped craniectomy of the vertex, and a large horse-shoe-shaped division of the bone on the lateral aspect of the skull.

Dangers of the Operation. These are chiefly: (1) Shock. (2) Hæmorrhage. Hæmorrhage from the scalp may be met by drainage tubing passed round the head or by Makka's clamps, but other bleeding may be encountered. (3) Injury to the dura mater, especially adherent in children. (4) Infective changes in the wound; these patients, restless and ill-regulated in their behaviour, may make the maintenance of asepsis very difficult, especially in older and thus less easily managed cases, by tearing off their bandages. (5) Hyperpyrexia of obscure origin.

TREPHINING IN GENERAL PARALYSIS OF THE INSANE, AND IN OTHER FORMS OF INSANITY

This operation has been recommended on the authority of Dr. Claye Shaw [3] and Dr. J. Batty Tuke,[4] but the results have been such that it does not deserve encouragement even as a palliative step. It must not be forgotten that here is no morbid condition that can be cured; that the excess of fluid—the removal of which, and so the relief of tension, is the object of trephining—is variable; and while it is clear that in those cases which have improved after the operation the benefit has been only temporary, it must be remembered that temporary periods of spontaneous marked improvement are not uncommon.

As the question of trephining occasionally arises in traumatic insanity, Dr. Da Costa's incisive remarks as to the principles which should guide us may be quoted.[5]

Having condemned operation in cases of non-traumatic insanity, hypochondriacal delusions and hallucinations, Da Costa divided cases of traumatic insanity into two classes. To the first belong those cases in which the injury has caused no gross lesion and in which, on account of trivial shock, mental or physical, the

[1] *L'Union Médicale*, July 8, 1890.
[2] *Loc. supra cit.*
[3] *Brit. Med. Journ.*, vol. ii, 1889, p. 1090; vol. ii, 1891, p. 581.
[4] *Ibid.*, vol. i, 1890, p. 8.
[5] *Journal of Nervous and Mental Diseases*, June 1904.

patient has developed a distinct neurosis, on the basis of which a psychosis has supervened. In this group operation is not to be thought of. In the second group are found cases in which the injury is the direct and sufficient exciting cause of the condition. Here the insanity may develop at once or some time after the injury. Whether the insanity follows sooner or later, the chief indications are depression of bone, local tenderness, fixed headache, or some localising symptom. When there are positive signs of increased pressure, trephining as a palliative measure may be considered proper. "One should not operate upon a case simply because there is a dubious record of an antecedent fall or blow, which merely suggests the possibility of a traumatic origin for the insanity." Da Costa believes that injury is the direct cause of insanity in only 2 per cent. of the cases.

OPERATIVE TREATMENT OF HYDROCEPHALUS. DRAINAGE OF THE VENTRICLES

In hydrocephalus there is distension of the ventricles with cerebro-spinal fluid. The condition may be congenital or it may commence during the first few years of life. As medical treatment is ineffective, surgical treatment may be called for. Unfortunately, in the majority of the cases, the distension of the ventricles is secondary to some disease in the cerebellum, corpora quadrigemina, or crura cerebri obstructing the veins of Galen, or, as Mr. Hilton showed long ago,[1] to occlusion of the cerebro spinal opening in the fourth ventricle—all equally hopeless forms of disease. In other cases the collection of fluid is due to meningitis, tuberculous, syphilitic, or cerebro-spinal. By others hydrocephalus is regarded as dependent upon an arrest of development of the brain.

Simple tapping of the ventricle through a lateral angle of the anterior fontanelle has been often carried out, with the result of often giving marked relief, obviously, from the nature of the cause, only temporary, convulsions and coma carrying off the patient after a varying interval. Withdrawal of the fluid slowly by a Southey's tube has been equally unsuccessful.

Drainage of the Lateral Ventricles. Prof. Keen, of Philadelphia, was the first to formulate this operation, as distinguished from the ordinary puncture.

The ventricle, in a boy aged 4 years, was exposed by trephining one inch and a quarter above and behind the external auditory meatus, and by puncturing the brain with a needle at this spot. At a depth of about an inch and three-quarters the ventricle was reached and cerebro-spinal fluid escaped. Three double horsehair sutures were then introduced and the needle withdrawn. Drainage thus established was kept up for fourteen days, when the horsehair was replaced by a drainage tube. On the twenty-eighth day after the operation, the symptoms returning, a corresponding operation was performed on the right side. The child died on the forty-fifth day.

Intracranial Drainage of the Ventricles by making a communication between the ventricles and the subdural space. This method was brought before the Clinical Society by Dr. Sutherland and Sir W. Watson Cheyne.[2] The operation is based upon the experiments of Dr. Leonard Hill.[3]

The child, aged 6 months, was markedly hydrocephalic, emaciated, anæmic, with intelligence undeveloped, and quite blind. The condition was attributed to congenital syphilis. The dura was exposed at the left lower angle of the anterior fontanelle. To form a drain a bundle of the finest catgut, containing some sixteen strands and about two inches long, had been prepared, one end of the strands being tied together, and the other end free. The dura mater was incised and the tied end

[1] *Rest and Pain*, Lectures ii and iii. Mr. Hilton first noted this fact in 1844.
[2] *Trans.*, vol. xxxi, p. 166.
[3] *Physiology and Pathology of the Circulation*, 1896.

of the bundle was pushed downwards and backwards between the brain and the dura, *i.e.* in the subdural space; the other end was pushed through the thinned cerebral substance into the lateral ventricle. The incision in the dura was closed. On the fifth day, when the wound was healed, it was noticed that the head was distinctly smaller in all dimensions. This diminution in size continued, but without any improvement as regards the child's intelligence or vision. Symptoms of basal meningitis began to appear nine weeks after the operation, and death followed three weeks later. At the necropsy, though the ventricles were not distended, a considerable quantity of fluid remained in the subdural space.

The best material for gradual drainage would appear to be strands of sterilised silk as used by Mr. W. S. Handley in the operation of lymphangioplasty. Mr. Pendlebury thus describes an operation in which this material is used.[1]

"A sharp pedicle needle with a good curve is threaded with No. 12 plaited silk, both having been carefully sterilised. The thread when doubled is at least thirty inches long. The head is shaved and made thoroughly aseptic. A spot about one inch to one side of the middle line is chosen as near the posterior part of the anterior fontanelle as possible. With a tenotome make a tiny incision through the skin in this position. Push the threaded needle into the lateral ventricle, curve it through the falx cerebri into the opposite ventricle, and bring it through the skin in a corresponding position on the other side of the mid-line. Withdraw the pedicle needle, leaving the silk in situ. Thread the double silk of one side on to a long probe and push the probe beneath the skin backwards into the nape of the neck. Do the same with the silk on the other side. Cut off the superfluous silk and put a stitch into each of the small wounds that have been made in order to introduce the probe and the silk it carries beneath the skin. The doubled silk now connects both ventricles with each other and with the connective tissue of the neck."

Drainage of the Fourth Ventricle. This was performed by Mr. Stiles in a case of acquired hydrocephalus due to basal meningitis.[2]

The patient, aged 13, with well-marked evidence of congenital syphilis, presented symptoms of chronic basal meningitis, viz. irregular pyrexia, persistent head retraction, nystagmus, gradually increasing blindness, great weakness and emaciation. This condition becoming critical, with marked cyanosis and rigors, it was decided to open the fourth ventricle and drain the ventricular system. Mr. Stiles trephined in the middle line over the lower part of the occipital bone, including the margin of the foramen magnum, and enlarged the opening by forceps. The dura mater was opened after the occipital sinus had been secured between two ligatures. Separation of the two tonsils of the cerebellum allowed of the escape of much cerebro-spinal fluid. Immediate improvement followed the operation and lasted for a week, when there was again a rise of temperature. Death occurred with hyperpyrexia nineteen days after the operation, much cerebro-spinal fluid having drained away in the interval.

[1] *System of Treatment*, Latham and English, vol. ii. p. 1193.
[2] Bruce and Stiles, *Trans. Edin. Med.-Chir. Soc.*, 1898, vol. xvii. p. 73.

CHAPTER XVI

OPERATIONS ON THE EAR

A. OPERATIONS ON THE EXTERNAL EAR

THESE will require but a brief description. Growths, especially papillomata and epitheliomata, are occasionally met with. The latter require free removal. Rodent ulcers are not infrequently found invading the external ear: they should be treated on the lines recommended at p. 394.

Boils or Furuncles in the external auditory meatus are often exceedingly troublesome. They are the source of much severe pain, and often, as one abscess subsides, others make their appearance.

Treatment. Owing to the extreme tenderness a general anæsthetic is necessary: a free incision is then made into the centre of the swelling which usually contains a small amount of thick pus. The cavity is then lightly plugged with sterilised gauze and a hot boracic fomentation is applied. The plug should be changed daily, and the meatus syringed with carbolic lotion (1 in 40). A bacteriological examination of the pus should always be made, for, in recurring cases, a vaccine is often of the greatest service.

Exostoses are occasionally found in the external auditory meatus. They may be sessile and composed of cancellous bone, or exceedingly hard (ivory exostosis). Should the growth be pedunculated it may be removed through the external auditory meatus. If sessile or diffuse the treatment will depend upon the symptoms present. Should there be suppuration in the middle ear they should always be removed, as the retention of discharge which is certain to occur is liable to favour an extension of the septic process to the mastoid or to the cranial cavity. In other cases operation will be indicated if there is a tendency to occlude the meatus, or if they are causing deafness. If the growth is situated near the external orifice of the canal it may be removed by a dental drill, or burr, through the external auditory meatus. If its attachment is more deeply situated it is best to make a curved incision immediately behind the auricle, to detach the cartilaginous meatus from the bone, and then to remove the tumour by one of the above means or by a chisel. The greatest care must be taken to avoid damage to the tympanic membrane and other important structures. When the operation is completed the wound is closed and the meatus lightly packed with sterilised gauze. This must be changed daily and all blood and discharge washed away by gentle syringing with dilute carbolic lotion.

Foreign Bodies in the Ear. These may usually be removed by syringing, or by the use of aural forceps, or a small ear hook. In rare cases where the foreign body is firmly impacted it will be necessary to make a curved incision behind the ear, detach the cartilaginous meatus, and, after incising this in the longitudinal direction, displace the foreign body by passing a small elevator beyond it and so levering it out through the wound.

Removal of Aural Polypi. It is first necessary to point out that aural polypi are really masses of granulation tissue,[1] of inflammatory origin, and that their presence denotes the existence of suppuration. Treatment of the polypi must therefore be only a part of the treatment of the suppuration of which they are a complication. If of sufficient size to cause any obstruction they should always be removed: indeed, not infrequently, the removal of a polypus, by allowing of free drainage, may lead to a termination of the suppuration.

Before the operation the meatus should be cleansed as thoroughly as possible by careful syringing, *e.g.* by Lot. Hydrarg. Perchlor., 1 in 3000. It must be remembered that the discharge which is always present is very infective and that removal of a polypus may, by opening up some fresh channel for infection, be followed by some acute trouble in the mastoid or the middle ear. The operation may be carried out under local anæsthesia, induced by the application of a 20 per cent. solution of cocaine and a solution of adrenalin hydrochloride (1 in 1000): in children or in nervous patients a general anæsthetic is desirable. The polypus is best removed by a small wire snare (Wilde's or Gruber's). The attachment of the polypus may be verified by a fine probe, after which the wire loop is pushed deeply into the meatus and pushed over the polypus till it encircles the latter. The snare is then tightened, and, as soon as the pedicle is gripped, a gentle pull brings the polypus away. If the polypus is presenting at the meatus no speculum will be required. The hæmorrhage, which is sometimes severe, may be controlled by syringing with hot saline solution. The meatus is then lightly packed with a little ribbon gauze and a pad of gauze is applied over the external ear. The gauze packing is removed at the end of twenty-four hours, and the meatus is syringed, daily. It may be necessary lightly to touch the point of attachment of the polypus with the galvano-cautery. Drops of rectified spirit are often of service in the after-treatment.

Incision of the Tympanic Membrane. This operation is indicated under the following circumstances. (*a*) In acute suppurative otitis media, when spontaneous perforation of the drum has not taken place, and when there is severe pain accompanied by pyrexia. (*b*) In acute otitis media where, though perforation has occurred, pain still continues, owing to the opening being too small to allow of free escape of the pus. Occasionally the pain and discharge cease after the escape of pus, only to be followed by a further abscess owing to the perforation being of insufficient size to secure free drainage. This process may be repeated a number of times. (*c*) In some cases of chronic catarrh where there is excessive secretion and the drum is bulged outwards.

Operation. Owing to the extreme tenderness of the inflamed structures, and the necessity for deliberation on the part of the operator, a general anæsthetic such as nitrous oxide gas and oxygen, is desirable. The external meatus must be irrigated with some dilute antiseptic lotion to remove all cerumen or epithelial debris, and is then dried with pledgets of cotton wool. The incision is made with a small, sharp triangular myringotome (Fig. 138 B). A large speculum is introduced and a strong light thrown on the membrane either from a forehead mirror or a head lamp. Generally speaking, the cut should be made below and behind

[1] Hence after the removal of the polypus the treatment must be directed to the suppuration and its cause.

the handle of the malleus. The knife is pushed through the drum close to its inferior border, and then cuts in an upward and backward direction, passing midway between the malleus and the margin of the membrane. If cut in this direction the edges of the wound will retract and so ensure free drainage. Owing to the oblique position of the membrane, the knife, if it be made to cut downwards and forwards, must also be directed inwards; otherwise a mere puncture instead of a free incision will be made. If there is already a perforation or if there is a localised bulging the incision must commence at this point. The inner wall of the tympanum must be avoided. At the conclusion of the operation the meatus is again gently irrigated and then lightly plugged with sterilised gauze.

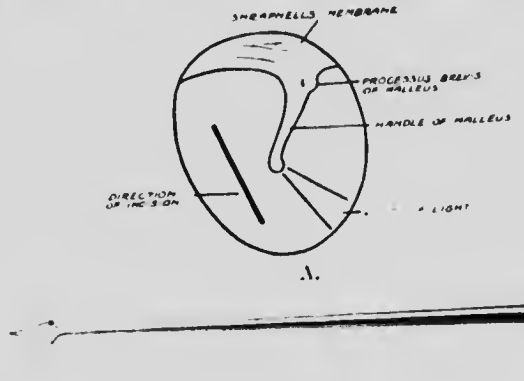


Fig. 138. A. The tympanic membrane, showing the line of incision in myringotomy. B. Politzer's myringotome.

B. OPERATIONS FOR THE COMPLICATIONS OF SUPPURATIVE OTITIS MEDIA. POINTS OF PRACTICAL IMPORTANCE TO THE SURGEON IN THE ANATOMY OF THE PARTS CONCERNED.[1]

I. **Tympanum.** (*a*) Roof always thin, not more than a line and a half in thickness, often thinner; indeed, the bony roof may be more or less deficient, when a thin membrane alone intervenes between the middle ear and the cranial cavity. Through this, inflammation in otitis media readily reaches the brain, causing meningitis, subdural or cerebral abscess. (*b*) Parts of the brain and cerebellum which are in relation with the middle ear. These are the middle and back part of the temporo-sphenoidal lobe, and the outer and front part of the lateral lobe of the cerebellum. (*c*) The mucous membrane and the endosteum lining the tympanum are in most intimate contact; hence, in otitis media caries and necrosis readily occur, especially if the blood-supply to the tympanum from the dura mater is cut off. (*d*) The skin of the external auditory meatus is continuous with the membrane tympani, and thus otitis media may be set up from without, as well as by mischief reaching the tympanum through (*e*) the Eustachian tube, which enters in front, and makes the mucous membrane of the throat continuous with that of the tympanum. (*f*) The outlet of the mastoid cells and antrum is inadequate for drainage through the cavity of the tympanum, partly because the greater part of the cavity

[1] These should be studied together with a skull and one or two sections of a temporal bone.

of the antrum is situated below the level of the aditus, and partly because the attic of the tympanic cavity into which the channel opens contains the head of the malleus and the body and short process of the incus, which will hinder the free escape of pus. The floor of the tympanum is, in part, below the orifice of the Eustachian tube, which thus only imperfectly drains the cavity of the middle ear.

II. **Mastoid Antrum and Mastoid Cells.** (*a*) Their development varies

Fig. 139. A, Macewen's triangle. B, Posterior margin of the external auditory meatus. C, External auditory meatus. D, Posterior root of zygoma. E, Zygoma cut across.

with age. In adults, if well marked, they may measure an inch and a half horizontally, two inches vertically, and reach quite up to, and even around, the lateral sinus. (*b*) Two groups of cells are present, and their relations are of the utmost importance—A, The upper, or antrum, present both in early and later life, horizontal in direction and closely adjacent to and communicating with the tympanum. B, The lower, or vertical. These cells are not present in early life, and vary much as regards their contents. In only about 20 per cent. do they contain air. The mastoid antrum is of far greater importance. This is a small chamber lying behind the tympanum, into the upper and back part of which (the tympanic attic) it opens. Its size varies, especially with age. Present at birth, it reaches its largest size, that of a pea, about the third or fourth year. After this it usually diminishes somewhat owing to the encroachments of the developing bone around it. Its roof, the tegmen antri, is merely the backward continuation of the tegmen tympani. The level of this is indicated by the horizontal root of the zygoma. "The level of the floor of the adult skull at the tegmen antri is, on an average, less than one-fourth of an inch above the roof of the

external osseous meatus; in children and adolescents, from one-sixteenth to one-eighth of an inch" (Macewen). The outer wall of the antrum is formed by a plate of bone, descending from the squamous to join with the mastoid part of the temporal. This is very thin in early life; but as it develops by deposit from the periosteum the depth of the antrum from the surface increases. Macewen gives the average for this depth as varying from one-eighth to three-quarters of an inch. At

FIG. 140. Oblique section through the right temporal bone passing through the carotid canal, the tympanic cavity, and the antrum. The two portions of the bone are opened out so that on the left the outer boundaries of these structures are seen from within, while on the right the inner aspect is shown. *A*, the tegmen tympani. *B*, the attic. *C*, the carotid canal. *D*, the handle of the malleus. *E*, the tympanic membrane. *F*, the meatus. *G*, the mastoid process. *H*, the mastoid cells. *I*, the stylo-mastoid foramen. *J*, inner wall of tympanic cavity. *K*, carotid canal. *L*, entrance to the Eustachian tube. *M*, ductus faloppianus. *O*, antrum. *P*, adhesions.

the junction of the two parts of the outer wall of the mastoid antrum is the squamo-mastoid suture, often still present. Through the floor, formed by the petro-mastoid part, the antrum communicates with the lower or vertical cells of the mastoid. This is usually at a lower level than the opening into the tympanum, and thus drainage of an infected antrum is difficult, fluid readily passing into the lower cells. Behind the mastoid antrum and cells is the lateral part of the petrous portion of the temporal bone. The sinus lies more superficially than the antrum, being usually one-fourth of an inch, occa-

[1] Körner, of Frankfort, has shown (Journal of Laryngology, vol. xviii, 1889, p. 311) that fatal intracranial diseases (meningitis, sinus disease of the right petrous than the left, and its sigmoid flexure, come (in excess) more frequently occur with sinus, and its sigmoid flexure, come more frequently into contact with the dura mater, lies nearer to the primary petrous than does the left, and therefore due to the fact that the right lateral disease.

stonally halt an inch from the surface. The outer wall is formed partly by the petrous and partly by the mastoid portions of the temporal bone.

The exact position of the antrum, a little above and behind the bony external auditory meatus, is represented by Macewen's "suprameatal triangle." This is a triangle bounded by the posterior root of the zygoma above, the upper and posterior segment of the bony external meatus below, and a straight line joining the above boundaries. "Roughly speaking, it corresponds to the external meatus if bisected horizontally.

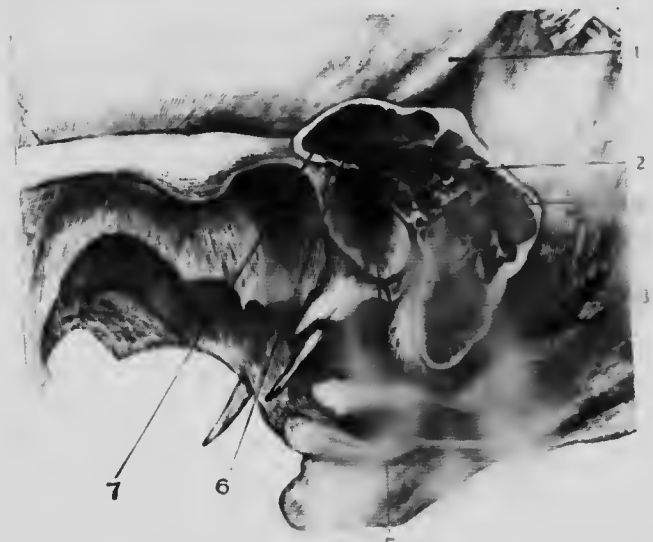


Fig. 141. The outer wall of the tympanum, together with the [illegible] removed here in order to show [illegible] extensive disease. It will be [illegible] and vertical, are widely developed. (1) Posterior root of the zygoma, forming the upper boundary of Macewen's triangle. (2) Antrum and, in front of it, the attic. (3) Vertical cells of the mastoid. Where these are well developed and become infected, Bezold's mastoiditis (p. 338) will occur. (4) Ridge on the inner wall of the tympanum indicating the Fallopian aqueduct. (5) Fenestræ in the inner wall of the tympanum, indicated in shadow. (6) A natural deficiency in bone [illegible] with a small osteotribe to remind my readers how thin is the [illegible] the antrum and tympanum. (7) Cells present in this case, even in the zygoma [illegible] its junction with the middle root. This will show how difficult it is in some cases to [illegible] about complete asepsis.

the upper half would be on a level with the mastoid antrum. If this segment be again bisected vertically, its posterior half would correspond to the junction of the antrum and middle ear, and immediately behind this lies the suprameatal fossa (Macewen). When opening the antrum through the triangle the operator should work forwards and inwards, so as to avoid the sigmoid sinus, while to keep clear of the facial nerve (Figs. [illegible] should lay the roof of the zygoma and the upper part of the bony meatus as closely as possible, and not continue his perforation more forwards than is absolutely needful. The level of the base of the brain will be a few lines above the posterior root of the zygoma (Fig. 141) and about one-quarter of an inch above the roof of the bony meatus.

In the first few years of life certain points of difference exist in the anatomy of the antrum, which are of practical importance. Speaking generally, the thinness of the outer wall and the presence of the squamo-mastoid suture favour the escape of infected material to the outside of the skull, while the small degree of development of the mastoid cells also helps to render less frequent intracranial complications at this age, especially thrombosis of the sigmoid sinus. Mr. H. Stiles [1] points out two more anatomical details which should be remembered. During early life the undeveloped condition of the mastoid process leaves the stylo-mastoid foramen exposed upon the lateral, not the under, surface of the base of the skull. In making the first incision, therefore, by which the soft parts are reflected from the bone, the surgeon should take care, below a point on a level with the middle of the meatus, to make his incision a superficial one only, to avoid injuring the facial nerve. Secondly, the posterior root of the zygoma, which in the adult forms a surface-guide to the level of the roof of the antrum, does not now exist.

B. The lower, or vertical. These cells are not developed in early life, and vary much in their contents. The mastoid process begins to develop in the second year. As it increases in size, the mastoid air-cells make their appearance, but they do not reach their full development until puberty. They are developed as diverticula from the antrum and present a very varied arrangement. They may extend throughout the whole process, in which case they are only separated by very thin bony lamellæ from one another and from the lateral sinus. In some cases they are small and numerous, while at other times the mastoid process may be solid. The air-cells may extend beyond the limit of the mastoid, over the roof of the meatus towards the zygoma and in other cases towards the jugular process of the occipital. Their mucous lining is continuous with the mucous membrane of the tympanum and the antrum.

The following are the different ways by which infection may reach the interior of the skull from the ear: (1) Through the roof of the antrum, especially if the bone be naturally deficient here, into the middle fossa; (2) Through the posterior wall of the antrum to the lateral sinus, the sigmoid groove and the posterior fossa; (3) By the labyrinth and internal auditory meatus into the posterior fossa; (4) By the different sutures with their contained processes of dura mater; [2] (5) By the veins which drain the tympanum and the mastoid cells. These fall into three chief groups: (*a*) Those opening into the lateral sinus; (*b*) Those passing through the mastoid foramen into the occipital vein and soft parts outside the skull; (*c*) Those running through the petro-squamosal suture to the dura mater. All these veins carry sheaths of connective tissue, and thus inflammatory products may reach (*a*) the lateral sinus, causing septic phlebitis; (*b*) the soft parts outside, causing periostitis, cellulitis, &c.; (*c*) the dura mater and brain, causing meningitis and abscess.

Five Results of Otitis Media which may come under the notice of the Surgeon. (1) Acute inflammation of mastoid cells: mastoid abscess; (2) Chronic mastoid suppuration; (3) Abscess in the brain or cerebellum;

[1] *Brit. Med. Journ.*, vol. ii, 1891, p. 1142.

[2] The sutures may be of fatal significance. Thus in cases where there is infective mischief outside the bone, the infection having made its way there by an opening in the mastoid, or, where this is sclerosed, by dissecting its way along the external auditory meatus, if it reach a suture and its contained process of dura mater, infection of the inner surface and meningitis may easily follow.

(4) Infective thrombosis of the sinuses and pyæmia; (5) Meningitis;[1] one or more of these often coexist, and thus the symptoms may be much blended together and confusing.

Acute Mastoiditis and Acute Mastoid Abscess. This trouble usually arises in the course of chronic middle ear suppuration. It is a rare complication of acute otitis media, except when scarlet fever or influenza is the cause of the latter. The chief symptoms are pain, tenderness, redness and œdema over the mastoid process, with pyrexia and possibly rigors occurring in a patient suffering from middle ear suppuration.

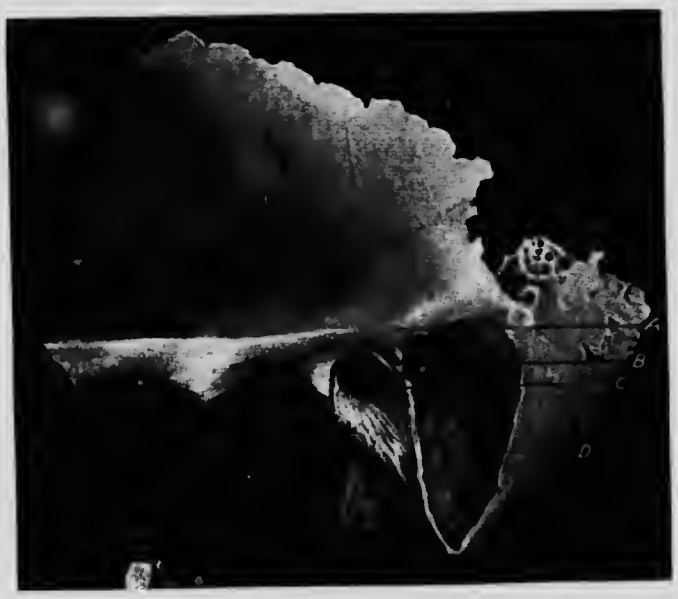


FIG. 142. A left temporal bone showing the antrum and the mastoid cells which have been opened up for an acute mastoid abscess. A. Posterior root of the zygoma. B. The antrum. C. The external auditory meatus. D. The mastoid cells which have been opened and which extend to the apex of the mastoid process.

The auricle is commonly displaced forwards and outwards in adults, and in a downward direction in children. This is due to pus having made its way through the thin sheath of compact tissue of the mastoid, thus giving rise to a subperiosteal abscess.

Indications for Operation. In adults the presence of a subperiosteal abscess is always an indication for at once opening up the mastoid antrum and cells; but in young children, if the swelling is but slight and if constitutional symptoms are absent, treatment by fomentations may lead to a spontaneous escape of the pus through the external ear.

Occasionally the mastoid abscess bursts into the external auditory

[1] According to Poulsen (*Arch. of Otol.*, July 1892, p. 346) the relative frequency of the three latter complications is about the same. Thus, out of thirty-six cases of complications of otitis media, there were thirteen cases of abscess, twelve of sinus thrombosis, and eleven of meningitis.

[2] It must be remembered that in these cases the appearance of the mastoid abscess may coincide with a diminution, or even entire cessation, of the discharge from the ear.

meatus, when there will be an opening on the posterior wall through which a probe can be passed into the mastoid cells. In some cases, where there are large air-cells extending to the apex of the mastoid process, the pus may make its way through the bone in this situation into the digastric fossa whence it will extend deeply among the muscles at the side of the neck: this variety of the disease is known as **Bezold's mastoiditis.**

In other rare cases, where the cells extend forward to the root of the zygoma, the pus may make its way in this direction and even extend into the squamous part of the temporal bone. There will be pain and swelling in the root of the zygoma and the temporal fossa, and probably œdema of the eyelids.

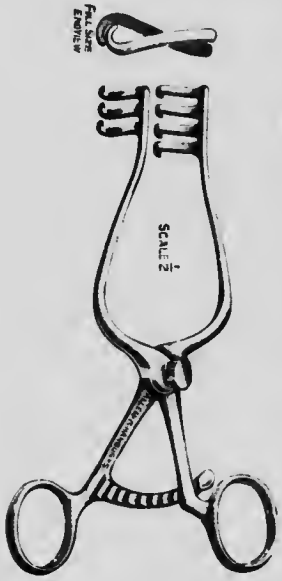


FIG. 143. Automatic mastoid retractor.

In all these cases opening the antrum and mastoid cells is urgently called for.

Antrectomy. Operations based on those of Schwartze and Stäcke. The name of Schwartze, of Halle, is associated with the first attempt to put operations on the antrum on a satisfactory footing, he having published, in 1873, a series of cases in the *Arch. f. Ohrenheilkunde*, Bd. vii, u. ix. Replacing such very limited operations as that of Wilde's[1] incision and drilling the bone, Schwartze opened up the mastoid cells and antrum, establishing drainage between these and the tympanum, and keeping the communication open by plugging or by a leaden nail. This pioneer operation, though excellent and based on correct principles, admitted of improvement. It was used extensively for many years, with the result that it was found admirably adapted for acute, but insufficient for some chronic cases where the mischief was extensive. Stäcke, in 1892, published[2] his operation which modified that of Schwartze in the following important details—viz. the detachment of the auricle, the removal not only of the outer wall of the antrum but the upper and outer part of the bony meatus, the taking away of the ossicles and membrana tympani, and the replacing of the auricle, drainage being effected through the external auditory meatus.

Generally speaking, in acute cases, an operation based on Schwartze's is called for, while in chronic cases, Stäcke's operation, or some modification of this, is indicated.

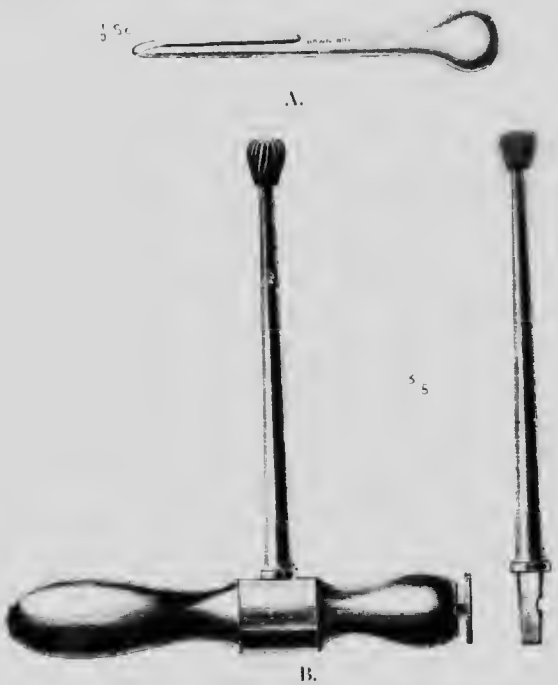
The Operation for Acute Mastoid Abscess. The hair must be shaved and the skin carefully cleansed for a distance of about three inches behind and above the ear. In the case of a woman the hair may be kept out of the way by a bandage round the head or by a rubber cap. Owing to the extreme tenderness the cleansing process will usually have to be carried out after the patient is anæsthetised.

The position of the patient at the operation is of considerable importance: the head and shoulders should be slightly raised, and the head

[1] In Wilde's operation an incision is made down to the bone about three-quarters behind the auricle. Drainage of a subperiosteal abscess is thus effected, but the antrum is not opened.

[2] *Arch. of Ohrenheilkunde*, Bd. xxxi.

turned well over to the sound side so that the diseased ear is uppermost. A loosely-filled sand-bag beneath the head is often of great service in the maintenance of this position during the operation. The sterilized towels should be arranged as follows: one towel is placed beneath the patient's head and shoulders, while a second, folded diagonally, is fastened tightly round the head so as completely to cover the hair. The patient's body is then covered by one or more large towels, and finally, a small towel with a central slit is arranged so as to cover the patient's face and the anæsthetist's hands and apparatus and to leave the ear and seat of operation alone exposed. A good light is absolutely essential, as the field of operation



A.

B.

Fig. 144. A. Macewen's gouge. B. Osteotredes or burrs made for use with a trephine handle.

is at the bottom of a deep wound, easily obscured by hæmorrhage, and in close proximity to structures of the utmost importance. The most satisfactory illumination is obtained from an electric head-lamp, which is comfortable to wear and which throws a bright light into the depths of the wound without in any way obstructing the field of vision.

A curved incision must be made parallel to, and from half to three-quarters of an inch behind, the attachment of the auricle; it should commence above at the level of the top of the pinna and extend downwards to the apex of the mastoid process.[1] It should at once be carried down to the bone. If a subperiosteal abscess is present it is in this way opened and an area of bone, bare and devoid of periosteum, of variable extent, will be felt. Free hæmorrhage may follow, but this can be checked by picking up the cutaneous vessels with Spencer-Wells forceps.

[1] In children the superficial position of the facial nerve must be remembered.

Whether a subperiosteal abscess is present or no the periosteum must be stripped with a raspatory from the mastoid process in a forward direction until the posterior wall of the external auditory meatus, the suprameatal spine, and Macewen's triangle are exposed. Care must be taken to avoid injury to the cartilaginous meatus and its cutaneous lining.

In order to obtain a free view of the area involved the margins of the incision must be widely retracted. This is best effected by the retractor shown in Fig. 143. By tightening the screw it is automatically retained in the desired position, and also to a great extent checks the oozing from the cutaneous vessels. The surface of the bone is now dried and carefully inspected for a sinus or depression from which pus is oozing or for a discoloured patch of bone. Such an opening may, or may not, be present, and the next stage of the operation will depend to a certain extent upon the existence or non-existence of such a sinus.

A. If a sinus is found this should be opened up and explored, for here the pus has made its way through the bone and consequently this sinus affords a direct track to the abscess cavity.

The bone must be removed by some form of gouge or chisel. Most surgeons prefer gouges with curved cutting edges; others, however, use flat chisels with slightly rounded corners to the cutting edge. In either case several sizes should be ready to hand. The gouge or chisel must in all cases be used so as to remove thin shavings of bone from the exposed surface. This is ensured by holding the gouge so that it makes an acute angle with the surface of the bone, and then giving it a few light taps with the mallet until a grip is obtained: the handle is then depressed and a few more blows will cut away a shaving of considerable extent. On no account is the gouge to be driven vertically into the bone so that it becomes locked; this may lead to a fracture of the skull or to some serious injury to the brain or lateral sinus. The gouge or chisel must always be held so that it cuts from behind forwards and from above downwards. In this way it is cutting from the lateral sinus and the fossæ of the skull, and hence, even if these structures are exposed inadvertently, they will probably escape injury. If cutting in the reverse direction, however, the edge of the instrument may be driven into the lateral sinus or brain and inflict serious injury on these structures. The gouge should be lightly but firmly grasped by the thumb and the four fingers, while the wrist rests against the patient's head: in this way it may be kept under perfect control, and, even if it unexpectedly should penetrate any thin portion, can be prevented from damaging the underlying structures. The best form of mallet is a small well-balanced metal hammer which can be easily sterilised. In many patients, especially children, the bone is so soft that the gouge can be quite easily used by the hand alone without the assistance of the mallet except perhaps for the first few cuts.

The condition revealed when the sinus has been opened up in the way described above will vary a good deal in different cases. A large abscess cavity, the size of a hazel-nut, may be found, or, instead of a single abscess cavity, a number of cells containing pus and septic granulation tissue may be present. In either case the extent of the cavity should be investigated by a small blunt-ended probe. The compact tissue of the mastoid must now be gouged away so as to thoroughly expose the whole of the infected area. When there is a single large cavity bone must be removed so as to avoid any overhanging edge beneath which suppuration might

still go on. When many septic cells are present each must be opened by gouging away the bony septa, and the various extensions of the cells mentioned on p. 336 must be remembered, those at the apex receiving special attention. The wound must be carefully inspected after each application of the chisel to make sure that the lateral sinus and the dura mater are not exposed. The former is especially likely to be injured as bone is removed to expose the posterior part of the cavity. Indeed, sometimes the bone has been destroyed by the backward extension of the suppuration to such a degree that the lateral sinus and dura of the posterior fossa form part of the boundary of the abscess cavity. The

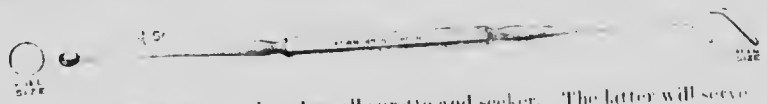


Fig. 145. Macewen's combined small curette and seeker. The latter will serve as an ossicle hook.

middle fossa, which very rarely extends below the level of the posterior root of the zygoma, is unlikely to be exposed at this stage of the operation. Directly the gouge opens up any new space it is advisable to explore this with the blunt probe as described above. If the space is an air-cell it will be felt to have a definite deep bony wall: if it be a lateral sinus or cranial cavity the soft yielding dura mater will be felt. Haemorrhage is not often troublesome: blood is best mopped away by small strips of sterilised lint or gauze introduced into the depths of the wound by means of fine bayonet-shaped forceps. It is a not uncommon mistake for the surgeon to rest content with opening and draining the abscess cavity. This, however, is not sufficient: the mastoid antrum, which is the cause of the abscess and which is always infected, must also be opened and drained. If this is not done chronic inflammation with further caries and necrosis is bound to continue and will probably lead to a persistent sinus behind the ear as well as to a further extension of the septic process in the bone.

In many cases the probe will readily pass along a channel leading in an upward and forward direction to the antrum, which is then easily opened up. In other cases, though it certainly exists, the channel may be so narrow and sinuous that it is not found by the probe. It will then be again necessary to identify Macewen's triangle and the posterior root of the zygoma. Bone must then be gouged away in a forward and upward direction and the antrum will soon be found beneath this spot. The antrum can be identified by the following tests: (*a*) Investigation by the probe shows that its deep wall is bony; (*b*) A bent probe can be made to pass in a forward and upward direction towards the tympanic cavity. The antrum must be thoroughly exposed by the removal of any overhanging edges and must then be carefully curetted by a small Volkmann spoon to remove all septic granulation tissue and carious bone. The mastoid cells must be treated in the same manner.

Fig. 146. Stäcke's gouge.

B. If no opening or discoloured bone is seen, it is best at once to proceed to open the antrum. To effect this the operator should, after having first identified the superficial landmarks mentioned above, proceed to cut a shallow groove with a half-inch gouge. The upper limit of the groove is the root of the zygoma, while its posterior limit should be rather less than three-quarters of an inch behind the posterior wall of the meatus. When the depth of the groove is about a quarter of an inch a smaller gouge should be selected and bone now be taken from the region of the antrum, immediately above and behind the external auditory meatus. As this is done one or more cells, probably containing pus, may be opened: that they are air-cells and not the antrum may be determined by examination with the probe as described above. Any cavity which is opened must be carefully investigated, as the middle fossa does occasionally descend below the level of the root of the zygoma. The depth of the antrum varies within wide limits. It may be only a quarter of an inch from the surface or as much as three-quarters of an inch. In the latter case, if the bone is sclerosed, as does sometimes happen, the exposure of the antrum may be a matter of considerable difficulty. If the surface marking is remembered and is carefully followed, however, a small antrum will be found even under these conditions. When it is opened its roof is examined both by direct inspection and by the probe for any carious patch or perforation which will open the middle fossa and expose the dura. The infected mastoid cells are then opened up as described above and the whole cavity is thoroughly curetted and scraped to remove all septic granulation tissue.

All loose chips of bone are then sought for and removed by the curette or forceps and the whole cavity is irrigated with lot. hydrogen peroxide (5 per cent.), which probably will find its way through the tympanum to the external auditory meatus. In any case the meatus should also be washed out.

The wound behind the ear is then lightly packed with a strip of sterilised ribbon gauze and a small length of the same material is introduced into the external auditory meatus. A few fishing-gut sutures may be used to close the upper part of the wound, but free drainage must be secured. A gauze pad is applied and a thick layer of absorbent wool, and the whole is firmly bandaged.

After-treatment. The first dressing may remain unchanged for forty-eight hours: the gauze plugs are then removed, after moistening with hydrogen peroxide. The post-aural wound is then gently syringed with the same lotion, which will probably, in part, escape through the meatus. Should it not do so the meatus must be cleansed separately. The gauze plugs and the external dressings are then replaced. For a time the dressing will have to be changed daily, but as the discharge lessens, they may remain untouched for two and then three days. The wound soon shows healthy granulations with but little discharge, and the escape of pus from the meatus also soon ceases in most cases. Should this, however, continue, and should a fistulous opening behind the ear also persist, further treatment will be called for (*see* p. 344).

Possible accidents and complications. (1) *Injury to the Lateral Sinus.* This may be brought about by the gouge or by the sharp spoon or curette during the removal of the septic granulations. In either case there is severe hæmorrhage and the wound becomes at once flooded with blood. Fortunately this can at once be checked by pressure. While an assistant

thus controls the bleeding a piece of ribbon gauze is prepared, and, when the pressure is removed, the end of this is placed over the opening into the vessel by the help of a director. More gauze is then packed in, and the operation is proceeded with. It may be necessary to leave a special piece of gauze over the opening at the conclusion of the operation. The greatest care must be taken to avoid injury to the sinus, on account of the possibility of a resulting septic thrombosis of the vessel. Should the sinus be accidentally wounded every precaution must be taken to guard against infection.

(2) *Opening the middle or posterior fossa of the skull.* Should this happen, without injury to the dura, serious consequences are very improbable. Should, however, the dura be injured, there is a possibility of

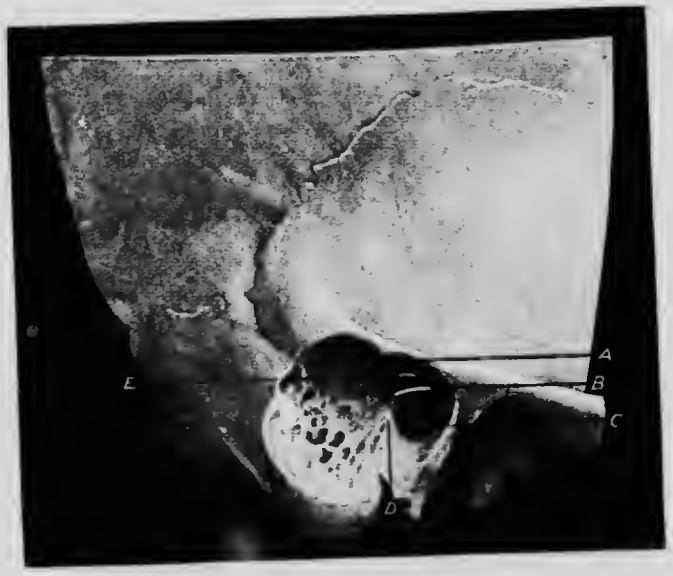


FIG. 147. A preparation of the right temporal bone to show the bone which must be removed in Stäcke's operation. A. The antrum. B. The aqueductus fallopii. C. The external auditory meatus. D. The remains of the posterior wall of the external auditory meatus. E. The external semicircular canal.

septic infection extending to the brain or the meninges. Thus when the dura is known to be exposed the gouge and curette must be used in that region with great caution.

(3) *Injury to the facial nerve.* This is very unlikely to occur in the operation described above except in the case of children (*see* footnote, p. 339). It may, however, be damaged if, when curetting the antrum, the curette is introduced so as to press against the posterior part of the floor of the aditus. When working in this situation the curette must be used with caution, and a watch kept for any twitching of the face.

THE RADICAL MASTOID OPERATION

It will now be necessary to consider the indications for the more complete, or radical, operation, founded on that originally described by Stäcke. In this operation the mastoid cells and antrum are opened

up, the posterior wall of the meatus is removed, so that antrum, mastoid cells, attic, tympanic cavity, and external auditory meatus are thrown into one cavity. The aim of the surgeon is to remove all septic granulation tissue and all the diseased bone including the ossicles, and then to get the cavity completely covered by epithelium, thus leading to a cessation of the discharge. Generally speaking, this operation is called for in chronic suppuration in the middle ear and mastoid. The following are the chief indications for the operation in a patient suffering from chronic otitis media.

(1) When acute mastoid disease becomes chronic, *i.e.* the wound behind the ear does not heal and discharge of pus from the ear persists.

(2) Recurring attacks of swelling and pain over the mastoid process.

(3) The spontaneous occurrence of facial paralysis.

(4) Recurrent attacks of vertigo, either spontaneous or from syringing. This shows erosion of the bony wall of some part of the labyrinth.

(5) When cholesteatomata are present in the attic and the mastoid. These masses of epithelium are usually regarded as derived from proliferation of the epithelium of the external auditory meatus through a perforation in the tympanic membrane. They may reach the size of a marble, are accompanied by a foul purulent discharge, cause absorption of the bone by pressure, and may penetrate the cranial wall opening up one of the fossæ of the skull.

(6) For tuberculous disease of the mastoid.

(7) For necrosis of the temporal bone or for recurring masses of granulation springing from carious areas.

(8) When occlusion of the meatus is associated with a chronic purulent discharge.

(9) When intracranial complications are present.

(10) In addition to these there are a number of cases in which a chronic otitis media persists, resisting all means of treatment. It is often very difficult to decide if operation is required in these cases. If the perforation is in the postero-superior quadrant of the membrane and is marginal in position bone disease is likely to be present. In some of these cases removal of the ossicles or providing free drainage by removing the outer wall of the attic [1] may suffice. Should these operations fail the more complete operation is indicated.

In chronic disease of the mastoid it is often surprising to find the extent to which the bone has been destroyed with very slight symptoms. It is quite possible to find the mastoid process a mere shell, containing pus and granulation tissue with possibly one of the fossæ of the skull opened and the dura mater in contact with the septic cavity, and yet no symptoms beyond the discharge from the ear.

In other cases one of the acute intracranial complications to be described below may suddenly develop without previous warning.

The Operation. This may be considered in two stages, (1) the operation on the bone, (2) the plastic operation to provide the resulting bony cavity with an epithelial covering.

The operation on the bone will, to a great extent, follow the lines of the operation described above for acute abscess. The preliminary preparations, the incision, and the exposure of the field of operation are similar, but the cartilaginous meatus must be separated from the bony meatus.

[1] For the indications for, and the mode of performing, these operations, the reader is referred to some standard work on diseases of the ear.

without tearing or injuring the former. In Stäcke's original operation the antrum was exposed by chiselling away the postero-superior part of the meatal wall. It is, however, easier and more satisfactory to open the antrum in the manner described above by gouging the bone in the area bounded above by the posterior root of the zygoma, and in front by the wall of the meatus. The position of the lateral sinus must be remembered and the posterior limit of the field of operation should not extend farther back than half an inch behind the rim of the meatus. When the antrum has been exposed any diseased mastoid cells are to be thoroughly opened up in the way described above. A probe, or a Stäcke's guide (Fig. 146), is now passed from the antrum into the tympanic cavity to exactly identify the position of the additus. The posterior wall of the external auditory meatus must now be gouged away, so as to expose the additus, or communication between the antrum and the tympanic attic. At first the bone may be freely removed, but as the bridge of bone between the two cavities is diminished in size the greatest caution must be exercised, for it is at this stage that the facial nerve and the horizontal semicircular canal are in considerable danger. The semicircular canal is contained in a smooth white ridge of bone at the junction of the floor of the additus with its inner wall. The aqueductus Fallopii, which encloses the facial nerve, is situated immediately below and in front of this. Both these bony canals are extremely thin, and, should the gouge slip through the last portion of the bridge of bone between the antrum and the attic, and impinge against them, these structures are very liable to be injured. Injury to the facial nerve will result in complete paralysis of the muscles supplied by it; while injury to the semicircular canal, besides causing serious vertigo, may be the starting-point of labyrinthine suppuration. The utmost caution must therefore be exercised in removing the last portion of the bridge of bone. After each chip of bone has been cut away the wound must be carefully dried by a pledget of sterilised gauze introduced into the depths of the wound. A Stacke's guide may be left *in situ* in the additus with the view of protecting the nerve, or a piece of gauze may be packed into this cavity with the same object. When only a narrow bridge remains, this should be divided by the gouge cutting from above downwards just below the level of the tegmen tympani, *i.e.* as far from the nerve as possible. The removal of this piece of bone allows a probe to pass freely from the antrum into the attic and the tympanum. All overhanging edges, beneath which suppuration might possibly be kept up, must be carefully removed until the cavity has the appearance shown in Fig. 147. This refers especially to the outer wall of the attic, which is in part formed by a plate of bone projecting down from the tegmen tympani, and to the spur formed by the remains of the posterior wall of the meatus. The latter must be cautiously carried out for the facial nerve is again in danger while the deeper part of this is being rounded off to secure a good view of the posterior part of the tympanic cavity. When these edges have been gouged away the whole cavity must be carefully curetted. All granulations must be removed and all carious patches in the bone thoroughly but gently scraped. A careful and systematic inspection of all parts of the cavity, including the tegmen tympani and tegmen antri, must be made with the help of a bright light. All discoloured or suspicious areas must be followed up with the curette, and, if necessary, the gouge. When the attic and the tympanum are curetted the incus and the malleus will very probably be found in a carious condition and more

or less embedded in granulation tissue.[1] They should be removed. The curette must always be used with care and gentleness: the wall of the cavity is in many places extremely thin and is in relation with very important structures. Thus in the floor of the tympanum a thin plate of bone alone separates it from the bulb of the jugular vein: the front of the tympanum is in close relation with the internal carotid artery; while the proximity of the lateral sinus to the posterior part of the cavity, the dura of the middle fossa to the tegmen tympani, and of the semicircular canal and the facial nerve to the additus, have already been insisted upon. It may here be pointed out that the facial nerve may be quite as readily damaged by the curette as by the gouge, for the bony aqueductus Fallopii is extremely thin and it is deficient in places or may be opened by caries of its walls.[2] While curetting in its neighbourhood it is therefore wise to keep a close watch for any twitching of the face. When the curetting has been satisfactorily carried out all edges and angles must be rounded off and a search must be made for any loose chips of bone which are removed. The cavity is then washed out with hot lot. hydrogen peroxide (3 per cent.).

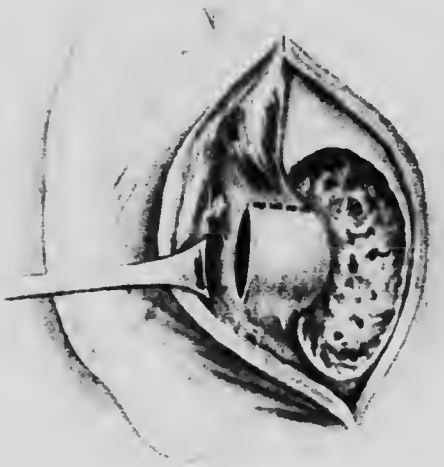


FIG. 148. Stacke's plastic operation. The vertical cut is shown with the edges gaping. The position of the horizontal cut is indicated by the dotted line.

The Plastic Operation. In all cases, except where there is some intracranial complication which requires drainage, the wound behind the ear should be closed and a flap be cut from the cutaneous lining of the meatus, to ensure drainage of the entire cavity and, at the same time, to provide a covering for part of it from which epithelium will eventually grow to cover the whole. There are a number of ways in which this can be accomplished.

(1) *Stäcke's method.* This is described in the following words by Heine.[3] "After the tympanic cavity and the rest of the wound have been temporarily packed with gauze, one hand (for the left ear the left hand,

[1] The stapes should not be disturbed on account of the danger of opening the labyrinth.

[2] In such cases even gentle pressure by a piece of gauze for the purpose of drying the wound may cause twitching of the face. In these cases paralysis of the face coming on some hours after the operation is not uncommon and is probably due to inflammatory exudation pressing upon the nerve in its canal. Such paralysis will disappear, though sometimes tediously. This paralysis is especially likely to occur when there is any natural gap or pathological erosion. Paralysis noticed immediately after the operation is probably due to injury, and is likely to be permanent.

[3] *Operations on the Ear*, translated by W. L. Murphy, 1908.

and vice versa) holds the auricle and turns it forwards, while with the other hand a narrow scalpel is pushed from behind through the soft parts at the level of the superior wall of the meatus, until the point appears in the entrance of the meatus at the junction of the posterior and superior walls (Fig. 148). The point at which the knife is inserted lies close behind the anterior lip of the wound. The auricle must be turned a little backwards while the blade is being pushed through from behind, in order that the surgeon may make sure that it emerges at the proper spot. Care must also be taken not to wound the anterior meatal wall. When the point is seen to appear at the spot indicated the knife is carried vertically downwards; that is, towards the apex of the mastoid, and in a direction perpendicular to the long axis of the auditory canal. In doing this the posterior part of the meatus itself and the soft parts behind it are cut

Fig. 149. A. Körner's flap. B. Panse's flap. C. Mollison's flap.

through. The point of the knife must divide the skin of the meatus in the line where it passes on to the auricle. If the incision is lateral to this line, it will divide the cartilage of the ear; if it is to the median side, the outer end of the meatus will remain attached to the auricle and the opening into the operation cavity will be too narrow. The second incision for the formation of the flap runs horizontally at the junction of the posterior and superior walls of the meatus, and splits the canal in its long axis. A small retractor is inserted into the slit in the posterior meatal wall and pulled forwards, in order to bring the lumen of the canal into view. The wall of the meatus is then grasped from behind with toothed forceps, and the soft parts are pulled backwards and outwards until the lumen gaps sufficiently. The gauze packing is now removed, and straight scissors are inserted through the vertical incision in such a manner that one blade lies in the meatus and the other outside. The scissors are brought as high as possible, and are pushed inwards until the point of the blade lying inside the canal comes into view deep in the wound. A single cut is then made with the scissors in the desired direction (Fig. 148) and the formation of the flap is complete." In order that the flap shall fall nicely into position it is necessary to snip away with a sharp knife some of the thick soft tissues at the outer end, taking care that the skin itself is uninjured. The flap is not kept in position by sutures, but is pressed against the lower and posterior part of the bony cavity by gauze packed through the external auditory meatus. The wound behind the ear is then completely closed by a few silkworm-gut sutures.

Various modifications of the mode of cutting the flap have been

suggested. Korner (Fig. 149 A) cuts a rectangular flap by two incisions, one at the junction of the superior and the posterior walls and the other at the junction of the posterior and inferior walls of the meatus. These incisions are continued outwards for a short distance on to the concha. After the cartilage has been dissected away this tongue-shaped flap is turned backwards, and, after the post-aural wound has been closed, is kept in position by ribbon gauze packed into the cavity through the external auditory meatus. In Panse's method (Fig. 149 B) a single incision is made in the axis of the canal, along the middle of the posterior wall of the meatus. This extends to the concha: at its outer end two small cuts are made at right angles to the first, one in an upward direction and the other downwards. In this way two small flaps are formed, one of which is sutured to the upper and the other to the lower angle of the wound.

Milligan's flap (Fig. 149 C) is thus described by its originator:[1] "A long and thin-bladed knife is inserted into the cartilaginous meatus at the junction of its upper and posterior walls and an incision made vertically outwards into the concha. With a sweeping motion an incision is made through the concha parallel to the curve of the antihelix down to the floor of the meatus (Fig. 149 C). The flap thus formed is turned downwards on to the floor of the bone wound and is kept in position by means of a couple of sutures passed through it and the adjacent skin and tied over a piece of rubber tubing."

Mr. Ballance[2] recommends a different plan of after-treatment, which, when successful, saves much time, and avoids frequent dressings and pluggings—a point of great importance in hospital patients and in those who are timid. The first special point in Mr. Ballance's treatment concerns the cartilaginous canal. After the completion of the post-aural operation he introduces a long thin knife along the meatus and divides the inferior wall in a vertical direction: the incision is then continued in an upward and backward direction into the concha until it reaches the anterior commencement of the helix (*see* Figs. 150, 151). After the flap has been thinned by the removal of all redundant soft parts it is turned backwards and its raw surface is attached by a few salmon-gut sutures to the interior surface of the original mastoid flap (Figs. 152, 153). The post-aural wound is then closed. At the end of about ten or fourteen days an anæsthetic is given and the original wound is opened up and the pinna displaced forwards as at the first operation. The cavity in the bone, now covered by healthy granulations, is thus exposed. All oozing is now stopped by irrigating the wound with hot saline solution, or, if necessary, by the application of adrenalin (1 in 1000). A large thin skin graft is cut from a previously sterilised area of skin on the thigh. If possible this should be of such size as to cover the whole of the cavity. It should be transferred to the wound by a large microscopical section lifter, and is then, by careful manipulation, worked by needles so as to come evenly into contact with the whole raw area, care being taken that all air bubbles and blood have been removed. Should the first graft be of insufficient size, one or more further grafts must be cut until the whole surface is covered. As a protection for the grafts Mr. Ballance employs thin gold leaf, which, after being cut to the requisite size, is placed in exact position over the grafts. A strip of dry sterilised gauze is now evenly

[1] *Latham's System of Treatment*, vol. iii, p. 925.
[2] *Med.-Chir. Trans.*, vol. lxxxiii.

packed into the cavity and the retro-auricular wound again closed and the usual external dressings applied. At the end of four days the plug of gauze is removed from the external auditory meatus and the gold leaf then picked out with forceps or by gentle syringing. In a successful case rapid healing results, but, to ensure success, it is essential that no infective material shall have been left behind and that the bony surface must have been thoroughly smoothed at the original operation.

After-treatment. When skin-grafting is not employed the outer dressings should be changed on alternate days, [illegible] advisable, to avoid disturbing the flap, to remove the packing on the fifth or sixth days, unless there is some special indication for so doing such as pain, a rise of temperature, or excessive or foul discharge.

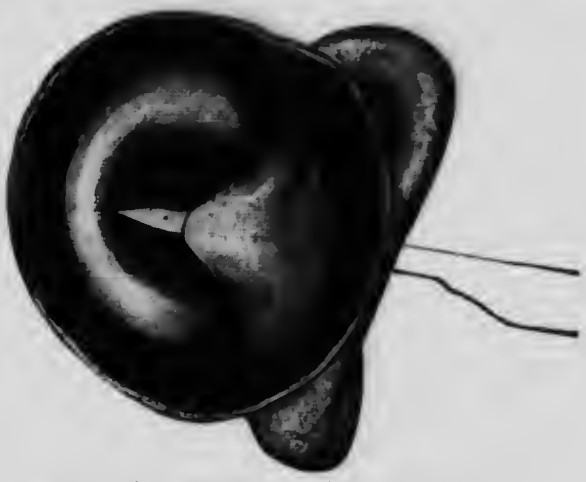


FIG. 150. The posterior edge of the inner extremity of the cartilaginous meatus is shown dislocated outwards, and a long narrow knife has been passed along the length of the meatus through the concha opening. The white space shown in this and in Figs. 152 and 153 represents the bony area which has been operated on. (Ballance.)

FIG. 151. The white line here shows the direction of the incision in the concha. The knife is first carried through the concha backwards, and then backwards and upwards till the anterior extremity of the helix is reached. (Ballance.)

The removal of the plug is facilitated by soaking it with hydrogen peroxide (3 per cent.). The packing should be renewed every second day and the cavity then be syringed with saline solution or some mild antiseptic. Later on the packing is omitted and the granulating surface treated with drops of a solution of boracic acid in alcohol. Any excessive formation of granulations must be kept in check by the application of lactic acid (20 per cent.), or of trichloracetic acid, or by touching with a bead of chromic acid.

The Treatment of the Intracranial Complications of Otitis Media. These are extra dural abscess, cerebral or cerebellar abscess, thrombosis of the lateral sinus and meningitis.[1] In all except the last immediate operation is indicated, while in some cases of early meningitis operation offers a possibility of recovery

[1] A more unusual condition than these is an intra-dural abscess (pachymeningitis Interna Circumscripta). "A circumscribed collection of pus internal to the dura mater, between it and the surface of the brain covered by the pia mater, occurs mostly when there is a fistulous perforation of the dura, provided an adhesion of the dura with the pia mater takes place in the neighbourhood of the ulceration. Such a collection of pus either leads to ulceration and softening of the cortex of the brain or to a brain abscess." (Politzer.)

When, however, pus is diffused over the whole hemisphere, surgical interference offers no prospect of success. In the great majority of

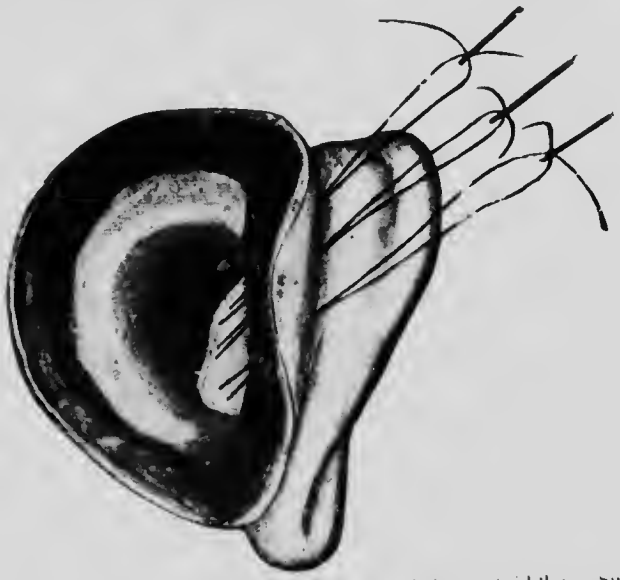


FIG. 152. The concho-meatal flap is seen behind the mastoid flap. Supporting stitches (one, two, or three as the case may be) are carried through the edge of the conchal cartilage. The two threads of each stitch are now threaded on one needle, so that they can be passed through the skin and other tissues of the mastoid flap without constricting them. Before the supporting stitches are passed the thick layer of tissue behind the posterior wall of the meatus is cut away so as to facilitate the application of the meatal to the skin flap. (Ballance.)

cases the septic process reaches the cranial cavity by direct extension from the tympanum or the antrum by gradual destruction of their bony walls. Destruction of the thin tegmen tympani will open the middle fossa and will allow of the development of meningitis or of a cerebral abscess, while an extension backwards through the posterior wall of the antrum will admit of an extension of the septic process to the posterior fossa resulting in the formation of a cerebellar abscess, or of thrombosis of the lateral sinus. In unusual cases no such direct track may be seen. In such cases the intracranial infection may have been caused in one of the following ways: (1) By extension through the labyrinth (2) By extension through the

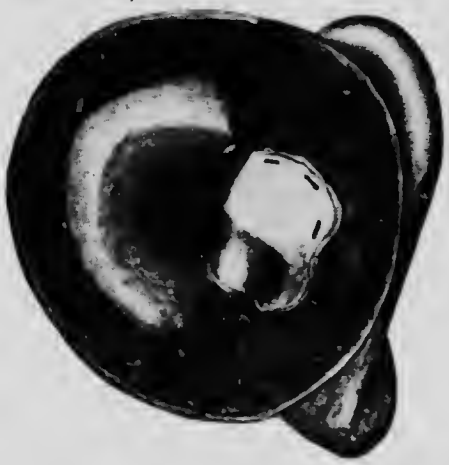


FIG. 153. The supporting stitches are shown drawn tight, and supporting the raw surface of the concho-meatal flap against the raw surface of the mastoid flap. (Ballance.)

and the internal auditory meatus.

floor of the tympanum to the bulb of the jugular vein. (3) By extension along some of the minute canals for emissary veins. (4) By extension through the anterior wall of the tympanum to the carotid canal and thence to the apex of the petrous. (5) An abscess may be pyæmic, and situated at some distance from the affected ear, even in the opposite hemisphere.

In typical cases, the diagnosis of an intracranial complication is easy but occasionally it is exceedingly difficult. More than one of the above may co-exist, which increases the difficulty of an exact diagnosis. Occasionally a cerebral abscess may be present with few or no symptoms, while it is often only possible to suspect some intracranial trouble without

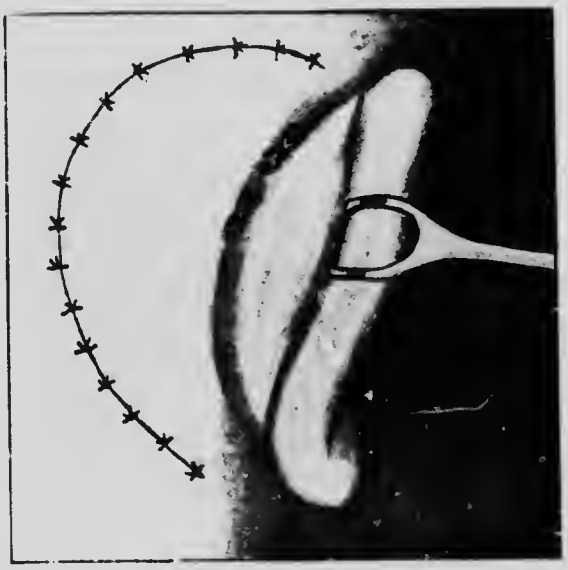


FIG. 154. The supporting stitches are shown passing through the angle of junction of the pinna and the mastoid flap. They were two in number in the case from which the drawing was made. They are tied over pieces of rubber tubing. This is shown too small, and the threads are tied too tightly. The curved incision is entirely closed by gossamer silkworm gut sutures. (Ballance.)

being able to locate it or to be certain of its nature. Needless to say the appearance of such symptoms as a rigor, severe pain, marked rise of temperature, convulsions, or drowsiness, will be an indication for an immediate exploratory operation.

Extradural Abscess. The pus will be found between the bone and the dura mater. These abscesses occur more frequently in the posterior fossæ, especially as a collection of pus and granulation tissue in the sigmoid groove—a peri-sinous abscess. The symptoms vary very much indeed. Not infrequently, in the case of a peri-sinous abscess, they may be completely absent, the condition being found unexpected during a radical mastoid operation. In other cases there may be very severe pain, while in others this symptom varies from time to time owing to the pus being able to drain and the abscess occasionally to empty itself through the middle ear.

Abscess in the Brain. When in the cerebrum the collection of pus is usually in the middle and back part of the tempero-sphenoidal

lobe; when in the cerebellum in the front and outer part of the lateral lobe.

Symptoms. These may be divided into the following three groups:

I. *General.* There may be pyrexia, which is, however, usually due to the otitis or to some other complication. A typical cerebral abscess will show a slightly subnormal temperature. A rigor may occur at the early stages but is rarely repeated. In an old-standing case there will be loss of flesh and constipation.

II. *General symptoms of cerebral disturbance.* Headache is a very constant symptom though the position of the headache is not, as a rule, any indication as to the situation of the abscess. Nausea and vomiting are common, the latter having no relation to the taking of food. Some mental disturbance is nearly always present. In the earlier stages there is mental dulness and apathy; later on there is stupor, or more or less complete coma. Optic neuritis may be present, but, on the other hand, is often absent. The pulse in a typical case is slow.

III. *Localising symptoms.* These are usually but slightly marked and are often entirely absent. A temporo-sphenoidal abscess may, owing to pressure on the internal capsule, produce some paresis in the opposite arm and leg. Occasionally there will be some paralysis of the ocular muscles or alteration in the pupil. The symptoms vary a great deal and are often very indefinite. "Abscess in the brain may be latent,[1] producing no symptoms directly referable to the brain, only general symptoms of ill-health, until excited to activity by a blow, or some minor operation, such as the removal of a polypus" (Ballance). Such latent abscesses possess a well-marked capsule. This is of twofold importance. It prevents the risk of rupture and, as will be seen later, it may baffle attempts to find the pus. On the other hand a rapidly enlarging abscess is very likely to rupture into the lateral ventricle, and the more acute the abscess the more will it be accompanied by an advancing affection of the surrounding brain.

This condition, by causing such symptoms as a high temperature and delirium, will be an additional cause of the masking of the typical symptoms of cerebral abscess. By leading to a diagnosis of meningitis, they may cause the abscess to be overlooked.

Abscess in the Cerebellum. The above remarks also apply to abscesses in the cerebellum. Abscesses in this situation may, however, present well-marked symptoms which aid in the localisation of the trouble. Such are vertigo and ataxy, rigidity of the muscles of the neck, and in some cases well-marked optic neuritis. Dr. Acland and Mr. Ballance[2] have carefully gone into the question in an elaborate article. They throw some doubt upon the opinion usually held, that abscess in the temporo-sphenoidal lobe is more common than in the cerebellum. They quote statistics by Korner, showing that in 100 cases of abscess in the brain, secondary to ear disease, 62 were in the cerebellum and 32 in the cerebrum, and in 6 in both cerebrum and cerebellum. Of 33 cases collected from St. Thomas's and the Great Ormond Street hospitals, 21 were cerebellar

[1] With reference to the diagnosis of latent cerebral abscess, the reader is referred to a valuable paper read by Sir Victor Horsley before the Otological section of the Royal Society of Medicine (*Proc. Roy. Soc. Med.*, February 1912, p. [illegible]). In this paper Sir Victor Horsley discusses also the significance and importance of a number of symptoms such as optic neuritis, subnormal temperatures, and insists on the importance of careful neurological examination.

[2] *St. Thomas's Hospital Reports*, vol. xxxii, p. 133.

and 11 temporo-sphenoidal. In two cases an abscess was present in both the temporo-sphenoidal lobe and in the cerebellum. Dr. Acland and Mr. Ballance drew attention to the fact that in their case certain symptoms were present which so closely resembled the effects produced by removal of one lateral lobe of the cerebellum, that they deserve to be fully considered. These are: (i) Paralysis of the upper extremity on the same side as the lesion. (ii) Conjugate deviation of the eyes towards the opposite side. (iii) Lateral nystagmus. (iv) Exaggerated knee-jerk on the same side as the cerebellar lesion. (v) A tendency to face towards the side of the lesion in walking. (vi) Staggering gait, and a tendency to fall towards the side opposite to the lesion. (vii) Attitude in bed: the patient tends to lie on the side opposite to the lesion with the limbs flexed, and with the side of the face corresponding to the lesion uppermost.

Thrombosis of the Lateral Sinus. This is a grave complication, from its tendency to cause general pyæmia and distant suppurations. The onset is usually sudden and is accompanied by a rigor, headache, and vomiting. Mr. Ballance [1] believes that the following group of symptoms, when present together, are pathognomonic of septic thrombosis: (i) A history of purulent discharge from the ear for a period of more than a year. (ii) The sudden onset of the illness, with headache, vomiting, rigor, and pain in the affected ear. (iii) An oscillating temperature, *i.e.* 104° in the evening and 98 in the morning. (iv) Vomiting repeated day by day. (v) Repeated rigors. (vi) Local œdema and tenderness over the mastoid, or in the course of the internal jugular vein.[2] (vii) Tenderness on deep pressure at the posterior border of the mastoid and below the external occipital protuberance. (viii) Stiffness of the muscles of the back or side of the neck. (ix) Optic neuritis.[3]

In the great majority of cases metastatic abscesses are found in the lungs, though occasionally the toxæmia causes typhoid fever-like symptoms.

Meningitis. Several forms of this serious complication must be recognised. (*a*) Suppurative meningitis, in which pus is widely diffused over the hemisphere in the pia-arachnoid. In this condition the temperature rises to 102 or 103° and there may be a rigor: there is intense headache with delirium and more or less loss of consciousness. There is rigidity of the neck muscles and Kernig's sign will be present. Other symptoms are optic neuritis, vomiting, and there may be convulsions or paralysis of the opposite arm and leg. Later there will be coma, Cheyne Stokes breathing and a rapid irregular pulse. The prognosis in this diffuse form is absolutely unfavourable.[4]

(*b*) In rare cases, though the infection has penetrated the dura the suppuration remains localised forming a subdural abscess, *i.e.* an abscess between the dura and arachnoid, while the latter membrane and the pia mater escape infection.

(*c*) In some cases there will be a serous meningitis in which there is an

[1] *Loc. supra cit.*

[2] Œdema or tenderness over the internal jugular may [illegible] extension of the clotting and phlebitis, or to enlargement of the deep lymphatic glands. Any examination of the internal jugular should be conducted with the utmost gentleness for fear of detaching thrombi.

[3] The occurrence of optic neuritis is very valuable. It may be present in any of the intracranial complications of otitis media [illegible] the other hand is often absent.

[4] Lumbar puncture offers an excellent [illegible] diagnosis of the various forms of meningitis.

increased amount of clear fluid in the subarachnoid space. There may be symptoms suggesting suppurative meningitis, or the condition may only be found and recognised during an operation. This form of meningitis can seldom or never be diagnosed with certainty. Though general suppurative meningitis will not be benefited by operation, the latter two forms of this disease are amenable to operative treatment.

"If the clinical picture makes the diagnosis of suppurative meningitis probable, lumbar puncture should be carried out to remove any doubt that may remain. If the cerebro-spinal fluid is found to be purulent and to contain bacteria, further operative measures are useless. If the fluid is only turbid, even though bacteria are found, the cranium should be opened. If the fluid is purulent without micro-organisms or clear with micro-organisms, I now always operate. When a patient is so weak that any operation is dangerous, lumbar puncture should be done, so that the surgeon may learn whether there is anything to be hoped for from further interference or not."[1]

For further information on this subject reference may be made to an interesting paper by Mr. F. G. Wrigley on "The Cerebro-spinal Fluid as an Aid to Diagnosis in Suppurative Meningitis of Otitic Origin," with subsequent discussion.[2] Mr. Wrigley says: "The diagnosis of suppurative meningitis cannot be made with certainty although it may exist without the presence of bacteria in the cerebro-spinal fluid, and I consider that the following features are usually necessary before an absolute diagnosis can be made. The fluid is either turbid or deposits a coagulum quickly on standing. The albumen is increased 0·1 Esbach or above. Microscopic examination shows a polymorphonuclear leucocytosis, and bacteria are found either in films or cultures. If these features are present the diagnosis may be made with certainty."

Operations for the treatment of intracranial complications of Otitis Media. In former days these were usually carried out by trephining in the region of the suspected disease. It is now, however, recognised that the intracranial complication should, as a rule, be exposed and treated via the mastoid process and the antrum or tympanum. The reasons for this are as follows: (1) Suppuration in the mastoid antrum and cells is the cause of the intracranial trouble. If the latter alone is treated the septic process continues in the bone and may extend, in other directions, to the cranial cavity.

(2) Usually there will be a direct track through the bone from the antrum leading to the intracranial lesion. As will have been gathered from the remarks above the operation is often of an exploratory nature, and the information thus gathered is of the greatest service in discovering the nature and the situation of the lesion.

(3) The pus will in this way be found where it is nearest the surface and will thus be drained with the minimum amount of damage to the normal brain tissue. (4) Occasionally pus will have made its way into both fossæ. In this case there will be probably a direct track from the antrum through its roof and posterior wall. By trephining to expose one fossa, it is very likely that the suppuration in the other fossa might be overlooked.

There may, however, be cases where it may be desirable to trephine directly over the situation of the pus. For example, there may be distinct localising signs of an abscess in the brain at some little distance from the situation of the antrum, or possibly the condition of the patient may be so grave that it may be felt advisable to drain the pus at once, leaving the treatment of the antrum and the mastoid cells until the condition of the patient has improved.

[1] Heath, *Operations on the Ear*, p. 196.

[2] *Proc. Roy. Soc. Med. Otol. Sec.*, July 1912, p. 171.

The different sites for applying the trephine are shown in Fig. 155. Mr. Ballance advises that the point of the trephine should be applied, for draining a cerebral abscess, ¾ inch above the supramental spine, the object being to expose the lowest part of the middle fossa just above the tegmen antri and tegmen tympani. Immediately above the tegmina are the tissues in which, as a rule, the infective process develops. Sir W. Macewen gives the following rule for exploring a temporo-sphenoidal abscess: The centre-pin should be placed in a line with the posterior wall of the meatus, and three-quarters of an inch above the posterior root of the zygoma. Mr. Barker thinks that nine-tenths of the abscesses in the brain

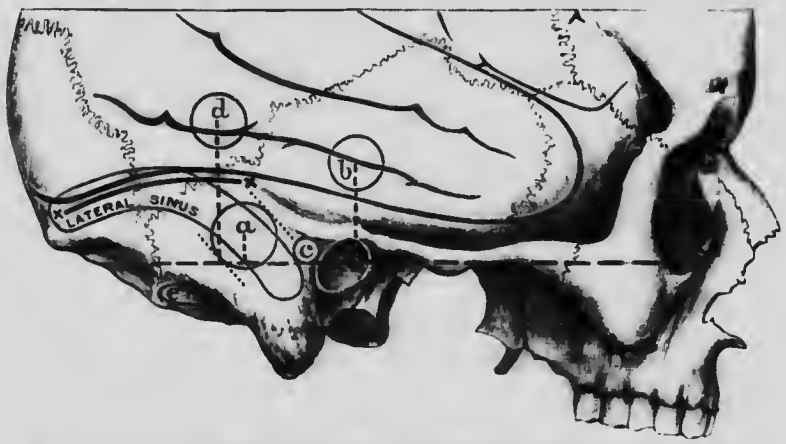


FIG. 155. The figure shows the relations of the lateral sinus to the outer wall of the skull, and the position of the trephine-opening, a, for exploring it. Reid's base-line is shown passing through the middle of the external auditory meatus and touching the lower margin of the orbit. x x indicate the site of the tentorium as far as it is in relation to the outer wall of the skull. The anterior x shows the point where the tentorium leaves the skull and is attached to the upper border of the petrous bone. a, Trephine-opening to expose lateral sinus, its centre being 1 inch behind and ¼ inch above the centre of the meatus. This opening can easily be enlarged upwards, backwards, downwards, and forwards (*see* the dotted lines), by suitable forceps. It is always well to extend it forwards so as to open up the mastoid antrum. b, Trephine opening to explore the anterior surface of the petrous bone, the roof of the tympanum and the petro-squamous fissure, its centre being situated a short inch above the centre of the meatus. At the lower margin of this trephine-opening a probe can be insinuated between the dura and the bone, and made to search the whole of the anterior surface of the petrous. c, Trephine-opening for exposing antrum, ¼ inch above and behind the centre of the meatus. d, Trephine-opening for temporo-sphenoidal abscess (Barker), 1½ inch behind and above centre of meatus. The needle should be directed at first inwards, and a little downwards and forwards. e, Trephine-opening for cerebellar abscess, 1½ inch behind and 1 inch below the meatus. The anterior border of the trephine should be just under cover of the posterior border of the mastoid process. Such an opening is well removed from the lateral sinus, and a needle, if directed forwards, inwards, and upwards, would enter an abscess occupying the anterior portion of the lateral lobe of the cerebellum, the usual site of an abscess in this part of the brain. (Barker.)

are within a circle with a ¾ inch radius, whose centre lies an inch and a quarter above and the same distance behind the centre of the bony meatus.

For a cerebellar abscess Mr. Barker advises a point an inch and a half behind the centre of the meatus and an inch below Reid's base line (a line running from the lower border of the orbit backwards through the centre of the meatus). Mr. Ballance writes:[1] "A cerebellar abscess arising from ear disease is usually in the anterior part of the lateral lobe, close to the diseased bone (inner side of the mastoid or posterior surface of the petrous) which has caused the infection. Place the trephine so that its anterior border is just behind the posterior border of the mastoid process, and so that its upper border is below Reid's base line.

[1] *Loc. supra cit.*

For exploring the lateral sinus Mr. Dean recommends that the pin of the trephine should be applied an inch and a quarter behind and a quarter of an inch above the centre of the external auditory meatus. Bone is then removed by bone forceps in an upward and downward direction so as to admit of exploration both of the temporo-sphenoidal lobe and of the cerebellum.

Treatment of extra dural Abscess. The mastoid cells and the antrum having been opened in the way described above, and the tympanum having been exposed by removal of the posterior meatal wall as has been described in the account of the complete mastoid operation, a careful inspection is made of the tegmina and the posterior antral wall. This will probably show a carious patch through which a probe may be passed into the affected fossa: pus in some quantity may be seen escaping through the opening. In the case of the middle fossa a few cuts with the gouge in an upward direction will suffice to expose more freely the abscess cavity. As soon as a sufficiently large opening has been made for their introduction a pair of gouge forceps may be employed to remove sufficient bone to secure free drainage. The dura should be exposed until its surface is devoid of granulations and is practically normal in appearance. Septic granulations and pus should be washed and sponged from the surface of the dura: the curette must not be applied to it for fear of injuring the membrane and thus opening up a fresh channel for the extension of infection.

An extra dural abscess in the posterior fossa means that the infection has extended through the posterior wall of the antrum, and thus pus and granulation tissue are present in the sigmoid groove (perisinous abscess). This condition may be present with few or no symptoms and without thrombosis of the sinus. When the antrum is opened inspection and careful investigation with the probe will reveal a track leading directly backwards to the posterior fossa. This must be opened up by removing bone in a backward direction with gouge or cutting forceps. This must be carried out most carefully on account of the risk of injury to the sinus. Should it be accidentally opened it must be treated on the lines described at p. 342. Drainage must be secured and the diseased dura exposed and treated in the same way as for an abscess in the middle fossa. In all these cases the retro-auricular wound ought not to be completely closed even when the abscess is unexpectedly found in the course of a radical mastoid operation.

Operation for Abscess in the Temporo-sphenoidal lobe. The antrum and the mastoid cells having been opened up as rapidly as possible the middle ear is exposed by removal of the posterior wall of the meatus and the external wall of the aditus. Examination of the tegmen will then probably show a carious area opening the middle fossa. Bone is next gouged away in an upward direction above the posterior root of the zygoma and the whole of the diseased portion of the tegmen is also removed. With Hoffmann's forceps or gouge forceps the dura is now widely exposed for an inch and a half above the level of the meatus and is then carefully examined. If an abscess is present the membrane will be unduly tense and will bulge forward into the wound: its surface may be dull, hyperaemic, or show an area covered by granulations, while in other cases it may appear to be normal. Typically the usual pulsation of the brain cannot be felt. A pulsation may, however, be present with a small abscess with firm walls rather deeply placed, and hence, though pulsation of the brain is noticed, if the symptoms point to the presence of an abscess a search must be made for pus.

The presence of pus should be verified and its situation determined by means of an exploring syringe fitted with a large bore needle: this is a point of considerable importance, for a small needle may easily get blocked by brain substance. Other operators use a grooved director, an expanding trocar, or an exploratory incision. The needle must not be pushed too deeply for fear of wounding and infecting the lateral ventricle, which is always in close proximity to the deep aspect of the abscess. As soon as the pus is found the abscess is opened by a thin-bladed knife introduced by the side of the needle which is then withdrawn. A free incision must be made, not a mere puncture, or the drainage will not be satisfactory. If the pus is found to one side of, or above the opening in the skull, more bone must be removed so as to allow of direct access to the abscess cavity. The pus is often remarkably offensive: the quantity may be only ℥j or ℥ij, but on the other hand there may be a large collection amounting to ℥j or ℥ij, or even more. The smaller abscesses will be the more difficult to find: the larger ones will be in dangerous proximity to the lateral ventricle.

The question of drainage is a difficult one owing to the soft consistency of the brain substance and the likelihood of portions of the soft brain tissue blocking up the lumen of drainage tubes. When a tube is removed its satisfactory replacement, for the same reason, may be a difficult matter. The tube must be of sufficient length to enter the abscess cavity, but must not press against its inner wall on account of the danger of opening and infecting the lateral ventricle. A couple of windows may be cut close to its inner extremity and it should be securely fixed in position by a stitch passing through the margins of the skin incision, or to the dura mater. Mr. West, in the discussion before the Otological Society referred to above, says: "Where the abscess is well defined, I think it will be generally admitted that tubes form a satisfactory means of drainage. I use rubber tubes of good size, up to the thickness of the little finger or a pair of tubes of smaller size stitched together with a silkworm-gut suture. If the tube is stitched to the edge of the dura mater, or to some other convenient point, and is of good size, it will not be pressed out by the brain. I have abandoned all lateral holes in tubes. They become blocked immediately, and large plugs of brain are torn away each time the tube is rotated or removed, exposing fresh surfaces to infection. The problem of drainage of areas of diffuse infection seems to me one of extreme difficulty. Tubes are ineffective and gauze, in my hands, has been very unsatisfactory. In bad cases I believe that the only method which offers any hope is the bold removal of a wide area of bone and dura mater, and then of the overlying cortex, so that a large amount of the infected brain is exposed, and free to drain on the surface. In this way, free drainage is secured, and I can testify that the result may be little short of miraculous." Sir Victor Horsley recommends concentric tubes, so that, as far as possible, there is always a tube in the wound until final granulation occurs. In any case the tube should be left in position for six days before it is removed.

The lower part of the wound is drained separately by a strip of ribbon gauze which is lightly packed into the antrum and the cavity in the mastoid. A similar strip is inserted into the meatus, and the size of the wound may then be diminished by a few sutures at its upper and lower extremities.

The after-treatment of the abscess has been indicated above. The external dressing must at first be changed daily. The gauze plugs will

require changing daily or on alternate days according to the amount of suppuration, and the cavity in the bone must be kept clean by gentle syringing with some dilute antiseptic lotion.

In a successful case the pressure symptoms, such as coma and paralysis, usually disappear at once, but death may occur some time after the operation. This may be due to infection of the lateral ventricle or to a diffuse infection of the brain, while in other cases no definite cause of death may be found at the post-mortem. An occasional complication is the appearance of a hernia cerebri. This may be cut away, or, as in the following case, be allowed to slough away.

A. J., a boy æt. 10 years, was admitted to Guy's Hospital in March 1910 with the following history: For three weeks he had suffered from headache which was occasionally very severe. There had also been vomiting and troublesome constipation. For a few days he had been very drowsy. There was a purulent discharge from the right ear, but the cause and the duration of this were not known. On admission the pulse rate was 52 and the temperature subnormal. The right pupil was dilated and fixed, there was ptosis of the right eyelid, some paresis of the left arm and leg, and double optic neuritis. There was no tenderness over the mastoid. A radical mastoid operation was quickly performed, when pus and granulations were found in the antrum and the mastoid cells, while the tegmen was carious. On removing bone in an upward direction tense, non-pulsating dura mater covered by granulations was found in the middle fossa. A large temporo-sphenoidal abscess was opened and drained. On the following day all pressure symptoms had completely disappeared. In the next few days a hernia cerebri the size of a golf ball appeared. The superficial part of this eventually sloughed away, when the rest of the hernia receded. The wound then healed, and he was discharged seven weeks after the operation. Fifteen months later he was re-admitted for a polypus in the right ear. This was removed and he made a complete recovery.

Operation for an abscess in the cerebellum. The method of trephining for an abscess in this situation has been described above. When the abscess is found in this situation drainage is likely to be unsatisfactory, since the abscess is usually close to the posterior surface of the petrous and hence will only be reached after traversing a considerable distance through normal brain tissue. A cerebellar abscess may thus usually be found and drained in the front of the vertical portion of the lateral sinus in the small area bounded by the superior petrosal sinus, the vertical part of the lateral sinus and the posterior surface of the petrous. In the case of a large abscess a counter incision below the horizontal part of the lateral sinus may also be indicated.

Exploration of the posterior fossa is indicated if the symptoms point to the presence of a cerebellar abscess, or if symptoms of an abscess in the brain are present and exploration of the temporo-sphenoidal lobe has been negative.

The mastoid cells and antrum having been opened the posterior wall of the bony cavity is examined and in the majority of cases an opening into the posterior fossa will be found so that the dura mater is here exposed. Bone is then removed in a backward direction, at first with the gouge and then with the bone-cutting forceps, due care being taken to avoid injury to the lateral sinus, which must, however, be freely exposed. The dura in this situation is then inspected and pus is sought for by one of the methods described for abscess in the temporo-sphenoidal lobe. The opening of the abscess and the mode of securing drainage will be similar to that described above. Should a counter opening be considered desirable the lateral lobe of the cerebellum may be exposed by removing bone in a backward and downward direction: should

pus not be found in the former situation a second exploration may be made here. The after-treatment will be similar to that described for a temporo-sphenoidal abscess.

Operation for septic thrombosis of the Lateral Sinus. The great danger in these cases is that the thrombosis may extend in a downward direction to the jugular bulb and to the internal jugular vein, and also that portions of the septic clot may become detached, with the result that metastatic pyæmic abscesses are formed in the lungs. The treatment of these cases must thus, in the words of Mr. Ballance, "be twofold—viz. the free exposure and removal of the focus from which the pyæmic infection has occurred or is threatening; and secondly, the establishment of a block in the highway along which the infecting agents are travelling from the local focus into the general circulation." The operation will thus be considered in two stages: (*a*) The treatment of the infected sinus; (*b*) The treatment of the internal jugular vein along which the infective process travels. When septic thrombosis can be diagnosed with certainty the latter may be carried out before the former.

(*a*) *The exposure and treatment of an infected sinus.* After the antrum and mastoid cells have been opened, the posterior fossa is thoroughly exposed in the manner described for the opening of a cerebellar abscess. Sufficient bone must be removed to secure a good view of the sinus. If necessary, the sinus can be laid bare, with the help of gouge forceps from the torcula herophili to the jugular bulb, but this will not be necessary at this stage of the operation. The appearance of the sinus will vary: it may be hard and bulging, or its outer wall may be covered by granulations or may be grey or green in colour. Sometimes a perforation will be seen through which pus is oozing. In doubtful cases a sterilised needle may be inserted obliquely through the outer wall, or even an exploratory incision made into the interior of the sinus. It must, however be remembered that such interference with a normal sinus may result in septic infection occurring, as the puncture is necessarily made through septic tissues. If possible the sinus should be exposed in a backward direction until it appears to be healthy. The sinus is then incised here and the bleeding arrested by packing sterilised ribbon gauze into the cavity. The whole of the exposed and thrombosed portion of the sinus is now slit by a small thin-bladed knife and the septic clot removed by a small man's spoon, which is also used to scrape the clot from the lower part of the sinus as near the jugular bulb as is possible. If bleeding then occurs from the lower end of the vessel, it should be plugged with gauze.

In some cases the sinus may be found to be thrombosed, but the clot is not infected. This condition may be found unexpectedly in the course of a radical mastoid operation when there is a perisinous abscess. Needless to say, in these cases, the lateral sinus should not be interfered with. The aseptic nature of the thrombus may be inferred from the absence or slightness of the symptoms.

(*b*) *Treatment of the internal jugular vein.* This is still, to a considerable extent, under discussion. In those cases where the clot in the sinus is localised and where its lower extent is reached, ligature or other treatment of the internal jugular is not indicated. Too often, however, it is found that the thrombus extends downwards to the jugular bulb and vein. Hence the whole of the septic clot cannot be removed from above and some treatment of the internal jugular is then indicated. The vein

may be exposed low down in the neck and then be divided between two ligatures, or the vein may, after ligature, be freed up to the base of the skull and then excised. If the vein is merely ligatured a considerable amount of infected clot will be left, from which the septic process may easily extend along the tributaries of the internal jugular above the ligature, and so still lead to pyæmia or septicæmia. Removal of the infected portion of the vein, though a more severe operation, is the ideal procedure, for, since it has been shown that the lateral sinus can be opened up as far as the torcula herophili, it permits of removal or opening up of the whole infected venous trunk with the exception of the bulb which is in relation with such important structures that its exposure is practically impossible. It must be understood that in any case infection may spread via the petrosal sinuses or some emissary veins and so render pyæmia possible in spite of all treatment of the internal jugular vein.[1] To expose the internal jugular vein an incision three inches in length is made along the anterior border of the sterno-mastoid which is made tense by turning the patient's head well over to the sound side: the centre of the incision is opposite the cricoid cartilage. The platysma and the deep fascia having been divided the sterno-mastoid is well retracted, thus bringing the carotid sheath into view. The position of the carotid artery may be recognised by feeling for its pulsation: the internal jugular vein is external to this and at rather a deeper level. It is exposed by incising the carotid sheath. The vessel may appear empty and collapsed and its wall thickened, or a definite thrombus may be felt. In the latter case it must be followed lower in the neck until the lower limit of the thrombus is reached. An aneurysm needle is then passed and the vessel is divided between two ligatures. It is next traced upwards until the common facial is reached, the latter vessel being also ligatured as far as possible from the jugular, which is again tied above the common facial and the portion between the upper and lower ligatures completely removed. If a more extensive removal is considered desirable and the condition of the patient permits, the vein may be dissected away as high up as possible and then ligatured just below the jugular foramen. Any tributaries that may be met with are, of course, ligatured and divided as far as possible from the jugular. It has been suggested that the septic clot in the bulb may be syringed away by means of a small syringe inserted into the upper end of the divided vein, the fluid escaping through the opened lateral sinus exposed in the retro-auricular wound. If the upper end of the vein is drawn forwards and fixed by a stitch in the upper end of the wound in the neck, this process may be repeated at the first few dressings.

The wound in the lateral sinus is then packed with sterilised ribbon gauze and a second strip of the same material loosely inserted into the bony cavity. If the skin wound is very extensive a few silkworm-gut sutures may be used to reduce its size, but free drainage is essential. The wound

[1] Prof. Heine (*loc. supra cit.*, p. 116), says: "Many writers under-estimate the importance of the collateral circulation and of the back-flow. Some even state that it is impossible for metastatic deposits to be carried in a direction opposite to the normal course of the blood-stream. It is well known that fever and rigors often persist after ligature of the jugular vein, but these are mostly put down to metastases which were formed before the operation. The autopsy, however, provides a different explanation in many cases. The direct path to the heart is found to be closed, but it is obvious that infective material has entered the circulation from the emissary veins, from the other sinuses, or even from the distal end of the decomposing thrombus, which has been found extending as far as the lateral sinus of the opposite side."

in the neck may be partly closed, but here also, as infection must necessarily have occurred, drainage is essential. Both wounds will require dressing with removal of the gauze plugs at the end of forty-eight hours, by which time there will probably be no further bleeding from the sinus.[1] After gentle syringing with saline solution, or with lot. hydrogen peroxide (3 per cent.), the drains must be replaced. The dressings will then require to be changed daily at first, and later, when the discharge has diminished, every second day.

It must always be remembered that thrombosis of the lateral sinus may occur in addition to some other intracranial lesion, especially cerebellar abscess, or even suppuration in the middle fossa. Any indications of these troubles should, therefore, always be carefully looked for. Should such be present the thrombosis should be treated first and the abscess subsequently opened and drained with freshly sterilised instruments.

Operation for Suppurative Meningitis. If diffuse suppurative meningitis can be diagnosed with certainty, operation will not be successful and hence is not indicated. This condition may, however, be closely simulated by other lesions, especially cerebellar abscess, serous meningitis, and localised suppurative meningitis (subdural abscess). In doubtful cases an exploratory operation will be undertaken and hence suppurative meningitis may be unexpectedly met with.

Prof. Heine[2] says: "The operation for suppurative meningitis consists in eliminating the focus of disease in the bone and exposing the dura as far as it is affected. If necessary, the membranes may be incised to allow of the escape of fluid, as is done in the serous forms of meningitis. Following Wätzel's suggestion, Hinsberg recommends the insertion of large strips of absorbent gauze in the neighbourhood of the focus of suppuration in order to drain the subarachnoid space. As I have already stated, I doubt if effective drainage of this space is possible. Finally, lumbar puncture may be performed for the removal of some of the purulent cerebro-spinal fluid."

For further information as to the diagnosis and treatment of these very grave and difficult cases reference may be made to a discussion on the "Treatment of Meningitis of Otitic Origin," opened by Dr. W. Milligan before the Otological Section of the Royal Society of Medicine.[3] Dr. Milligan in his opening remarks said: "Some form of decompressive operation is called for, the essential feature of which is to provide by a sufficiently free removal of bone a window large enough to efficiently relieve existing pressure, and at the same time to provide a means of freely draining the infected meninges. . . . Some operators content themselves with the making of such a window and with the relief of pressure thus obtained. No doubt in certain cases of incipient meningitis this is sufficient, but in purulent meningitis it merely delays the fatal issue. To drain the pia-arachnoid cavity the dura may be dealt with in several ways: (1) By excising narrow strips in parallel rows: (2) by raising as large a flap as the bone wound permits of, and (3) by removing entirely the dura corresponding to the bone wound. To Charles Ballance we owe the suggestion of attacking meningitis by the occipital route. In 1891 he performed the now classical operation of draining the posterior subarachnoid space after trephining the occipital bone on both sides of the mid-line close to the foramen magnum. In 1893 Alfred Parkin proposed drainage of the cisterna magna, while in the same year Ord and Waterhouse drained the posterior fossa after removal of a portion of the occipital bone and incision of the underlying membranes. Whether decompression be performed over the temporo-sphenoidal or cerebellar area, great difficulty is encountered in dealing with the brain substance. The moment the dura has been incised the cortex is thrust into the wound and not only prevents the escape of infected cerebro-spinal fluid, but tends to lacerate its substance against the edges of the bone. To obviate this tendency, Haynes, of

[1] Should bleeding occur it may readily be checked by packing a fresh strip of gauze into the opening of the sinus.

[2] *Loc. supra cit.*, p. 194.

[3] *Proc. Roy. Soc. Med., Otol. Sec.*, February 1913, p. 41.

New York, has suggested drainage of the cisterna magna through the cerebello-medullary angle as there is here no brain tissue in the immediate neighbourhood, and also because infected fluid is prone to collect here. An incision is made in the mid-line from the occipital protuberance to the spine of the axis, the soft parts retracted, and a disc of bone removed by a trephine about one inch above the margin of the foramen magnum. The dura is then separated from the bone and two grooves made through the bone into the foramen magnum. When this triangular piece of bone has been removed, the dura presents under pressure. A small incision is then made through the dura and the arachnoid with the immediate escape of cerebro-spinal fluid. The incision is enlarged and an inspection made of the posterior poles of the cerebellum, the notch between them and the posterior surface of the medulla. A drain is then inserted into the cisterna magna and suitable dressings applied." This operation has been performed a number of times, but does not appear to have been attended with much success. Dr. Milligan and other speakers point out the necessity of early diagnosis if operation is to have any chance of success, and give many valuable hints with regard to this point.

CHAPTER XVII

OPERATIONS ON THE FACE. OPERATIONS ON THE FIFTH NERVE. OPERATIVE TREATMENT OF LUPUS, RODENT ULCER AND NÆVI. REMOVAL OF PAROTID GROWTHS

OPERATIONS ON THE FIFTH NERVE

Preliminary remarks. As the surgeon will not be called in until all other treatment has failed, and as the patient will be desirous of relief as radical as may be, neurectomy alone will be described here. Operations with this end fall into Peripheral and Central groups. Of the former or extracranial operations, some, the truly peripheral, are slight; others performed near the base of the skull, are severe, not without risk, and leave considerable scars, which may greatly interfere with the use of the mandible. The central intracranial, or removal of the Gasserian ganglion, is a severe and difficult operation, with many risks and a mortality that is not a small one, but it is the only one which can be relied upon to give, with very few exceptions, a complete cure. It is greatly to be desired that both the peripheral and central operations be performed at an earlier date than has hitherto been done. In the case of the former the earlier the operation the greater the probability that the neuralgia is limited to one trunk, and the longer will be the interval of relief. In the case of the intracranial operations, the still high mortality is largely due to the depressed vitality of the patients from the long continued inability to take food, the exhausting effects of the pain, the inability to sleep, and, perhaps, the morphia habit. We will suppose that all local causes connected with the teeth, nose, eye, ear, and cranial sinuses have been excluded, together with those such as growths or foreign bodies in the course of the nerves, and that medical treatment[1] has been fully tried where syphilis, alcohol, influenza, rheumatism, anæmia, &c., are possible causes.[2]

The first question which will now arise is the value of peripheral operations, to what extent are they justifiable in severe trigeminal neuralgia? To begin with, the answer must be that all mere neurotomies and nerve stretchings are absolutely futile. Radical lasting cures by peripheral neurectomies are practically unknown.[3] All that can be promised is that, if performed with as thorough extraction as possible

[1] Injection of alcohol, a most successful form of treatment, should also be tried. For information on this method of treatment see two papers by Dr. Wilfred Harris (*Brit. Med. Journ.*, 1910, vol. i, p. 1404; and vol. ii, p. 1051).

[2] The pathology of tic douloureux is fully discussed by Mr. J. Hutchinson, jun. (*The Surgical Treatment of Facial Neuralgia*, p. 26), and Murphy and Neff (*Journ. Amer. Med. Assoc.*, October 11 and 18, 1902).

[3] Prof. Billroth, who had performed peripheral operations thirty times, stated that he never met with permanent cure.

of the peripheral branches[1] they will give relief for varying periods. Hitherto the majority of authorities have held that peripheral operations should be performed first, intracranial neurectomy being taken as the last step.

Thus Prof. Keen considers that this is the right step to take, and on these grounds: (1) the balance of evidence points to the ganglion itself being the last of all to suffer, the disease being in many cases at least primarily peripheral, and the ganglion involved by extension upwards. This view of an ascending neuritis has the support of Sir V. Horsley, who holds that the inflammation often begins in the small dental nerves and spreads upwards to the ganglion.[2] (2) While the mortality of peripheral operations, which usually relieve for some time, is very slight, that following on operations on the ganglion is high (p. 379).

Mr. J. Hutchinson, jun., whose successful experience enables him to speak as an authority, tabulates the following rules for the use of peripheral operations in epileptiform neuralgia.[3] With regard to the first division of the fifth, a case may now and then arise in which resection of the nerve is justified. "If the neuralgia be limited to the infra-orbital branches, resection of the nerve by following back the canal in the orbital floor may be tried. If the neuralgia concern also the palatine branches, intracranial resection of the superior maxillary trunk should be carried out. If the inferior dental nerve be alone affected, it should be resected through a trephine aperture in the outer table of the lower jaw. When the neuralgia concerns several branches of the inferior maxillary division (*e.g.* the inferior dental and the auriculo-temporal), intracranial resection of the trunk and adjacent part of the Gasserian ganglion is indicated.

"For all other cases, those in which the neuralgia has already invaded two of the main divisions of the fifth nerve, the major operation on the ganglion should be carried out as affording the only hope of permanent cure.

"If these rules be followed the subject is rendered simple, a host of elaborate operations may be discarded, and the disappointing results which have followed them in the past may be avoided."

Neurectomy of the First Division of the Fifth Nerve. The eyebrow having been shaved, and the parts sterilised, the incision should be horizontal and lie below the margin of the eyebrow, thus leaving little

[1] Prof. Krause (Von Bergmann's "Syst. Prac. Surg.," *Amer. Trans.*, vol. i, p. 565) insists that in order to prevent regeneration of the excited nerve it should be extracted as extensively as possible, both centrally and peripherally, by Thiersch's method. This consists in dissecting the nerve freely from its surroundings, grasping it transversely in forceps which will not cut it through, then rotating these very slowly until the nerve trunk comes away. Where the nerve runs in soft parts or is not adherent in a bony canal a very long piece of the central portion can be removed. Occasionally paralysis, especially of the muscles of the upper lip and ala nasi, follow the operation owing to the endings of the anastomosing filaments of the facial nerve being also removed. These paralyses generally disappear in a short time. In all peripheral nerve operations the neuralgic pains do not always disappear immediately. They frequently come on as before during the first days after the operation, but they soon diminish and finally disappear. The attention of the patient should be drawn to this fact before the operation. On the value of this step the experience of Mr. J. Hutchinson, jun., *The Surgical Treatment of Trigeminal Neuralgia*, p. 43, is contradictory. "Unfortunately the results obtained by avulsion with Thiersch's forceps are little if at all superior to a well-planned neurectomy."

[2] Mr. J. Hutchinson, jun., from the negative results found in many cases of the excised Gasserian ganglion and peripheral nerves after removal dissents from this view. He considers that "the pathology of epileptiform neuralgia is still unknown."

[3] *Loc supra cit.*, p. 74.

sear. The supra-orbital notch[1] being made out by firm pressure when the patient is under an anæsthetic, the eyebrow is drawn up and the eyelid down, and an incision an inch and a half long is made along the supra-orbital margin, with its centre opposite to the notch. The skin, occipito-frontalis, orbicularis, and palpebral ligament being divided, the cellular tissue is separated, the nerve found in the notch set free—if a complete foramen be present, part of the ring of bone must be removed with a small chisel—traced back as far as possible so as to include the supra-trochlear, if that be feasible, drawn up with a strabismus hook, and a full inch removed. Thiersch's method, if employed here, might involve some risk to the cornea.

A small spatula will best depress the orbital fat. It is difficult to avoid injury to the closely contiguous supra-orbital vessels, which may cause a little trouble. As with the other branches of the fifth, the supra-orbital often appears smaller than it does in the dissecting room, and the arrangement of its branches is not constant. The wound should be closed by a few horsehair sutures.

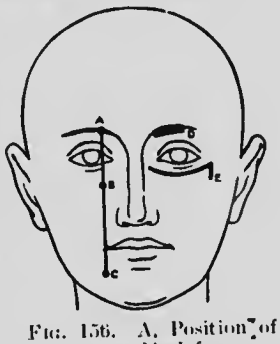


Fig. 156. A, Position of the supra-orbital foramen. A line drawn downward from this, passing through the interval between the two bicuspid teeth, passes through B, the infra-orbital foramen, and C, the mental foramen. D, Incision for exposing the supra-orbital nerve. E, Incision for Carnochan's operation.

Supra-trochlear Nerve. In an inveterate case of neuralgia of the first division of the fifth nerve, if the surgeon does not feel sure that he has in the preceding operation got behind the point of origin of the supra-trochlear, this nerve must be cut down upon. Sir W. MacCormac[2] gives the following advice: "The position of the supra-trochlear nerve is indicated by an imaginary line drawn from the outer angle of the mouth through the inner canthus of the eye to the orbital margin; at this point the nerve will be found as a single branch, or as two or three slender filaments, escaping from the orbit above the pulley of the superior oblique. . . . To reach the nerve, make a convex incision at the superior internal angle of the orbit, immediately below the eyebrow, and search for the pulley of the superior oblique, above which the nerve runs."

Neurectomy of the Second Division of the Fifth Nerve. While this nerve, being most frequently the seat of neuralgia, has been most often subjected to peripheral neurectomy, there is no agreement as to the best route. The following have been proposed. Each has its advocates, and each its disadvantages.

A. *Infra-orbital Route.* An attempt is here made to follow the nerve along the infra-orbital groove as far back as the sphenomaxillary fossa. The disadvantages are great. The field of operation is very cramped, the oozing troublesome, and the operator is liable to divide the soft and comparatively slender nerve prematurely and to remove part only with the anterior dental branch, and hæmorrhage into the orbit and exomphalos have followed this operation.

[1] The supra-orbital notch or foramen occupies about the junction of the inner with the middle third of the supra-orbital margin. From this point a perpendicular line, drawn with a slight inclination outwards, so as to cross the interval between the two bicuspid teeth in both jaws, passes over the infra-orbital and the mental foramina. The direction of these two lower foramina look towards the angle of the nose. (Fig. 156.)

[2] *Operations*, part 2, p. 467.

B. *Antral Route.* Either the modified Carnochan's operation or that which bears Prof. Kocher's name. The first is described below, and the second at p. 368.

C. *Pterygomaxillary Route.* Krause's operation. The nerve is here reached in the sphenomaxillary fossa, not from the front, but at the side by turning down the zygoma and masseter. Prof. Krause, finding that the flap made by previous surgeons, Luke, Loosen, and Braun, injured the branches to the orbicularis and thus led to damage to the cornea, modified the operation so as to protect the branches of the facial running over the malar bone. The advantages of this route are that it enables the surgeon to get at the nerve before this has given off its posterior dental and palatine branches, and to resect the third division as well, if this be affected. The disadvantages are that, even if the wound heals by primary union, the troubles of the patient and surgeon are not over; they are best shown by Prof. Krause's own words:[1] "As soon as cicatricial contraction sets in, the mobility of the lower jaw is impeded in many cases. This may reach a very high degree, and will require careful treatment with Heister's mouth-gag." As the second division of the fifth nerve is often affected alone, and as it is to be hoped that in future patients will apply for surgical treatment earlier, before the palatine and posterior dental nerves are involved, two operations are described here, viz. the modified Carnochan's antral operation and that of Prof. Kocher. Where the patient comes late and the second division is involved far back, or where the third division is involved as well, the surgeon must decide between adopting the pterygomaxillary route, and resecting the two divisions by an intracranial operation, as strongly advised by Mr. J. Hutchinson, jun., on the grounds that this step is no more difficult, while it is certainly more radical.

Modified Carnochan's Operation. This has the advantage, if successfully performed, of removing the whole of the second division of the fifth, together with the spheno-palatine ganglion as far back as the foramen rotundum, the nerve forming the guide to the surgeon from the surface backwards. Carnochan[2] looked upon the removal of Meckel's ganglion as the key of the operation. Whilst his view was that this body could be likened to a galvanic battery, keeping up a continuous supply of "morbid nervous sensibility," there is no doubt that removal of the nerve beyond the ganglion is absolutely necessary, as by this step the spheno-palatine branches to the gums and the posterior dental branch are also removed.[3]

Carnochan's antral operation is, for the reasons already given when the infra-orbital route was spoken of, an extremely difficult one. Owing to these difficulties it is very often rendered incomplete, and the neuralgia tends to return after an interval varying from a few months to a year or two. Mr. J. Hutchinson, jun., who speaks with authority, considers that this operation should be abandoned.[4] He holds that if any extra-

[1] Von Bergmann's "Syst. Pract. Surg.," *Amer. Trans.*, vol. i, p. 583.

[2] *Amer. Journ. Med. Sci.*, 1858, p. 136.

[3] Chavasse, *Med.-Chir. Trans.*, vol. lxvi, p. 151; and Clutton, *St. Thomas's Hospital Reports*, vol. xv, p. 213.

In both of Mr Chavasse's cases the commencement of the pain was invariably referred to the periphery of the posterior dental branches, and it appeared very doubtful if stretching would have any effect on slender branches at some distance from the extension point. Both of these cases remained practically well two years and a year and a half respectively after the operation. Recurrence, "slight and relieved by quinine," ensued in both of Mr. Clutton's cases within the year.

[4] *Loc. supra cit.*, pp. 58 and 66.

cranial operation on the superior maxillary nerve be performed, the best one is that of Storrs, described by Dr. Cooke.[1] It is stated that Dr. Storrs operated on some ten or twelve patients, and that of these at least two remained free from neuralgia for over ten years, an unusually favourable result for any form of peripheral operation.

As the antrum will be opened, the mouth and accessory cavities must possess at least the normal germicidal power of health. The parts having been shaved and cleansed, and an anæsthetic given, a horizontal incision is made reaching from canthus to canthus just below the orbit, and a vertical one running downwards added if needful (Fig. 156). The flaps thus marked out being reflected, and all hæmorrhage stopped, the infra-orbital nerve is defined, its terminal branches dissected out as long as possible, and a piece of silk tied round it to make it serve as a guide. The periosteum is next incised horizontally down to the bone, and elevated with a blunt instrument from the floor of the orbit until the sphenomaxillary fissure is well exposed. The eyeball must be raised with a retractor under the periosteum. A bluish spot usually denotes the site of the nerve, thinly covered by bone, or the canal is found by a fine probe passed in through the foramen.

With a fine chisel the anterior wall of the antrum, including the foramen, is cut away for a space of half an inch square, and with the same instrument, aided by small and medium-sized bradawls, the roof of the antrum and its posterior wall—the latter for the same area as its anterior wall—are removed, so as to expose the sphenomaxillary fossa. Free and most troublesome hæmorrhage must be expected, partly from the vascular bone,[2] partly from the mucous membrane of the antrum, and in the fossa itself, where the bleeding is always copious from the terminal branches of the internal maxillary. Pressure with small gauze pledgets, wrung out of very hot sterile saline or adrenalin solution in holders, must be relied upon.

A good light is essential, and an electric lamp on the surgeon's forehead will be his best aid.

The rest of the operation will be given from the article above quoted from the *Annals of Surgery*: "By making slight traction on the ligature on the nerve, we can bring it into view, and by following it on can readily crush down the thin wall of the canal, removing the bone fragments with suitable forceps. When the nerve enters the sphenomaxillary fissure it passes out of the bony canal and is only surrounded by soft structures, which can easily be hooked or wiped away. Should the sphenomaxillary fissure be narrow and not readily admit the introduction of instruments, it can easily be widened by inserting a suitable blunt instrument, and by wedging or widening the walls. It is to be remembered that the upper wall of this fissure is the strong wing of the sphenoid, and that the lower angle is the thin wall of the antrum. If either bone should break, it would be the wall of the antrum, which would be crushed down and out of the way, and would cause no trouble. Having the nerve thus free to the foramen rotundum, next slip the ends of the silk through a loop of wire held with a small nasal snare. The loop of wire is passed down the nerve to the foramen rotundum. It is then closed, and the nerve is cut and removed." To return now to the distal end of the nerve.

[1] *Ann. of Surg.*, 1903, p. 854.

[2] The superficial hæmorrhage will be all the freer in proportion as the part has been recently submitted to blistering, liniments, &c.

The plexus of nerves going to the cheek, nose and lip is gathered up with a hook, and the distal end drawn out of the foramen. Storrs then put the nerve into the loop of a threaded needle and carried it down into the mouth, leaving the end which had been in the infra-orbital canal between the alveolus and upper lip; this end he cut off, even with the mucous membrane. This was to prevent any restoration between the distal end of the nerve and the stump left at the formamen rotundum. Arrest of bleeding, drainage, and, if needful, packing the wound and suturing, complete the operation.

Prof. Kocher's Antral Operation. This surgeon, by dividing the malar bone in front and behind, and turning it upwards and outwards, gains much freer access to the foramen rotundum.[1] The skin incision is planned so as to avoid division of the branches of the facial nerve. It begins just internal to the infra-orbital foramen and below the inner edge of the orbital margin, and is carried outwards and slightly downwards over the lower part of the malar bone to the zygoma. The angular artery is drawn aside or tied at the inner end of the incision; Steno's duct lies below it. At its inner end the incision passes down to the bone between the lowest fibres of the orbicularis and above the origin of the levator labii. The former muscle, along with the periosteum, is dissected up as far as the orbit; the latter is separated downwards sub-periosteally, so that the nerve may be exposed at the foramen and secured.

The outer part of the incision passes above the origin of the zygomatici, which are separated downwards, and the anterior fibres of the masseter are detached from the lower and inner aspect of the malar bone. The outer and inner surfaces of the malar bone are next laid bare with a periosteal elevator, and the three sutures—malo-maxillary, fronto-malar, and zygomatico-malar—are exposed previous to their being chiselled through. The malar process of the upper jaw must be exposed on its anterior surface up to the infra-orbital foramen, and upon its upper surface as far back as the sphenomaxillary fissure. Anteriorly, the process is chiselled through from above the infra-orbital nerve downwards and outwards to just below the anterior fibres of the masseter, and superiorly along the orbital plate. In this way the outer part of the orbital plate and the superior external wall of the antrum, together with its posterior angle, remains in connection with the malar bone, and are levered out with it. Before this can be done the fronto-malar suture, exposed by upward retraction of the upper edge of the wound, is so chiselled through towards the back of the sphenomaxillary fissure, that its upper border, together with part of the zygomatic crest and of the orbital plate of the sphenoid, is removed along with it.

The malar bone is dislocated upwards and outwards with a strong hook, and the orbital fat carefully raised with a blunt retractor. The nerve, which is kept drawn upon, can now be readily followed above the opened-up antral cavity as far as the foramen rotundum. A small hook is now passed behind the descending sphenopalatine nerves around the main trunk, which is either cut across, or, better, removed by Thiersch's method. The infra-orbital artery is avoided or tied. The operation is completed by replacing the malar bone (fixation sutures being unnecessary) and closing the wound with sutures. No bad results have followed the free opening of the antrum. The resulting scar is not disfiguring.

[1] *Kocher's Operative Surgery*, translated by Stiles and Paul, p. 221.

Operations on the Third Division of the Fifth Nerve. Immediately below the foramen ovale this division of the fifth nerve consists of a large sensory portion and a smaller motor portion which supplies the muscles of mastication. These two parts are intimately bound together so that division of the trunk in this situation will be followed by paralysis of these muscles. Neurectomy of the individual branches is thus to be preferred to division of the main trunk. Neurectomy, first of the inferior dental, a nerve so commonly the seat of neuralgia, and then of the lingual gustatory, which is much less frequently affected, will be described here.

Inferior Dental: Neurectomy. This nerve may be attacked in three places; at the mental foramen, in the dental canal, and above the dental canal. Experience has shown that the relief after the first two methods is so transitory that the higher operation should always be resorted to. Neurectomy here usually gives relief for one, two, or more years. The face having been shaved and cleansed, the external auditory meatus cleansed and plugged with aseptic gauze, the patient is anæsthetised. The surgeon then identifies the point of bone to be aimed at on the ascending ramus by taking the point of meeting of the two following lines—one perpendicular to the lower border of the jaw passing upwards from the angle, and the other a continuation backwards of the alveolar margin (Jonathan Hutchinson). This point on the cheek is well below the parotid duct and behind the facial vein. The skin incision here should be about an inch and a half long, mainly horizontal, to avoid the facial nerve, but curved slightly upwards. Kocher's incision is a curved one, with the angle of the jaw for its centre.

The subjacent periosteum and masseter are separated from the bone, and the pin of a three-quarter inch trephine is then applied exactly over the spot above mentioned, and when the outer table has been cut through the crown is removed by an elevator.[1]

The inferior dental nerve and vessels will almost certainly be exposed in their groove. This is carefully enlarged by a small gouge or chisel, until the nerve, now freely exposed, can be raised on a blunt hook. It is then treated by Thiersch's method (neurexeresis), or as long a piece as possible resected. Care must be taken to avoid injury to the vessels which lie just behind the nerve. Another method[2] is to expose the bone more freely by a larger flap, and to turn this upwards. The sigmoid notch and adjacent parts of the condyle and coronoid process are next laid bare. Care must be taken not to injure any of the branches of the facial nerve or lobules of the parotid gland during these steps. When the bone is reached, smart oozing must be expected from the mesenteric artery, and arrested by firmly applied sponge pressure. The next step consists in enlarging the sigmoid notch as far as the upper orifice of the dental canal. This is done by applying a three-quarter inch trephine exactly on the spot mentioned above, the narrow bridge of bone between it and the sigmoid notch being subsequently clipped away with gouge forceps. Great care must be taken, owing to the varying thickness of the bone, in the use of the trephine; otherwise the inferior dental artery will be wounded or the bone fractured. De Villbiss's forceps are likely to be useful for this purpose. The bone having been removed

[1] If preferred the bone may be removed by means of a gouge or chisel.

[2] Sir V. Horsley, *Brit. Med. Journ.*, 1891, vol. ii, p. 119; Sir W. Rose, *ibid.*, 1892, vol. i, p. 160.

sufficiently, the inferior dental artery, and the internal maxillary, if this be in the way, should be secured between two ligatures. The inferior dental nerve is next identified and secured by a silk ligature. The external pterygoid having been levered upwards, or divided if needful, the nerve is traced close up to the foramen ovale, and divided as high up and as low down as possible, or dealt with by the method of Thiersch. If needful the lingual nerve, which lies somewhat anteriorly and on a deeper plane, is then treated in a similar way. Any venous bleeding which cannot be dealt with by ligature should be controlled by firm pressure with small aseptic swabs. There is no need to replace any bone. The wound, carefully kept aseptic throughout, is now thoroughly dried, a small drainage tube inserted if there be still much oozing, or if the parts have been much disturbed, and the incision accurately sutured. If primary union occurs there is no interference with the movements of the mandible.

Lingual Nerve. Neurectomy within the mouth. In a few cases of epithelioma of the mouth, not admitting of removal, this operation may be performed in the hope of relieving the pain, and diminishing the rapidity of the growth, the profuseness of the dribbling saliva, &c. In another small group of cases, neuralgia of the tongue, resisting other treatment, this operation may be resorted to with complete success.

The best method is that of Roser, of Marburg, who introduced it in 1855. The mouth having been widely opened in a good light, and the tongue drawn over to the opposite side, an incision is made in the fold of mucous membrane between the side of the tongue and the gum, the centre of the incision being opposite to the last molar tooth. The overlying mucous membrane is here so thin that the nerve can usually be seen below it. The nerve having been exposed where it lies, beneath mucous membrane only, just before it dips beneath the mylohyoid, is raised with an aneurysm needle, and a full inch removed. The only after-treatment is the frequent use of a mouth wash. Mr. Jacobson performed this operation on two occasions. In one the patient remained absolutely free from her neuralgia for twelve months, after which there was some recurrence owing to her entire neglect to avail herself of the fresh air and rest which were so necessary in the after-treatment. The second patient remained free from the neuralgia for the six months she was kept under observation.

Neurectomy of the Second and Third Divisions of the Fifth Nerve in Front of the Ganglion inside the Skull. Peripheral operations on the second division of the fifth nerve in cases where the palatine and posterior dental branches are not yet involved, and one on the inferior dental and the lingual gustatory in cases where these branches are alone affected, and the mischief has not spread to other branches, *e.g.* the auriculo-temporal, have now been given. It remains to consider the operative treatment of cases in which the second or third division of the fifth is more deeply affected, cases in which peripheral operations have failed, and lastly those in which the neuralgia has already invaded two of the main divisions of the fifth nerve. Reference to p. 364 will show that Mr. J. Hutchinson, jun., is emphatic in his opinion that in these cases the operation should be intracranial, as this method alone gives radical relief. We have seen, however, that the extracranial routes which attack the nerves at their exit from the skull may be followed by serious fixity of the jaw (p. 366).

The following is an instance in which Mr. Hutchinson put his opinion

to the test by resecting the second division of the fifth intracranially.[1] The case was one of typical epileptiform neuralgia confined to the distribution of the second division, occurring in a robust patient of 60.

The cranial wall having been removed as described at p. 373, the dura mater and brain were then carefully pushed upwards and inwards, the foramen rotundum being aimed at as a landmark. Much difficulty was experienced in doing this owing to the thinness of the dura mater, and some cerebro-spinal fluid escaped. The trunk of the second division and the ganglion were thoroughly exposed and the whole intracranial part of the nerve was removed, the nerve being divided close to the Gasserian ganglion and again at the foramen rotundum. A small drain was used, but no bone replaced. Primary healing followed, and for eighteen months the patient had not had the least return of his trouble.

Mr. Hutchinson considers this operation in every way superior to that of Carnochan, and where, as in this case, the second division is alone affected, removal of the Gasserian ganglion is unnecessary. He expresses himself as confident that no recurrence is likely to take place.

Operation on the Gasserian Ganglion. *Indications.* For these see Mr. Hutchinson's rules quoted on p. 361. This structure has been reached by two routes. (i) **The Extracranial.** This method was brought into prominence by Sir W. Rose, whose name it bears. By it the ganglion and the nerve trunks are reached by trephining at the base of the skull from without. (ii) **The Intracranial.** Here the ganglion and nerve trunks are got at within the middle fossa, through the side of the skull. This is the Hartley-Krause method. Of the above the first has been abandoned owing to the difficulties, the possible bad results, which are given below, and the uncertainties of its results. It will therefore not be described here. While, as will be fully shown, the intracranial method is not without its own serious difficulties and dangers, it gives far better access, and its results are incomparably better.

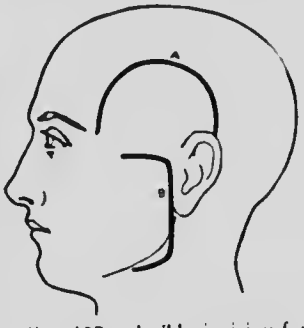


FIG. 157. A. The incision for the Hartley-Krause operation. B. The incision for Rose's pterygoid operation.

Those who desire full details of the extracranial route will find them given by Sir W. Rose.[2] Sir W. Rose himself gave up this method and advocated extensive resection of, first, the superior maxillary, and secondly (after an interval of a few weeks), of the inferior maxillary, division.

The following are the chief difficulties and dangers of the extracranial route:

(1) The very limited field in which the surgeon has to work in this, one of the most difficult operations in surgery.

(2) Hæmorrhage. This, from the presence of the pterygoid plexus, is certain to be troublesome and may be baffling.

(3) Injury to the Eustachian tube. In one case there was free hæmorrhage from the nose and mouth during the operation. The necropsy, five days later, showed that injury to the Eustachian tube had led to infection of the wound and meningitis.

(4) The division of bone required, viz. zygoma and coronoid process, has been followed by necrosis.

[1] *Surg. Treat. of Facial Neuralgia*, p. 70. [2] *Brit. Med. Journ.*, 1892, vol. i, p. 261.

(5) The fixity of the jaw and a disfiguring scar; these, especially in women, are common sequelæ.

Operations on the Gasserian Ganglion by the Intracranial route. *The Hartley-Krause Operation.* The following description is based upon Prof. Krause's article,[1] Mr. J. Hutchinson, jun.,[2] and the account given by Dr. Hartley.[3] As the operation, affording as it does the only complete cure of inveterate neuralgia of the epileptiform type, is likely to be increasingly performed, and as it is liable to be one of the most difficult in surgery, a detailed account will be given.

Preparatory Treatment. As shock from a prolonged operation and hæmorrhage are the chief causes of death, accounting in the published cases

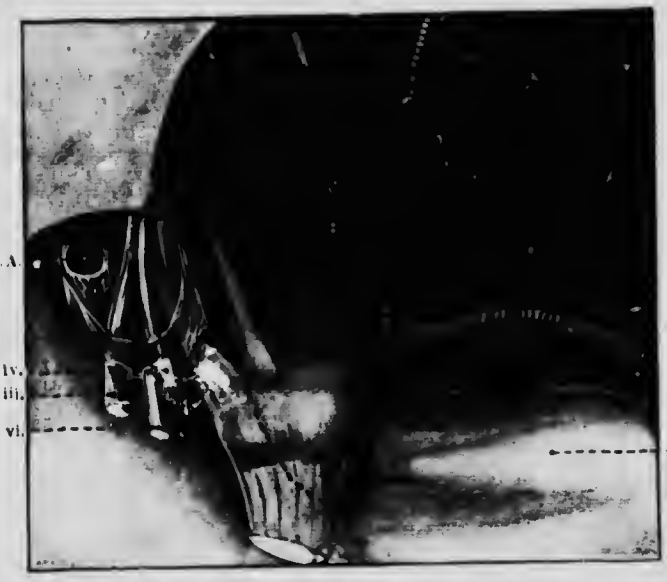


FIG. 158. The cavernous sinus and Gasserian ganglion seen from above. P.B., The petrous bone. C.A., Carotid artery. iii. iv. and vi. The oculomotor nerves, showing their relation to the ophthalmic division of the fifth nerve. The relative positions of the middle meningeal artery and the inferior maxillary nerve are shown. The dotted line crossing the Gasserian ganglion represents the section advised in removing the latter, together with the superior and inferior maxillary trunks. (J. Hutchinson, Jr.)

for nearly half the mortality, all the well-known precautions must be taken before, during, and after the operation.

In the previous sterilisation of the field of operation the external auditory meatus should be cleansed and plugged with sterile gauze. Some writers advise paring and suture of the centre of the lids before the operation is begun. Prof. Krause does not recommend this step, as it interferes with examination of the cornea, and because "healthy eyes in ge- do not become inflamed after the Gasserian ganglion is remov.[4] He admits that the danger is greater if there is any suppuration about the lachrymal sac, or if earlier peripheral operations have

[1] Von Bergmann's "System of Surgery," *Amer. Trans.*, vol. i, p. 585.
[2] *The Surgical Treatment of Facial Neuralgia*, p. 75.
[3] *Ann. of Surg.*, 1893, p. 509.
[4] As will be seen later, Prof. Krause removes the entire ganglion.

interfered with closure of the lids by facial paralysis. Mr. Hutchinson considers this step not only irksome but needless, owing to the great rarity with which it is needful to interfere with the ophthalmic division, as this is so seldom the seat of neuralgia. He further points out that temporary closure of the lids affords no guarantee for the future safety of the cornea when the ophthalmic division has been divided.

Operation. This may be considered in the four following stages.

(1) *The Division of the Soft Parts.* The following special instruments should be at hand in addition to those mentioned at p. 310 and the succeeding pages for removal of bone in opening the skull: a special broad flexible retractor (highly polished so as to reflect the light) at least 8 cm. long; an aneurysm needle with a short curve and smaller than usual, or a flexible-eyed probe, which may be useful for securing the middle meningeal artery; sharp and blunt-pointed tenotomy knives; fine-pointed blunt dissectors and elevators; an electric head-lamp; and a dental chair for raising the patient to a sitting position. A horse-shoe shaped flap is cut, the base being situated at the level of the zygoma and the convex upper border extending about an inch and a half or two inches above this level. The anterior border should be just behind the external angular process and the posterior should terminate just above the condyle of the jaw. All the soft parts, including the temporal muscle and the pericranium, are divided down to the bone and the flap is turned down by means of an elevator. In order to minimise the possibility of damage to the branches of the facial nerve which supply the muscles around the orbit, Prof. Kocher employs an incision which commences a finger's breadth behind the frontal process of the malar, and is carried obliquely downwards and backwards to the posterior extremity of the zygomatic arch, and from thence upwards and backwards in front of the ear at right angles to the first part of the incision. This second part of the incision is carried down to the bone, the superficial temporal vessels being ligatured. The incision divides the skin, and the strong temporal fascia is cut through a finger's breadth above the zygoma. The malar is now exposed subperiosteally immediately behind its frontal process, and is chiselled through vertically. The zygoma is divided posteriorly close to its root, and the whole zygomatic arch is then carefully drawn down with a hook. The outer surface of the temporal muscle is now exposed, and its posterior and lower border is separated from the skull and drawn well forwards with a blunt hook over the infratemporal crest, at the same time detaching the periosteum and soft parts from the under surface of the skull.

(2) *Opening the Skull.* Very little need be added here to the directions given at pp. 310 *et seq.*. Here also the operator will be guided by his experience and the remarks made above as to whether he will remove the bone or perform an osteoplastic operation, and the means he will adopt in either case. Mr. Hutchinson gives the following as a reason for preferring removal of bone in addition to the fact that the gap will be completely filled up. "The bone forming the temporal fossa is thin and deeply grooved in old subjects (and nearly all the patients are elderly), and in using Gigli's saw or chisel, &c., the dura mater is readily injured. Although in the late stage of the operation this sometimes cannot be avoided, and the escape of cerebro-spinal fluid even facilitates access to the ganglion, at an early stage it is undesirable. Should the osteoplastic method be adopted, the words of Krause must be remembered. When

the base of the flap is fractured, the fracture line runs about 1 cm. above the zygoma; the crest of bone which remains here and which interferes with the view is removed with gouge forceps down to the base of the skull—that is, to the infratemporal crest. It is absolutely necessary that the base of the skull be fully exposed and the dura down to the point where it turns inwards below. The flap should be well rounded, with its base at the zygoma and its upper edge two inches above this ridge. The two extremities of the incision should begin at the eminentia articularis behind and the malar bone in front. The bone to be removed is the front half of the squamous portion of the temporal.

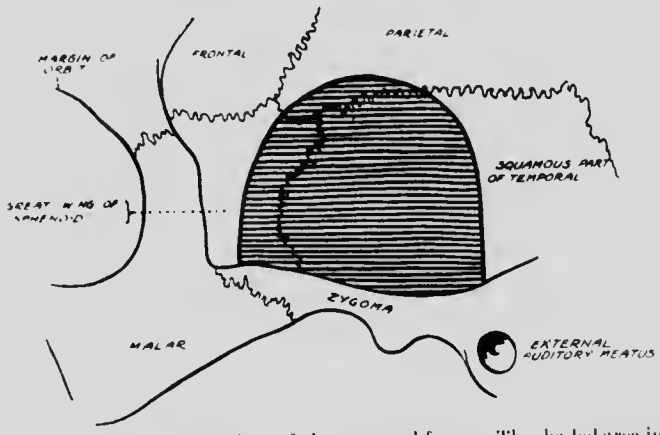


FIG. 159. View of the bony floor of the temporal fossa. The shaded area indicates the bone which is removed in the Hartley-Krause operation. (Hutchinson.)

If, as is preferable, the bone is completely removed, the pin of a three-quarter-inch trephine should be inserted midway between the upper border of the external auditory meatus and the external angular process of the frontal. The opening thus made is then enlarged with Hoffmann's or other suitable forceps. The position of the patient is of the greatest importance. He should, at this and the subsequent stages of the operation, be propped up into an almost sitting posture; the head rests upon the occiput, and an assistant holds it as directed. In this position the blood and the exuding cerebro-spinal fluid which would otherwise collect at the bottom of the funnel-shaped wound will flow out, and thus the view will not be so readily obstructed. This position also lessens the hæmorrhage, and the brain moreover tends to fall back. Mr. Hutchinson, indeed, has found that, with due care, the sitting position in a dentist's chair will not increase the difficulties of the anæsthetist, and recommends the adoption of this posture.

(3) *Finding the Ganglion.* The Gasserian ganglion is situated over the apex of the petrous part of the temporal bone outside the dura mater and immediately external to the cavernous sinus. Partly with a blunt raspatory or closed curved blunt-pointed scissors, partly with the finger, the surgeon now separates the dura mater very carefully from the base of the skull, working directly inwards towards the foramen rotundum and the foramen ovale, which lie at a depth of an inch and a quarter from the wall of the temporal fossa. The foramen spinosum is, however, placed externally to, as well as slightly behind, the foramen ovale, and will therefore

probably be reached first. Mr. Hutchinson has found that the eminentia articularis is a sufficient landmark for the two, being situated on the same vertical plane, 3 cm. external to and slightly below them.

The next step will vary somewhat according as the middle meningeal is tied as a rule or not. It will be remembered that hæmorrhage of different kinds and from various sources is one of the chief difficulties, and the chief cause of prolonging an operation always difficult and usually performed in patients of poor vitality. Prof. Krause strongly recommends this precaution. He allows that in cases where the foramen spinosum is situated exceptionally far behind the foramen ovale, this step may not be needful, "yet ligature and division are much safer and should be carried out by all means." The dura mater having been separated and the foramen spinosum reached, the brain surrounded by the dura is next carefully raised by a right-angled retractor held by an assistant. This elevation should go no farther than is absolutely necessary to obtain a clear view. By raising the dura with an elevator from the base of the skull internal to the artery, so that the second and third

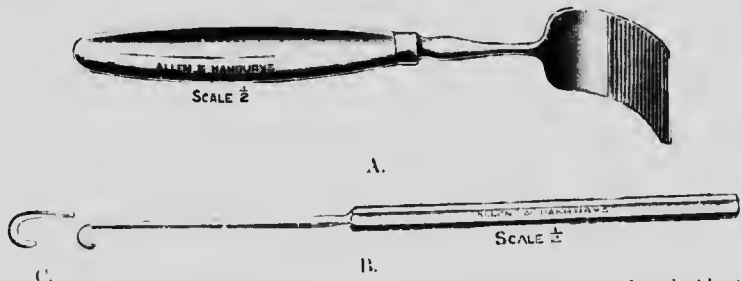


Fig. 160. A. Krause's retractor for exposing the ganglion. B. Rose's blunt hook. C. Rose's sharp hook

divisions of the fifth nerve become visible, the artery with its two companion veins comes into view as a distinct strand running up to the dura from the foramen spinosum, and can be isolated on all sides and divided between two ligatures passed by the means mentioned on p. 318. If the ligatures slip, or, owing to other cause, cut through the vessel, Krause introduces a blunt right-angled hook into the foramen, presses it down tightly by a raspatory, and turns it to and fro until the bleeding stops, or leaves it in place. Ligature of the external or the common carotid should not be performed as a preliminary step, or now, unless the bleeding cannot otherwise be arrested; in one case which occurred in Philadelphia, death of the flap and fatal septicæmia followed this step. Mr. Hutchinson has found that while it is possible to remove the ganglion without ligature of the middle meningeal, its division between two ligatures undoubtedly facilitates the raising of the dura mater and exposure of the inferior maxillary nerve and the lower edge of the ganglion. With regard to ligature of the external carotid he considers that this procedure will affect the arterial bleeding very little, owing to the free collateral circulation. He has only once taken this step, and in this case, the ligature being performed in the middle of the operation, no apparent effect was produced. "Keeping the patient in an upright sitting position is far more effective than ligature of the external carotid, since it checks both venous and arterial bleeding."

The dura mater is next raised still farther towards the middle line, very carefully on account of the tension within the dura and the vicinity of the cavernous sinus. To check the oozing, pledgets of dry sterilised gauze—the wound should be as dry as possible throughout—on Spencer-Wells forceps should be used, they also serve to raise the dura gently. If the oozing be very free the operation must be interrupted for a few minutes in order to pack in dry gauze, the retractor being removed, if needful, or slightly displaced forwards or backwards, a step which Krause has often found sufficient in checking bleeding from the dural veins. If exceptionally this should not be the case, he removes the retractor and introduces more gauze.

(4) *Dealing with the Nerves and Ganglion.* "If the retractor is well placed, the third branch is freed with a fine elevator, and then the second division, which lies about half an inch forwards and mesially; the dura is lifted off each from the foramina to the ganglion, and then the nerves are raised from the bone. The same procedure is now adopted with the ganglion itself; it succeeds perfectly well if several thin but particularly firm strands of connective tissue are cut through here and there with blunt-pointed scissors. In general, however, it is sufficient to push back the parts with small gauze pledgets on holders." Occasionally there may be a small tear in the dura, and cerebro-spinal fluid may flow out; this, however, is of no consequence in an aseptic operation. "This stage may be simplified by grasping the third branch with forceps, and rendering it tight so that the ganglion comes forward somewhat; for this reason the branches should be cut through last of all, since by them the ganglion is anchored, so to speak, in its place." At all events, Krause has in every case succeeded in dissecting free the ganglion to its inner edge, and so far backwards against the upper border of the petrous bone that the trunk of the fifth just became visible. The ganglion appears like a network of fibres and is greyish-red, the trigeminal trunk is almost white, and its fibres run longitudinally.

"The author has purposely exposed the first trigeminal branch only at its immediate junction with the ganglion, and has not followed up its farther course, since it runs forwards in the wall of the cavernous sinus. Besides this, the abducent and trochlear nerves lie in its immediate vicinity, and more mesially, the oculomotor nerve; all injury to these nerves must be avoided.

"Should the cavernous sinus be wounded, the resulting alarming hæmorrhage can be checked by pressing a small sponge on a holder against the site. As soon as the brain falls into its normal position the hæmorrhage stops without further effort, otherwise a small strip of gauze must be pressed against the bleeding site. It should be left in place and the end carried out of the wound. The pressure within the sinus is very slight.

"Before proceeding farther the surgeon should grasp the exposed ganglion transversely with longitudinally ribbed forceps at its posterior portion, where it passes into the trigeminal trunk. This is directly in front of the upper border of the petrous bone, and directly under the superior petrosal sinus. Great care should be exercised that none of the structures lying mesially, not even the smallest fold of dura mater, is caught in the tip of the forceps.

"The surgeon must now cut through the second and third branches with a sharp tenotome, or small curved scissors, close to the foramen

rotundum. The forceps which have grasped the ganglion can now be slowly rotated around its axis. The entire ganglion will always follow, and with it a larger or smaller piece of the posteriorly-placed trigeminal trunk. The first branch generally tears off close to the ganglion, but since only peripheral portions of it remain, it is as good as gone.

"In conclusion the author presses the peripheral stumps of the second and third branch as deep as possible into the foramen rotundum and ovale with an elevator." (Krause.)

Opinions differ as to the extent to which ganglion should be removed. Prof. Keen, like Prof. Krause, would remove the entire ganglion. He believes that the present methods of dealing with the eye are so improved that its preservation is ensured though the whole ganglion be removed. On this subject the remarks at p. 381 should be referred to. Secondly, any arbitrary line of removing the outer two-thirds and leaving the inner third will leave diseased ganglionic cells if the ganglion is affected. Any stimulus from the first division will excite sensation in these, and thus bring about a return of pain.[1]

Mr. Hutchinson, on the other hand, would limit the removal of the ganglion to its lower and outer part by the section shown in Fig. 158. The ganglion is exposed by removal of the outer layer of its sheath, which is always closely adherent. When this exposure has been thoroughly effected, and not before, the superior and inferior divisions are cut cleanly across at their foramina with a tenotomy knife or the hook (Fig. 160). The ganglion being firmly held by toothed forceps is now divided so as to leave the ophthalmic division intact. This method, which has given excellent results in his hands, is based on the fact that the opathalmic division is not often the seat of neuralgia. Mr. Hutchinson has not found a case in which, by leaving the ophthalmic trunk, neuralgia occurred in it. The advantages of the above method are: "(1) There is no anæsthesia of the cornea, and hence no risk of loss of the eye. (2) There should be no danger of injuring the oculomotor nerves, or the cavernous sinus. (3) The severity of the operation is rendered less, the hæmorrhage and the chance of injurious pressure on the brain being both materially diminished."

Closure of the Wound and After-Treatment. In many cases as soon as the operation is finished and the brain allowed to settle down in its place the hæmorrhage ceases, or can be checked by temporary pressure. If serious bleeding continue, the careful use of tampons must be trusted to. And here it is necessary to point out that the temporo-sphenoidal lobe has frequently been found injured in necropsies of fatal cases, and that a fertile source of such injury is the use of gauze during and at the close of the operation. During the operation the use of small pieces of gauze wrung out of hot saline, or sterilized adrenalin solution, and careful shifting of the retractor, will arrest the venous oozing. That from the middle meningeal has already been alluded to. Bleeding from the cavernous sinus is to be avoided by not interfering with the ophthalmic division and that part of the ganglion from which it springs. Infective meningitis and fatal injury to the brain have followed in several cases on the vigorous gauze plugging which has been required to arrest the hæmorrhage from injury to these two vessels. The question of operating in two stages may be mentioned here. Prof. Krause prefers

[1] The comparative infrequency with which the ganglion is found to show any signs of gross disease has been alluded to at p. 364.

to finish the operation in one sitting, even if it takes a long time owing to frequent interruptions due to the need of resorting to repeated packings; he only resorts to the operation in two stages in the extremest cases. For he does not consider it without risk to expose patients exhausted by protracted severe pains twice within a short time to the dangers of narcosis and an operative procedure. Besides the aseptic course is endangered if the deep wound remains open long, even if the flap is secured over a sterilised tampon with a few sutures. In general, the operation in one sitting, where the bone was preserved, required an hour and a half; with slight hæmorrhage he has frequently required only twenty to twenty-five minutes after the bone has been removed. Mr. Hutchinson thinks that while it is desirable whenever possible to complete the operation at one sitting, yet when exceptional difficulty from hæmorrhage arises, it is wiser to defer its completion for a few days. Those with necessarily limited experience will do well to bear this advice in mind. It is better to meet the risks of deferring the completion of the operation rather than those of fatally exhausting their patient, or incompletely removing the ganglion because they cannot see it. But with the experience now before us such hæmorrhage should more rarely be met with. On the completion of the operation a small drainage-tube is passed through the entire depth of the wound, between the dura and the skull, and brought out at the posterior angle of the incision in the skin. Should the osteoplastic method have been employed, the bone must be notched for this purpose. Where the cranial wall has been removed it is needless to put back the bone. The tube should be removed in forty-eight hours. In those cases where the dura has been opened accidentally or intentionally, in order to relieve the tension of the brain, the escape of cerebro-spinal fluid for the first few days may be such as to require daily change of the dressings.

The cornea will need careful attention. Those who suture the lids will divide the united portion in about two weeks, nothing stronger than boracic lotion having been used in the interim, and afterwards large protective glasses should be constantly worn to prevent access of dust. Prof. Krause, who, as we have seen, dispenses with suture of the lids, uses a Buller's eyeglass to be worn as long as any tendency to irritation remains. He advises that no bandage be employed to protect the cornea, as it always exerts some pressure. In two cases where the facial nerve had been injured by previous operation, he saw linear ulcers develop, which corresponded exactly to the edge of the upper lid. Mr. Hutchinson states that if the ganglion be completely removed there will always remain some risk of trophic ulceration and the loss of the eye. In support of this he has collected ten cases. While the danger is greatest during the first few weeks, an anæsthetic cornea is never really safe. This risk can be avoided by excision of the ganglion in the manner described at p. 376.

Results of the Operation. Prof. Keen, who in 1898 had operated by the intracranial method in fourteen cases, wrote: "What has been the history of the cases as to cure? So far as I know, there have been only four cases in which the pain has returned; one reported by Rose, one by Dana, and two by myself. But I especially desire to call attention to the fact that my own two cases of recurrence were my first two operations, that in Case 1 no microscopical examination of the fragments was made, and in Case 2 the examination revealed no ganglionic cells or nerve fibres. Case 1, as I now look at it, was imperfectly done, and Case 2, still more so. Therefore the recurrence of pain in these two cases cannot be

used as an argument against the removal of the ganglion." In addition to the above, Krause has reported one case in which the sensory root was found diseased, and the pain returned on the opposite side of the face. We can conclude, therefore, in general, as the result of this and later experience, that, practically, the pain will not return in over 1 or 2 per cent. in any such severity as to liken it to the original disease, and that it will not return at all in more than 4 or 5 per cent. Dr. Tiffany, of Baltimore, who has afforded much help to surgeons in this matter by his article with a collection of 108 cases,[1] shows that while recurrence of pain may follow intracranial excision of branches of the fifth nerve close to the ganglion, recurrence has not been observed in those cases in which the ganglion itself has been known to be removed.

"The place where the ganglion was supposed to be by the operator has been curetted, or pieces of tissue picked away with pincers, more or less in the dark; this does not constitute known removal; it does constitute attempted removal—a very different thing."

Prof. Krause, writing in 1902, with an experience of thirty-six cases, says that he has never seen a recurrence in any of his cases in which the ganglion was removed for typical trigeminal neuralgia, though nine years have elapsed since his first extirpation.

Mr. Hutchinson writes that the cases in which recurrence of epileptiform neuralgia has followed on the same side as the operation may be put into two classes. Either the patient was neurotic or hysterical (*i.e.* not a really suitable subject for the operation), or the operation has failed to deal adequately with (perhaps has never even touched) the Gasserian ganglion. With regard to recurrence of the neuralgia on the opposite side, this authority has only been able to find two or three instances amongst the records of several hundred cases.

Mortality of the Operation. We have seen that Prof. Krause, writing very briefly, says that of his thirty-six cases, "three died as an immediat result of the operation." Having collected 128 cases operated on up to the end of 1899 by the method he describes, Krause finds the mortality to be one of 15·6 per cent.; 15 to 20 per cent. may be justly taken as the mortality of the operation except in specially skilled hands.[2] Here, from the special experience gained, the mortality of the operation is much lower. Thus Mr Hutchinson[3] writes, "Lexer's eleven and my own eight cases amount to nineteen without a single death. Sir V. Horsley kindly tells me that his personal experience has increased to approximately 120, with six deaths.[4] Taking his cases with Lexer's and my own, we have 140 cases with six deaths, only 4 per cent., and this includes two fatal cases which some surgeons might have left out." Since the above was written (in 1905) there is reason to believe that the mortality has still further diminished.

Difficulties and Dangers of the Operation. From the account already given it will have been easy to estimate these. Perhaps the most striking testimony is that given by Prof. Keen, who, in the paper quoted above,

[1] *Trans. Amer. Surg. Assoc.*, 1896, p. 1.

[2] It must be remembered that while the majority of successful cases are published—many after too short an interval—it must also be borne in mind that many fatal cases have not been recorded at all.

[3] *Loc. supra cit.*

[4] "Of the six fatal cases, cerebral haemorrhage was the cause in three; one patient died from septic infection. In the other two cases an interval of three or four months occurred after the operation, the cause of death being doubtful."

writes: "Even now, after having operated on eleven cases, I always approach the operation with a certain amount of hesitation."

But while the Hartley-Krause operation will always remain one of the most difficult in surgery, and one from the gravity of its dangers not to be undertaken lightly, it has proved itself far superior to the extra-cranial method from the wider operation-field which it affords, the better access, and thus the far greater certainty of its results; and it may be confidently expected that by strict attention to the details of technique the mortality will now be lowered, especially if surgeons are able to operate on patients earlier, before their vitality is so much lowered, and if they avail themselves, when it is indicated, of the two-stage method. To recapitulate, the chief difficulties and dangers appear to be .

(1) Those met with in exposing the dura mater; these have been considered at p. 375.

(2) *Hæmorrhage.* Troublesome bleeding may proceed from several sources, (*a*) the diploe; (*b*) the middle meningeal artery. The methods of dealing with these have been fully given at p. 375. Harvey Cushing's direct infra-arterial method may be briefly mentioned here. In making the temporal flap, and removing the bone, the incision does not go quite so high as in the Hartley-Krause method; Cushing also divides and turns down the zygoma and detaches the temporal muscle and periosteum downwards with the object of fully exposing the infratemporal crest, and thus making certain of exposing the middle meningeal artery low down under the ante ior inferior angle of the parietal, when the skull is opened. The great wing of the sphenoid is removed in a downward and inward direction until the foramen ovale and the foramen rotundum are exposed. Mr. Hutchinson considers that in removal of the zygoma and in the opening of the skull low down, Cushing's method shows a reversion to Rose's operation, and that it is doubtful whether these slight modifications present any real gain. On the other hand Kocher [1] speaks very highly of it and maintains that it has provided the most satisfactory statistics. For further details Cushing's original papers may be consulted.[2]

Other sources of bleeding are, (*c*) the veins of the dura mater; (*d*) the small meningeal artery, especially the branch running under the ganglion; (*e*) the veins of Santorini; (*f*) the cavernous sinus; and even (*g*) the internal carotid. Means for dealing with the hæmorrhage have already been given. Speaking generally, tampons will suffice for venous bleeding; to be really reliable in the case of arterial, it will be necessary to push the strip into the bony foramina themselves. But the steps already fully given should amply suffice for dealing with the middle meningeal, and for avoiding the internal carotid artery.

(3) *Tension and Bulging of the Dura Mater.* It has been pointed out that the sitting position causes the brain to recede. This position, and opening the dura if needful to evacuate the fluid, may be trusted to ·et this difficulty.

(4) *Shock.* Owing to the usual condition of the patients and the severity of the operation, every precaution must be taken before, during, and after the operation to meet and lessen this danger.

(5) *Infection of the Wound.* During a necessarily prolonged operation this may enter by many paths. It is most likely to occur if the dura mater is opened, giving escape to cerebro-spinal fluid, if this membrane

[1] *Operative Surgery*, trans. Stiles and Paul, p. 207.
[2] Cushing, *Journ. of Amer. Med. Assoc.*, April 28, 1900, p. 1035.

and the subjacent brain are bruised by the retractor, or the use of gauze in arresting bleeding, and where the employment of tampons is extensive or prolonged. Locally, meningitis is the commonest result of infection; in one case a cerebral abscess proved fatal three months after the operation. Here an infected ligature was the cause of the suppuration.

(6) In addition to fatal hemiplegia and other evidence of damage to the brain, the use of the retractor and other manipulations has led to paralytic symptoms which gradually cleared up. There is reason to believe that collection of blood under the flap may also lead to hemiplegia, and call for removal of the clot.

(7) *Ulceration of the Cornea.* This serious complication, which may end in destruction of the eyeball, has already been discussed.

It has not been thought needful to go into details with regard to sparing the motor root of the fifth by dividing the sensory root above. While theoretically desirable, this step is not a practical one. "Repeated experiment has convinced me that, in the cavum Meckelii, it is impossible to divide the sensory portion completely without sacrificing the motor root; above the cavum it is so difficult as to depend almost upon chance" (Hutchinson). Krause, after repeated attempts to preserve the motor root, has given these up. Fortunately, the trouble and inconvenience caused by the resulting unilateral paralysis of the muscles of mastication is very slight. The loss of sensation causes the patients but little discomfort; they are able to take food far better than before, in spite of some limitation of the movement of the lower jaw, and the disfigurement is trifling.

OPERATIONS ON THE FACIAL NERVE. STRETCHING THE FACIAL NERVE. OPERATIVE TREATMENT OF INTRACTABLE FACIAL PARALYSIS OF PERIPHERAL ORIGIN

Stretching the Facial Nerve. This operation is sometimes performed for severe cases of spasm of the facial muscles not due to any gross lesion, and in which other treatment has failed. It is, of course, to be understood that no patient would be advised to submit to the operation without a thorough trial of other remedies. In any case, it is extremely doubtful if anything more than temporary relief, of a variable duration, can be promised by this measure.

Sir. R. J. Godlee published [1] a case in which he stretched the facial nerve in a case of tic spasmodique without pain. The steps given below, p. 385, will serve for the exposure of the nerve.

The operation is easy in thin patients; more difficult in stout and muscular ones. Experimentally on the cadaver it was found that the amount of tension that the nerve would bear differed very much; in some cases it resisted for an appreciable time the strongest possible pull; in others it snapped across with the greatest readiness. The line for the nerve is exactly parallel with the upper border of the digastric, and it will be found about half way down that part of the mastoid process which is exposed in the wound, viz. the free anterior border. The great auricular nerve will be in part divided, but as long as the operator keeps in the same plane as the digastric he can scarcely wound any vessel of importance. The deepest part of the wound is in close proximity to the internal jugular vein. The only vessels which should be met with are the posterior auricular vein superficially, and its artery more deeply, but a good deal of hæmorrhage may arise from glandular branches; and Sir R. J. Godlee's advice to keep the wound in a good light, well opened out with retractors, and carefully sponged dry, should be remembered.

[1] *Clin. Soc. Trans.*, vol. xiv, p. 45.

Points which deserve attention:

(1) *Finding the nerve.* To avoid needless injury and to shorten the operation, Prof. Keen[1] recommends a weak faradic current. A wet sponge was held on the cheek, and a fine wire at the other end was applied to various points in the wound till the nerve was found.

(2) *Mode of stretching the nerve.* Prof. Keen advises stretching from the periphery towards the centre. The amount of force to be used he estimates at four to five pounds, and this he thinks can best be achieved empirically, by attempting to lift the head (six to seven pounds), and abandoning the attempt the moment any fibres give way. In other words, the stretching should be as severe as the integrity of the nerve will allow.[2]

(3) *Results of the operation.* It appears that while many cases have been temporarily very much relieved, as a certain rule, when the nerve recovers itself, the spasms return.

Prof. Keen, in the table at the end of his paper, gives two cases in which the cure lasted much longer, if indeed it may not be called permanent, viz. Southam's,[3] in which there was absolute relief for five years; and one under the care of Jesas,[4] in which the cure had lasted two years and eight months.

Prof. Keen's concluding words are as follows: "It would seem, therefore, that, whether viewed from the point of palliation or of cure, the operation is, with our present knowledge, to be looked upon favourably."

Sir R. J. Godlee in a second paper,[5] in which he published the result of his first case—in which, after practically remaining absent for nine months, the convulsions suddenly returned subsequent to a severe nervous shock, and gradually increased until they regained all their former intensity—sums up less favourably: "In discussing the question of recommending the operation, we must not forget that the risk, with due care, is almost nil; that a certain immunity from the trouble may be safely promised for a time, and that this period may be very considerably prolonged, and, while Southam's remarkable case remains completely well, there is always the hope that the relief may be permanent. Were it not for this, however, I am afraid that the general verdict would be that the time has come when this small chapter of surgical therapeutics . . . must be closed."

And, after submitting to the stretching of the nerve, patients should be most careful to avoid any exciting and predisposing cause of a return of their trouble—viz. exposure to cold chills, sudden bright lights, mental worry, and insufficient or improper food.

OPERATIVE TREATMENT OF INTRACTABLE FACIAL PARALYSIS OF PERIPHERAL ORIGIN

Operations have lately been devised by anastomosis of the facial with the spinal accessory or hypoglossal nerve, with a view of improving intractable facial paralysis originating from injury in its course through the temporal bone, or just outside this bone.

[1] *Ann. of Surg.*, July 1886, p. 13. A strong current will produce muscular spasm at once, but a very weak current will only do so when the nerve is touched.

[2] Kocher advises that when stretching the nerve for facial spasm, a general anæsthetic should not be employed, because the stretching must be so measured that it produces a distinct but not a total paresis, which can readily be brought about by slight traction with an aneurysm needle.

[3] *Lancet*, August 27, 1881; *ibid.*, April 10, 1886.

[4] *Wien. Med. Woch.*, No. 2, 1884, and No. 27, 1887. It is an interesting fact that no paralysis followed in this case.

[5] Both Sir R. J. Godlee's second paper (*Clin. Soc. Trans.*, vol. xvi, p. 220) and Prof. Keen's (*loc. supra cit.*) contain tables, the former giving thirteen, the latter twenty-one cases. Sir R. J. Godlee's patient was unwilling to obtain relief from her complaint by submitting to permanent paralysis of the affected side of her face, owing to a dislike of the very obvious nature of the deformity.

Enough definite knowledge from a sufficient number of cases carefully watched for a sufficient period is gradually accumulating to show how far this operation will outweigh the disadvantages which it entails. To consider this in a little detail, the operation can only prove a cure if the cortex can be sufficiently educated, and if the patient will persevere with this education, so as to accomplish independent movements of the face dissociated from those of the shoulder or tongue. A few cases show that this result has been completely [1] accomplished. Short of this, the chief advantage is that in a certain number of cases, not in all, as the facial muscles gain some power of movement associated with those of the shoulder or tongue, they regain some tone also, and thus the flaccidity of the face disappears. But if this gain follows, it only shows itself when the muscles are at rest. In the great majority of cases the paralysed side of the face long remains motionless when the opposite one is in action, as in laughing. The only movements possible on the paralysed side, *e.g.* after facio-accessory anastomosis, are those associated with movements of the shoulder. If the patients desire to contract the facial muscles, they must move the shoulder. This is certainly true for a period varying from three to eighteen months. As the play of the facial muscles is the index of the state of the mind, it is clear that as long as they act only in association with those of the shoulder, any movement of the muscles of the shoulder may cause an expression of the face which is not in the least in harmony with the state of the mind. This has been met with frequently. A good instance is given in one of the seven cases published in a paper by Mr. C. A. Ballance, Mr. H. A. Ballance, of Norwich, and Dr. Purves Stewart.[2] The patient had been operated on nine months previously.

"The flaccidity of the face had disappeared, so that when at rest it was practically symmetrical. No voluntary movement could yet be performed without simultaneous elevation of the shoulder. Moreover, the facial movements were so easily elicited by slight shoulder movements that the patient had to carry her parasol or umbrella in the right hand instead of the left, otherwise involuntary facial movements so readily occurred that awkward misunderstandings with strangers resulted."

Another inconvenience is the atrophy of the shoulder muscles which follows, though this, as a rule, disappears if the anastomosis be performed as advised by Mr. Ballance and others. As to the nerve to be selected, the conclusion arrived at by the writers of the above paper is that facio-hypoglossal anastomosis is preferable to facio-accessory,[3] for these reasons. (1) The nearness of the cortical centre of the tongue to that of the face. (2) The fact that some of the movements of the tongue are closely associated with those of the face. To these, it may be added, that during the period in which the movements of the face continue dependent upon those

[1] In several of the cases so carefully reported in the paper alluded to below, evidence of partial recovery is given. Thus in the one treated by Mr. H. A. Ballance, of Norwich, the patient, eight months after the operation, could close the eyelids completely by a strong effort. Ten and a half months after the operation the food no longer lodged in the cheek. Dr. Kennedy (*Brit. Med. Journ.*, June 6, 1903, p. 1348) writes that his patient had "recovered the power to make independent movements of the orbicularis palpebrarum, giving a practically normal use of the eyelids, independently of any contractions of the sterno-mastoid or of the trapezius, and also that other imperfectly co-ordinated movements of other muscles of the right side of the face were recovered." "Distinctive improvement" was still going on four years after the operation. Mr. C. A. Ballance's latest results are given below (p. 385).

[2] *Brit. Med. Journ.*, May 2, 1903.

[3] In a letter (*Brit. Med. Journ.*, May 30, 1903) Mr. Ballance shows that Prof. Bernhardt, of Berlin, also prefers facio-hypoglossal anastomosis.

of the tongue, less awkwardness will result owing to the latter being hidden from view. As to the date of the operation, the writers are of opinion that when the paralysis has lasted six months, in spite of massage and other non-operative treatment, no recovery is to be expected by these means, and the sooner the operation is performed after this date the better.

Mr. Ballance and Dr. Kennedy pointed out that the surgeon should communicate to his patients as accurate a knowledge as possible of the extent of recovery, partial or complete, which the operation offers.

In the majority of cases the operation will be performed for paralysis due to disease of the temporal bone; much more rarely after fracture of the base (Case v. operated on by Mr. Ballance [1]), or of operation wounds, *e.g.* during the removal of a parotid tumour, or wounds outside the skull.

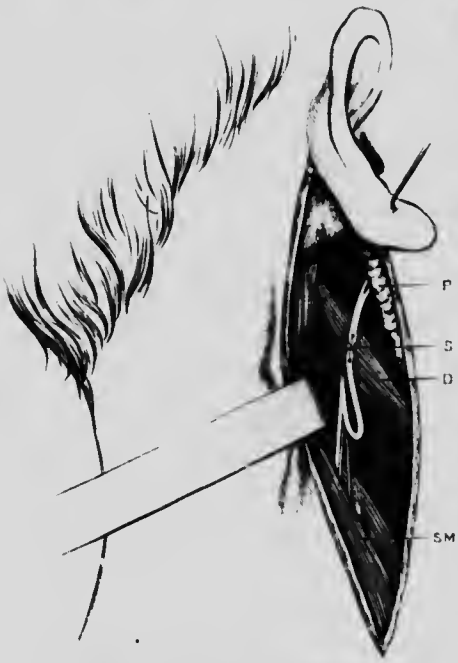


Fig. 161. P, Parotid. D, Digastric. S.M. Sternomastoid. At S the branch of the spinal accessory to the trapezius, cut long, has been looped up over the digastric, and united, end to end, to the divided facial. (Faure.)

Thus Mr. Ballance mentions a case of this kind in which he was unable to complete the operation as the trunk of the facial nerve had been carried away by a bullet. Harvey Cushing, who reviews the whole subject,[2] also reports a case of paralysis due to a revolver bullet.

After the removal of the bullet Cushing waited until the wound was soundly closed, fearing that otherwise it might cause infection of the one which he proposed to make. A facio-accessory anastomosis was made by end-to-end suture over the posterior belly of the digastric. Improvement as to lachrymation and taking food followed very early, and six months after the operation it is stated that "considerable improvement was appreciable."

It is pointed out that the success of the operation depends largely upon the delicacy with which the nerves are handled, upon their accurate approximation with the least possible suture-material, and that placed only in the nerve sheaths—Cushing used the most delicate strands of split silk—upon absolute hæmostasis, and upon the care with which the tissues are handled, since it is of the utmost importance that there should be a minimum of scar formation.

Operation (Fig. 161). The following steps will suffice for exposure of the facial, the spinal accessory, and the hypoglossal nerves.

A free incision is made along the anterior border of the sterno-mastoid, beginning at the level of the base of the mastoid process. After division of the dense fibrous tissue here the muscle is retracted, and separated if needful from the mastoid process, the anterior border of which must be

[1] *Loc. supra cit.*

[2] *Ann. of Surg.*, May 1903.

exposed. The posterior auricular vessels are cut. Lying a little anterior to this point, and on a deeper level, is the base of the styloid process across which the nerve runs towards the parotid gland. The lower and back part of this gland having been freed and drawn forwards and the digastric downwards, the facial nerve will come into view, and is to be followed up as high as the stylo-mastoid foramen. The spinal accessory will be found a little below the digastric, running downwards and outwards to the sterno-mastoid. When this nerve is chosen for anastomosis, different methods have been employed. M. Faure having found the main trunk preserved the branches to the sterno-mastoid. He took the branch to the trapezius, cutting it from this muscle as long as possible, separated it from the spinal portion, so as to bring it up easily in the form of a loop, with the concavity upwards over the posterior belly of the digastric, where it was fixed by end-to-end suture to the divided facial. Later, he preferred to fix the branch to the trapezius "end-to-side to the lower trunk of the facial" (Ballance). Kennedy divided the spinal accessory nerve, with the exception of one side of its perineurium, and sutured, end-to-side, the divided trunk of the facial into this gap.

The after-treatment consists mainly in a judicious stimulation by daily galvanism for months, after the wound is healed. This is continued until faradic excitability reappears, when faradism is substituted.

Mr. Ballance wrote, June 1905: "I do not do now the end-to-side anastomosis.[1] In facio-accessory anastomosis I divide the accessory, except a small portion of the sheath on one side, and then unite the cut end of the facial end-to-end to the upper segment of the accessory. This means temporary paralysis (two to three months) of the sterno-mastoid and trapezius. In facio-hypoglossal anastomosis I divide the hypoglossal at the posterior border of the hyoglossus; the proximal end is united to the facial end-to-end. I then divide the gustatory and unite its proximal end to the distal end of the hypoglossal so as to get a return of the movement in the muscles supplied by the hypoglossal."

"Case vi had a perfect dissociated movement of the face at the end of eighteen months. Case vii is dead of malignant disease, I believe. Case viii has now dissociated movement in speaking and laughing. I have been told of two cases of independent dissociated movement appearing after three months in facio-hypoglossal anastomosis. This anastomosis appears the best, as the centres for movement on the cortex of the tongue and face are close together."

Mr. A. H. Tubby has recorded an interesting case of facio-hypoglossal anastomosis for the treatment of post-operative division of the facial nerve.[2] The facial paralysis followed the opening of an abscess at the angle of the jaw by another surgeon in a young man of 19 in the early part of 1905. When Mr. Tubby operated in October 1905 there was a complete facial paralysis. A long incision was made and the divided ends of the facial nerve were found with difficulty. The hypoglossal was then freed and brought up to the facial. An incision was made into the former with a tenotomy knife and both ends of the facial were implanted laterally. The head was kept at rest for fourteen days. A week after the operation it was noticed that the left eye could be temporarily closed, while two weeks after the patient began to move the left angle of his mouth. In March 1907 there was great improvement; all movements had been recovered but were weaker than those of the other side, so that when both sides of the face were moved the right muscles overpowered the left. There was some atrophy of the left side of the tongue.

[1] Illustrated in Fig. 12, *loc. supra cit.*
[2] *Clin. Soc. Trans.*, vol. xl. p. 264.

RESTORATION OF STENO'S DUCT

Where, after burns, stabs, ulcerations, sloughing, operations for removal of growths, a most annoying salivary fistula persists, the patient suffering from disagreeable hot dryness of the mouth, and from constant irritation and inflammation of the soft parts from the dribbling of saliva, where previous measures—*e.g.* collodion and heated wire, paring the edges—have failed, the surgeon may adopt one of the following measures :

(i) The following will often succeed in a recent case.

The opening into the mouth is first found, or one in its position made, by passing a fine silver probe from the fistula into the mouth.[1] As soon as the oral opening is found or established, the probe is passed from the mouth along the duct, beyond the fistula, up to the gland itself. The other end of the probe is then brought out of the angle of the mouth, curved and secured by strips of gauze and collodion on the cheek, while the fistula is kept as dry as possible, and covered with collodion, in the hope that it will close,[2] now that the oral opening is re-established; otherwise the fistula must be closed by operation

Sir H. Morris[3] has recorded a case which he successfully treated on the same lines, but with a fine catgut bougie, which is much more easily worn than a probe. He also suggests that it would be well, if, during any operation on the face for removal of a new growth, it be found necessary to divide the duct, that a bougie should be passed at once, and the patency of the duct secured.

(ii) In cases of longer standing, where the duct is more obliterated, especially at its narrow oral end, and the restoration is not so easy, some such operation as Desault's must be performed. The following modification is that of Kaufmann. The account is given by Prof. Kuttner.[4] A fine trocar and cannula are pushed through the cheek from the fistula forwards and inwards into the mouth, following, as far as possible, the course of the duct. "A fine piece of india-rubber tubing is passed through the cannula, the latter being then withdrawn, so that one end projects into the mouth, while the other is cut off somewhat obliquely, and placed so that the saliva can flow directly into the tube. One can also simply permit the tube to project upon the cheek. The tube remains in place eight days, and is then shortened at both ends close to the level of the skin and mucous membrane. In eight or ten days more it is removed entirely. The saliva will now flow through the new canal into the mouth, and the external fistula will close by itself or after cauterisation or direct suture.

"Kaufmann's method is simple and rational and suited for buccal as well as masseteric fistulæ. With a buccal fistula it is simply necessary to puncture the cheek at the abnormal orifice in a straight direction, or with a slight deviation to the front; with a masseteric fistula, however, one must be careful not to push the cannula through the masseter, for a foreign body in the muscle is not borne well, since it causes severe pains and even trismus; besides, the long track will readily close again if it runs between muscle fibres. Hence, in a masseteric fistula the trocar must first

[1] Close to the projection of the mucous membrane, which usually denotes the position of the orifice of the duct, opposite to the second upper molar tooth.

[2] If this fails, a plastic operation of paring the edges and uniting them with numerous sterilised fishing-gut and horsehair sutures will probably be required.

[3] *Clin. Soc. Trans.*, vol. xiii, p. 144.

[4] Von Bergmann's "System of Practical Surgery," *Amer. Trans.*, vol. i, p. 614.

be pushed from the opening of the fistula subcutaneously to the anterior edge of the masseter before the oral mucous membrane is perforated." In order to thoroughly establish the patency of the new duct catgut or a very fine piece of laminaria tent [1] will probably be required to prevent the tendency to close.

Instances of treatment by direct suture and different plastic operations, especially indicated in masseteric fistulæ, will be found given by Prof. Kuttner. If every other step fails, he advises that a partial resection of the parotid gland, with careful avoidance of the facial nerve, be performed.

When the patency of the new duct is thoroughly established, the external aperture may be closed by collodion, the cautery, or paring the edges, according to its size.

OPERATIVE TREATMENT OF LUPUS [2]

Lupus, a tuberculous lesion of the skin, frequently attacks the face, especially the nose, lip, cheek, or eyelid. It may also invade or commence in the mucous membrane of the nose, mouth, pharynx, or larynx. There are various ways in which it may be treated, and in each individual case, the situation, extent, rapidity, and the time the patient can give to treatment must be considered when selecting the most desirable form of treatment. Lupus is frequently met with in this country, the deformities which it produces are so odious, and it is so certainly arrested and cured in many cases by local treatment vigorously applied and energetically repeated, that a few practical remarks will be made on the chief methods of treatment.

Before speaking in detail of these methods it will be well to say a few words about the chief forms of lupus.

For the purpose of operative treatment the surgeon should keep two great types before his mind. In one of these the lupus deposit takes the shape of more or less localised nodules or nests, reddish or yellowish-pink, often quasi-gelatinous, and prone to attack the cheeks near the junction of the alæ and the upper lip. In the other the lupus deposit is much more diffused, usually, too, more superficial and less inclined to form nodules or nests. This type is met with both on the cheeks and nose, but is best seen on the latter. It is the form most frequently met with in the surgical wards of a London hospital, and is the one most often responsible for marring the above important features in young patients, usually girls. This type is the lupus seborrhagicus of Prof. Volkmann,[3] the seborrhœa being of secondary importance, the essential point being the fine cell lupus infiltration of the cutis, which develops most freely in the neighbourhood of the sebaceous glands, in which the cheeks and

[1] Erichsen, *Surgery*, vol. iii, p. 557.

[2] The following account, while introduced here from the greater frequency of lupus on the face, is, of course, equally applicable to the disease elsewhere.

[3] Prof. Volkmann gives the following graphic description of this form: "Irregular, reddish-looking patches met with on the cheeks and nose, often covered with "dirty looking, thin crusts, which are distinctly fatty to the touch. They consist, in fact, of nothing further than an excessive secretion from the sebaceous glands of the skin mixed with epidermal cells. When we have succeeded, with great difficulty, in scraping off this fatty layer with the knife, the underlying skin appears red, sore, and as if studded with fine warts. But if you examine these warty points more closely with a glass, you see that it is by no means a question of papillary elevations, but of a large number of fine holes which, being closely adjacent to each other, produce the warty appearance. These holes are the enlarged openings of the sebaceous ducts, and you can also see on peeling off single fatty crusts how a fine prolongation of the latter becomes detached from each small opening."

nose are so rich, and gives rise to an increased secretion on their part. Of the following modes of treatment (1), (2), and (7) are not operative, but, from what has been said above, it has been thought desirable briefly to mention them. Though the Finsen-light treatment has been attended with such remarkable results the operative methods can scarcely yet be said to be obsolete.

(1) **Finsen-Light Treatment of Lupus**. This mode of treatment, originally introduced by Finsen of Copenhagen in 1901, is now universally admitted to be a most satisfactory method of treating lupus, especially when the disease attacks the face. The curative effect is due to the action of the ultra-violet rays, which are focussed on the affected area by means of quartz lenses, which permit these rays to pass freely. Either the Finsen arc lamp or the Kromayer mercury lamp may be used. The latter, though shorter sittings are required, appears to be more uncertain, and its use is not unaccompanied by the danger of severe dermatitis or even burns.

At the beginning of the treatment half-hour sittings are sufficient. A reaction, with much erythema, and often vesication, follows at an interval of twelve to twenty-four hours. The sittings are repeated at intervals of a week. Later on the duration of each may be increased to an hour.

The advantages of the method are: (1) The resulting scar is thin, supple, and pliable, and is far less disfiguring than that resulting from other forms of treatment. (2) No anæsthetic being required, it is easy, should there be any evidence of recurrence, to get patients to again submit to treatment. (3) The treatment is comparatively painless, though for the other side of this question reference may be made to a paragraph, "The Light Treatment of Lupus from a Patient's Point of View."[1]

The disadvantages must also be considered. Even at the present day it is not always possible for patients far away in the country to get to one of these centres where light treatment, with its very expensive plant, and especially skilled staff, is available. When they are able to do so, the long time required for the treatment is an important question. Even a small patch will require treatment by many sittings spread over weeks or months, while an extensive case may call for treatment for one, two, or more years. The expenditure of much time, and often of money, is thus called for. The latter was strikingly brought to the notice of the present writer when questioning a hospital patient who had been treated for a long time for extensive lupus. This patient, a man of the labouring class who lived some thirty miles out of London, stated that in coming up for treatment he had in all spent over £75 in railway fares. And with lupus, as with all tuberculous cases treated slowly, there must always be the risk of the disease spreading at one spot while it is being dealt with at another. The light treatment is best suited to cases in which the patch is limited. Where the disease takes the form of diffuse spot-like nodules, the treatment is much more prolonged, and the same may be said of cases attended with much scarring from previous operations. Lupus of the mucous membranes, from their inaccessibility, and the rate at which the disease spreads in cavities, always moist and warm and of low bactericidal power, are less suitable for light treatment.[2]

[1] *Brit. Med. Journ.*, 1902, vol. i, p. 162.

[2] The conjunctiva, especially about the inner canthus, is a region occasionally affected, and one which requires special skill in the necessary technique.

In such cases it is probably best that light and operative treatment should be combined.

(2) **X-Ray Treatment of Lupus.** This method of treatment is especially indicated when there is much ulceration. Its action appears to be less penetrating, and is therefore less effective than the Finsen light. It is frequently employed in conjunction with the latter. Under the action of the X-rays the ulcerated surfaces will usually quickly heal, and the Finsen light may then be employed to complete the cure. Most of the remarks made as to the advantages and disadvantages of light treatment also apply to treatment by X-rays. There are, however, two additional dangers to be considered. These are the supervention of dermatitis and of epithelioma. The latter serious complication is by no means uncommon. The following case furnishes an excellent example.

Alice L., aged 13 years, was admitted to Guy's Hospital in July 1911 for lupus of the buttock, knee and right shoulder. In the latter situation, in the centre of a large patch of lupus which was cicatrizing, there was an ulcerated area with a depressed base and raised everted edges. There were also enlarged glands in the right axilla. The disease appeared when she was 2½ years old shortly after an attack of measles. Six years before admission the patches were scraped but the disease recurred. Since then she had light and X-ray treatment: owing to the extent of the disease a very large number of sittings were required extending over several years. Under this treatment the patches on the knee and buttock healed completely and the shoulder much improved, but the deep ulceration made its appearance a few weeks before admission. The growth was freely excised and the axillary glands removed. Histologically the former was an epithelioma, but the glands were tuberculous. The patient died a year later with extensive recurrences.

(3) **Excision.** This is a very useful method for patches of lupus situated on the trunk or limbs. For the face, where lupus is chiefly met with, it is more rarely applicable, save in the case of small patches. It is almost impossible to make sure, unless by cutting more widely and deeply than is permissible here,[1] that the incisions lie in really healthy tissues. It is by no means easy to get away satisfactorily the diseased portion owing to their friability and the delicacy of the subjacent fat, and it is only by cutting very widely that it is possible to make sure that the infiltrated area, invisible to the unaided eye, is removed. Hence the frequency with which, within a year, minute reappearances are seen. It is extremely difficult to maintain strict asepsis during the healing of wounds near or on the nose or lips—very common sites of the disease; and the same fact, with the additional one that it is not always possible to obtain a level surface free from disturbance, interferes with the vitality of grafts in this region. Such wounds are likely to be followed by tedious healing largely by granulation, and scars, often prominent and keloid. Later on, when the incision wound is healed, small red spots of reappearance are very commonly met with in and around the scars. For these reasons excision is not advised here, save in the forehead, where the laxity of the soft parts admits of the free use of the knife. If used with the freedom which is absolutely requisite, it entails needless mutilation, especially on parts like the nose and cheek. It will be said that covering the fresh wound with grafts of living epidermis will prevent any contraction and deformity. Theoretically it will, but practically such a

[1] Mr. Bidwell, in the discussion at the Medical Society on Mr. Bruce Clarke's paper (*Med. Soc. Trans.*, 1893, p. 298), "recommended that in long-standing cases the subcutaneous fat should be removed in addition to the skin, since it is found to be altered in consistence in these cases." Every surgeon who has operated much on lupus will agree with this advice, but its result on the face in producing scars, if the grafts do not live, is easily to be foreseen.

result is by no means certain on the face, especially in restless children. Finally, erasion, if careful and thorough, and followed by adequate scarification, will bring about quite as good results, and with much less mutilation. The only other part of the face where excision may be widely carried out is in cases of extensive lupus of the lips. Here flaps of skin and mucous membrane may be turned up and down, and a long intervening wedge of the lupus-infiltrated tissue excised, the flaps being united by horsehair sutures. When the wound has healed it will be found that the teeth are somewhat unduly exposed, otherwise excision here gives excellent results. And where long-standing lupus of the face has extended to the gums, excision should be used freely. Teeth should be extracted beyond the limits of the disease, and the alveolar process should be removed with a gouge, as in the operation for epulis, p. 419. Owing to the freedom with which the diseased parts can be cut away here, the result is a speedy and permanent cure. The skill of the dental surgeons of the present day will prevent any resulting disfigurement.

Those who make use of excision must cut wide of the disease, and well into the fat beneath. All hæmorrhage must be thoroughly stopped, as, should it be impossible to bring the edges of the wound together, it is well to apply Thiersch's grafts immediately to obviate the contraction which would follow if the wound were left to granulate for a time, and also to do away with the need of a second anæsthetic. A collodion gauze dressing is more secure than bandages.

(4) **Erasion.** This is most strongly indicated in both the forms of lupus mentioned on p. 388. Combined with scarification, it is the mode of treatment best adapted to the largest number of cases. The best instruments are sharp steel spoons, with oval ends of varying size, some quite small; the best are two in which the curette and pointed scarifier are combined. Several sizes of scoops, down to very small ones, are most essential. One prolific cause of the reappearance of lupus is that the large spoons usually employed miss the smaller deposits lurking in depressions in the corium. Another is that after each application of the curette this or whatever instrument is used is rarely wiped, thoroughly cleaned, and placed in some sterilising fluid; thus, of course, a risk is present of carrying infected tissues into those which are sound. This precaution is often neglected. An anæsthetic having been given, the surgeon, using first one of the larger spoons, goes with deliberate thoroughness over the entire surface of the patch of lupus, using the spoon from below upwards; and if there are several patches, *e.g.* on the face, he begins with the lowest, so that his work shall not be obscured by hæmorrhage. With the spoon all the overlying yellowish-red, greasy crusts, all the surface below these that the spoon finds to be abnormally soft, *i.e.* something like a patch of decay in an apple or pear, are deliberately and thoroughly scraped away. The bleeding, which is usually free, is now stopped by firm pressure. The edge of the sore is then in its turn attacked in the same way, the track of the spoon being next smoothed down by running a pair of scissors, curved on the flat, around the edge of the patch. The surgeon, now that the hæmorrhage is arrested, returns to the surface of the patch. Any suspicious spots are scraped again with a smaller curette. There need be no fear of doing too much and thus causing needless scarring. The deeper layers of the corium are naturally tough and dense,[1] and there is

[1] As pointed out by Prof. Volkmann (*loc. supra cit.*, p. 114), in cases of lupoid ulceration of long standing, an almost fibroid tissue becomes exposed after the diseased parts

no danger of their yielding to the spoon, the action of which is at once checked when the operator, by the change in the sensation of resistance, is aware that he has reached healthy tissues. The bleeding having been again thoroughly stanched, minute nests may often be found lying in pockets amongst the meshes of the corium. These are a potent source of reappearance of lupus, being left after all that is soft and friable has been scraped away. They are to be dug out with small spoons, or destroyed with the scarifier, finely-pointed sticks of silver nitrate, or fine cautery. While the bleeding is being finally stanched, the operator turns his attention to the vicinity of the lupus patch which he has attacked. The minutest points, specks, and nests are scrutinised and destroyed with a fine-pointed cautery. Where the nose or its vicinity is affected, the inner aspect of the orifices should be inspected in case the mucous membrane is invaded. Before the patient is allowed to come round from the anæsthetic, all old lupus scars are examined. Any deposits in them are attacked in the same way, or, if they are the seat of a diffuse hyperæmia and infiltration, linear scarification (*q.v.*) is thoroughly resorted to.

The best application to the surfaces left by erasion has been much disputed. Knowing the inveterate tendency of the disease to reappear in minute islets overlooked (many of them) at the time of the erasion, fine-pointed sticks of nitrate of silver should be applied to the edge and surface of each erased patch, looking out especially for any suspicious specks or nests in the exposed corium. It is a painful remedy, but this objection must give way to its efficiency.

Lotions of hyd. perchlor. (1 in 2000) have the advantage of promoting asepsis, and of a germicide power which may be helpful here in destroying the bacillus with which we have to deal. If much pain be present, hot boracic acid fomentations should be applied. Powdered nitrate of lead is strongly recommended by Messrs. Ashby and Wright.[1] "The repeated application of powdered nitrate of lead has been very useful in our hands, both for lupus and other intractable tuberculous sores; it is somewhat painful, but very effective."

To two other points in the after-treatment attention must be drawn. One, the need of keeping the wounds clean and as aseptic as possible. It is well known how much the ravages of lupus are due not only to the lupus itself, but also to the presence of infecting cocci, this being especially the case on a part like the face, exposed to the air, particularly in regions like the nose and mouth. The second point is that as the wounds granulate there is a marked tendency to scab-formation. Nothing can be more dangerous than the advice sometimes given to leave these scabs alone, as the wounds will heal under them. They should be regularly removed daily, and some such application as equal parts of carbolic oil and compound tincture of benzoin applied to the surface itself of the sore that remains to heal. Any prominent granulations should be sedulously shaved down with scissors curved on the flat. When they become persistent, or the wound stationary—and this is certain—erasion under an anæsthetic is to be at once again resorted to. As in all tuberculous diseases which cannot be cured by one operation, the need of repetition of this, the necessity of prolonged watching and after-attendance, must be clearly accepted by the patient or friends before treatment is commenced.

have been scraped off, a condition which is to be regarded as the expression of reaction in the neighbourhood.

[1] *The Diseases of Childhood*, p. 747.

(5) **Scarification.** This is only useful in the more diffuse forms, and as an aid to erasion; it should be employed in two ways.

(*a*) *Linear.* With a fine and very sharp scalpel the surgeon makes scores of fine delicate cuts, parallel with each other, through the diffuse lupoid deposit, crossing these again with similar delicate incisions at a right angle to the first.[1] Each incision should start and end in sound tissues, the knife being quickly drawn through the lupus deposit. The depth to which the blade is sunk varies with the disease. All the incisions must be made quickly and with a light hand, and care must be taken, as far as possible, not to let them run into each other. The bleeding is extremely free, but is readily arrested by carefully maintained pressure. To save time an assistant keeps up pressure on one patch, while the surgeon attacks another.

(*b*) *Punctiform.* Here hundreds, maybe, of punctures are made in the diffused lupoid deposit, a delicate hand being again required, and a fine sharp scalpel-point, the pointed scarifier, or a large needle being used. In this case, also, every pains must be taken to place the punctures equidistantly. After arresting the bleeding, the surgeon looks carefully over the patch; if at any spots his incisions or punctures are crowded together, with intervening places but little touched, he again goes over the ground carefully.

If, after the completion of these operations, the tissues appear tallowy or whitish, there need be no fear of gangrene, the parts being far too well supplied with blood. The object of scarification is of course to obliterate the lupoid deposit by the formation of scar-tissue. It is also very useful when a scar, though not again ulcerating, remains obstinately dark bluish-red. Scarification is only to be used as subsidiary to the sharp spoon or other methods, especially when the lupus deposit is diffuse. Used by itself as a means of cure, it is tedious and brings about amelioration, not a cure.

An anæsthetic should invariably be given. Repetitions are usually required in severe cases, two or three times at intervals of three weeks or more, or whenever minute reddish specks appear and grow.

(6) **The Actual Cautery.** This method will be found occasionally useful in conjunction with erasion, or where lupus attacks mucous surfaces, *e.g.* the palate, cheek, &c.

In such cases, the patient being placed on one side near the edge of the table, the mouth well opened in a good light, all granulating or ulcerated surfaces are first thoroughly curetted with a sharp spoon. With the blade of a Paquelin's cautery these surfaces are then repeatedly treated, and any infiltrated tissue which has not yet broken down, and thus resists the sharp spoon, thoroughly destroyed. Both the surface and edges of the lupus patches should be energetically attacked, the blade being kept at a cherry-red heat. Care must be taken not to encroach upon the orifice of Steno's duct or to approach too closely the upper aperture of the larynx. As has already been pointed out, another and the chief use of the cautery is to destroy minute foci reappearing in scar-tissue after the use of the sharp spoon or other methods. As soon as such reddish specks appear they should be destroyed by the prickers or

[1] No scarring need be feared from either form of scarification. After three weeks have elapsed, the above incisions, however numerous, if done with proper delicacy, can only be detected by looking for them very closely. In three months it usually requires a lens to find them.

scarifiers mentioned above, or, failing these, by a fine-pointed electric cautery.

(7) **The Application of Caustics and other Chemicals.** This is decidedly inferior to the methods already described. They are apt to destroy portions of healthy tissue, and, at the same time, to leave behind many small lupoid nodules. The application is painful, the wounds heal slowly, and the resulting scars are thick and conspicuous. Silver nitrate in fine-pointed sticks, or acid nitrate of mercury applied on fine glass rods are best. Salicylic acid mixed with glycerine to form a paste, an ointment containing 10 per cent. pyrogallic acid, or a paint composed of hydrarg. perchlor. ℈j, collodion ad ℥j, are also recommended.

General Treatment. This is also of importance. It must be remembered that lupus is a tuberculous lesion, and though no drug has a specific action, the general health must be attended to. Injections of tuberculin have proved rather disappointing; they may, however, be used in conjunction with other modes of treatment.

The following hints will be found useful in the treatment and after-treatment of a disease which is second to none in its frequency, its inveteracy, its power of disfigurement, and for the care and watchfulness required in its eradication.

(1) Unsparing thoroughness is to be employed, especially at the first time of operation; there should be no hurrying; hæmorrhage should be completely arrested, and the minute foci spoken of above, deep-lying as well as superficial, searched for in a good light and energetically destroyed. (2) An anæsthetic should be given each time. (3) The very great probability of relapses and the need of repetition of operations should be explained to the patient and friends, and their co-operation secured from the first. (4) The patients are to be kept under observation for a long time. The points in the scars which at once call for operative steps are the appearance of reddish specks or nodules, one or more scars remaining obstinately dark bluish-red or purple, and the persistent appearance of scales or scabs. (5) As in all tuberculous affections, while local treatment is of the chief importance, the general health must be looked to and every possible step taken to improve it, more especially by nutritious food and the best air obtainable. In brief, routine after-treatment should be as carefully carried out as the minutiæ of the technique at the time of the operation.

OPERATIVE TREATMENT OF RODENT ULCER

Rodent ulcer is a form of carcinoma commencing either in the sebaceous glands or in the deepest layer of epithelial cells of the skin. It may be considered here on account of the frequency with which it occurs on the face. Commencing usually as a small, flat-topped warty growth, its progress is very slow. Though it does not disseminate or involve the lymphatic glands, it eventually extends deeply beneath the skin and causes extensive destruction of soft parts, and even of bone. Needless to say, it is desirable that cases should be treated and cured before this deep ulceration has taken place. The disease occurs in middle-aged or elderly people, and as it is not accompanied by pain or other inconvenience it is often allowed to make considerable progress before advice is sought.

It is now known that non-operative treatment by X-rays or radium will in many cases effect a cure. In deciding whether to recommend this,

or operative treatment, the following points have to be considered: (*a*) The age and general condition of the patient. (*b*) The position of the growth. Treatment is often complicated by its proximity to the eyeball or the nose. (*c*) The presence or absence of ulceration. (*d*) The involvement of deep parts, such as cartilage, bone, &c.

The various modes of treatment will first be considered, and then the indications for selecting each particular form.

(1) **Excision.** In many cases, especially where the disease is not very extensive, this is the best mode of treatment. In such cases, provided that the growth is widely removed, there will be no recurrence. In this form of malignant disease, owing to its extremely slow progress, its long connection with some flat-topped wart, patients sometimes keep on deferring the operation till their age and the extent or situation of the ulcer cause some difficulty in advising or urging an operation. In some of these cases X-ray or radium treatment may be tried, while in others diathermy will offer the best prospect of a cure.

The Operation Itself. In the case of small wart-like growths with but little ulceration and no extension to the deep tissues, the operation is simple. An oval incision is made, care being taken that this is at least a quarter of an inch from the growth. It must extend deeply down to the deep fascia or into the muscle. The isolated area of skin containing the disease is now seized with toothed dissecting forceps and is removed, together with the underlying subcutaneous tissue. The margins of the incision are then brought together with a few salmon-gut sutures. If this is impracticable the wound must be allowed to heal by granulation.

The following hints may be found useful in a more extensive operation:

(1) To diminish the risk of suppuration or of erysipelas the parts should be carefully cleaned and kept as aseptic as possible.

(2) *Steps of the operation itself.* The surgeon first makes a groove-like incision around the whole, or, in a very extensive case, around part of the growth,[1] and well wide of it, and arrests the bleeding by ligature, by Spencer-Wells forceps, or by sponge pressure. The next step—that of removing the affected soft parts—is often difficult, owing to their proneness to break away, and thus giving no firm hold to forceps. Scraping alone is not to be trusted, the base of the ulcer must be everywhere excised. When the growth has extended to bone, the worm-eaten surface must be freely removed with the gouge or chisel. In one region especially these must be used with the greatest caution, *i.e.* where the paper-like bones on the inner wall of the orbit are involved; in this place, if the surgeon is not satisfied with the limited use of the gouge or chisel, which is alone permissible here, he must be content with finally applying Paquelin's thermo-cautery.[2] In other places zinc chloride paste may be fearlessly employed, as long as precautions be taken to apply it in a thick paste and as little of it as possible, so that the discharges from the wound shall not allow it to liquefy and run either towards the eye or nose or throat.

(3) *Question of Removing the Eye in cases where the Conjunctiva is involved.* As a rule consent should be obtained when it is thought that this step may be needful. Cases clearly requiring it will be those where,

[1] In such cases complete excision will probably not be possible. Diathermy (*q.v.*) is likely to be useful.

[2] In this situation there is a possibility of damage to the eyeball if the high frequency current is employed.

(*a*) the eye is already useless or so distinctly deteriorated that it cannot improve; (*b*) where the lids have shrunk away from it, and left it irritable and painful from exposure; (*c*) where the disease cannot otherwise be removed or eradicated.

The After-Treatment. (1) The chief object here is to keep the wound scrupulously aseptic. Should suppuration threaten, the wound should be gently packed with aseptic gauze, and over this a boracic fomentation applied and renewed at frequent intervals. If caustics or the high frequency electric current have been employed, morphia may be required for the first day or two. The bowels must be kept acting regularly. (2) *Secondary Hæmorrhage.* This is rare, but it may occur when the sloughs separate if caustics or any form of cautery have been used. (3) *Reappearance.* The patient must always be most carefully watched, and, in the case of extensive and deep disease, any suspicious granulations, or, at a later date, induration of the scar, that appear, must be attacked at once. (4) After a severe operation, when there is much deformity, a plastic operation—*e.g.* the bringing down of a flap from the forehead, where this is possible—should be performed; and, this failing, much may be done by a well-made vulcanite or other artificial mask or obturator.

(2) **X-Ray Treatment of Rodent Ulcer.** Much of what has been said about the light treatment of lupus is also applicable here. In many cases the disease heals fairly rapidly with X-ray treatment but recurrences are very frequent. The patient will therefore have to be kept under observation, and any suspicious induration or recurrent ulceration again receive attention. The most suitable cases are the superficial ulcers, even when these are of considerable extent. Where there is much deposit about the edge and base, the outlook is less favourable, and the time required will certainly be much longer. In the later stages of the disease, when the deep tissues are involved, X-rays are often ineffective. In any case if no benefit results, the treatment should not be persisted with, but some other method should be employed. It is always advisable to continue the X-ray treatment for some little time after the ulcer has apparently healed in order to guard against recurrence. Cases in which X-ray treatment should be employed may be grouped as follows: (*a*) Cases of superficial ulceration or of the warty growth which precedes ulceration, especially when the growth is situated near the eyelids or in some other situation which renders excision undesirable. (*b*) Cases where Steno's duct or the facial nerve are involved. (*c*) In old people in whom operation is not considered advisable. (*d*) In some advanced cases, as a palliative measure, and in the hope of relieving the pain.

The resulting scar is usually supple and inconspicuous, but the resulting deformity will, of course, depend upon the extent of the disease. Finsen light is much less effective than the X-rays and is but seldom employed.

(3) **Curetting.** This form of treatment should not be employed except in conjunction with other methods, especially with excision, and when it is intended to destroy the growth with the help of the high-frequency current (*vide infra*). The use of caustics, too, has been practically superseded by more modern methods of treatment, though chloride of zinc paste is a valuable local application.

(4) **Freezing by the application of solid CO_2** is sometimes used as an aid to other methods of treatment.

Ionisation is sometimes employed in the early stages. Zinc sulphate

or chloride are the salts usually employed. For full information about this method a special work should be consulted.

(5) **Radium Treatment of Rodent Ulcer.** This, on the whole, is more satisfactory than X-ray treatment. In the early cases there is less likelihood of recurrence, and when there is deep ulceration radium is more likely to be successful in arresting the progress of the disease. The two modes of treatment may be combined in the same patient. In some cases, usually far advanced, neither X-rays nor radium has much effect, and the disease steadily progresses in spite of all treatment. It is in these cases that diathermy (*q.v.*) is especially indicated.

(6) **Fulguration and Diathermy.**[1] It will be convenient to mention here the attempts which have been made to destroy and eradicate new growths by the use of the high frequency electric current, especially in cases where the situation, the extent, or the relations of the growth render its complete removal by ordinary surgical means impossible. Fulguration was introduced by Keating-Hart, of Marseilles, in 1906. The growth is first removed as completely as possible by the knife, scissors, and curette, and then the electrode is applied to the surrounding tissues which are suspected to still be infiltrated by the growth.

In fulguration the ordinary high-frequency apparatus is used and is so tuned that a spark three inches in length is given off from the electrode connected with the top of the resonator. This electrode is merely a wire fixed in an insulated handle, and the spark from it is directed over the surface of the wound, from which all haemorrhage should be stopped as it is impossible to spark on to a fluid. This operation lasts for ten to twenty minutes and no change visible to the eye is produced. Every portion of the wound must be systematically treated, and it is essential that the length of the spark should not be less than three inches. If the operation can be repeated once or twice at intervals of two or three days the result is more likely to be successful and there is no likelihood of causing harm by overdoing the treatment.

In diathermy the same apparatus is employed, but instead of taking the current from the top of the resonator two electrodes are connected with the outer coats of the condensers. The resonator is tuned so that a short dense hot spark is produced. If the two electrodes are placed in contact with the patient a continuous line of heat is produced between them, and if one is small and the other large the high temperature is at the former. Hence the large electrode represented by a large sheet of metal is placed in contact with the patient's back and the small one is applied to the wound. This effect is produced much more conveniently and easily by the various diathermy machines now made. If the temperature is raised sufficiently a zone of coagulation is produced around the smaller electrode.

The surgical measures should, if possible, be the same as those used before fulguration, but the need for complete removal is less as the extent of destruction of tissue that can be produced is unlimited. The whole diseased surface is systematically treated, care being taken that the electrode does not remain in contact with any one spot for an undue length of time. As a general rule it is better to stop short of actual coagulation, especially when important structures are in close proximity. This treatment, like fulguration, immediately follows the surgical treatment, and, as a rule, takes about five minutes.

The effect of diathermy is to produce a cauterisation and coagulation of the tissues. It differs from the ordinary cautery in that the superficial action is far less but that the penetration of the coagulation is remarkably deep. Morbid cells and structures seem to be much more readily destroyed than normal tissues. The mode of action of fulguration is more uncertain, especially as, with this method, there is no cauterisation or coagulation. Dr. C. E. Iredell and Mr. Turner have tried fulguration and diathermy in a number of cases of malignant disease (epithelioma, carcinoma, and sarcoma), mostly in a very advanced condition, rodent ulcer, especially in advanced cases where other modes of treatment have failed, and in one case of very advanced tuberculous glands in the neck with many sinuses. Though not obtaining the results obtained by Keating-Hart, Juge, and others, it would certainly seem from the results obtained in these cases that the high-frequency current does have a very considerable local action in destroying the growth. Diathermy is certainly much more effective, especially where obvious masses of growth remain after the pre-

[1] These notes have been supplied by Dr. C. E. Iredell.

liminary surgical treatment. In many cases of malignant disease where the treatment of the local condition was attended with success, a fatal result followed from secondary deposits in glands or viscera. Hence these methods of treatment are only likely to be attended with complete success in the case of extensive localised new growths without any secondary deposits. This is unlikely to be the case with epithelioma and carcinoma, but this is the condition met with in advanced cases of rodent ulcer. Diathermy can be strongly recommended here as shown by the following case:[1]

Walter M., aged 56, was admitted to hospital in 1910 under Mr. Turner for a large rodent ulcer which had perforated the right cheek from the angle of the mouth to the anterior border of the masseter, and had also invaded the muco-periosteum of both the superior and the inferior maxillæ. The disease appeared nineteen years before in the form of a pimple; ulceration had been present for five years. In 1907, as the result of X-ray treatment, the ulcer cicatrised. About a year before admission the scar broke down and ulceration rapidly extended. Radium and X-ray treatment were tried for six months without benefit. At the operation the surface of the ulcer was curetted when a backward extension in the soft parts of the cheek beneath the masseter was found. The curetting was followed by an application of diathermy by Dr. Iredell. After ten days a number of superficial sloughs separated, leaving a healthy granulating surface. A sequestrum also separated from the superior maxilla, leaving a large opening into the antrum. The ulcer completely healed in about three months, the gap in the cheek being closed by an obturator suggested by Mr. F. J. Pearce. A year later a small recurrence about the size of a pea was excised, and the patient has since remained well.

The case of tuberculous glands treated by diathermy was remarkably successful, all the sinuses healing firmly and remaining sound after three years. The resulting scar after both fulguration and diathermy is surprisingly supple, and the deformity is much less than after application of the actual cautery.

REMOVAL OF PAROTID GROWTHS

The question of operation arises here under three somewhat different conditions, viz.:

(i) In the case of ordinary parotid growth.

(ii) In that of a sarcoma of the parotid, which has often started in the growth just mentioned.

(iii) In carcinoma of the parotid.

(i) **Removal of an Ordinary Parotid Growth.** These well-known growths, containing a mixture usually of fibro-cartilaginous, myxomatous, and imperfect glandular tissue, require no special allusion here, beyond the need of: (1) Exposing them sufficiently; (2) paying strict attention to the facial nerve; and (3) removing the capsule itself, after the growth has been shelled out, in any case of doubt—viz. soft consistency, or rapid growth.[2] (4) *Watching the After-Result.* This must be insisted upon, owing to the view recently held that these growths often originate in endothelial, not connective, tissue elements: in other words, that they are endotheliomata. If so, recurrence is always possible.

(ii) **Operation in Sarcoma of the Parotid.** This disease usually begins in one of the growths just mentioned; and here the malignant change

[1] *Proc. Roy. Soc. Med., Clin. Sec.*, vol. v, 1912, p. 95.

[2] On the Enchondromata of the Salivary Glands by W. H. A. Jacobson (*Guy's Hospital Reports*, vol. xxvi): "If the wound be made too small in the first case for fear of a scar, the edges will only be bruised, and primary union prevented. It is not uncommon for branches of the facial nerve to be in relation with the capsule of the growth, and if this has been much handled, or treated by counter irritation, they may very likely be firmly adherent. In either case injury to the nerve may be best avoided by slitting up the capsule and shelling out the enchondroma first. The capsule should then be examined to see if any nerve branches are adherent to it; after these have been separated, the capsule itself should be removed. This should always be done to prevent any recurrence, as the peripheral part of these enchondromata is often adherent to the capsule itself."

is often sudden and rapid, after a long benign period. This and the next group may, as far as operation is concerned, be considered together.

(iii) **Operation in Carcinoma of the Parotid.** The question of the advisability of interfering at all with really malignant growths of the parotid, especially carcinomata, has been much disputed, but as each case must be decided by itself, and as no hard-and-fast line can be laid down here, some useful practical points may be mentioned. Attention must be strongly drawn to the fact that reports of operations are often brief, and that too often they are published as soon as the patient leaves his surgeon, and thus two-thirds of their value are lost. There is scarcely any part of the body in which a malignant growth so quickly obtains a firm hold on the surrounding structures—a fact which has even a graver bearing on the operation than the importance of these structures themselves.

A case of carcinoma of the parotid, successfully removed, in a woman of 72, is recorded.[1]

At one spot the skin was adherent and ulcerated. The entire gland was extirpated, together with the affected skin, extending up as far as the temporal region. It was found needful to tie the external carotid, and the facial nerve was also necessarily sacrificed. The upper part of the sterno-mastoid, being infiltrated, was removed. The patient was well eight months later.

PRACTICAL POINTS IN THE REMOVAL OF PAROTID GROWTHS

Characters of the Growth. Amongst the most notable of these are :

(1) *Mobility*, viz. how far it can or cannot be lifted up by the fingers from the subjacent parts.

(2) *Rapidity of growth.*

(3) *Density.* Thus a great hardness or softness will be alike unfavourable, the latter from the fact that such soft growths will break down during attempts at removal, and leave a part behind.

(4) *Symptoms of pressure*, especially of deep pressure upon the pharynx. Of these, dyspnœa, dysphagia, presence of outlying masses in the fauces, alterations in speech and in hearing, and to a somewhat less degree facial paralysis,[2] are of evil omen.

(5) *Conditions of the overlying skin.*[3]

(6) *Involvement of the upper part of the sterno-mastoid*, sometimes giving the appearance of torticollis.

(7) *The presence of infiltrated glands*, especially if these involve the large vessels and nerves of the neck.

Points in the Operation Itself. To begin with, the growth must be sufficiently exposed by adequate incisions. Probably none will be more generally suitable than a ⊢-shaped incision, the vertical portion lying over the larger vessels, and the transverse one lying parallel with the zygoma and exposing the facial part of the growth and its accessory portion.

If the skin is adherent at any spot this should be included. The flaps are freely dissected back, covered with sterile gauze, and the hæmor-

[1] *Amer. Journ. Med. Sci.*, 1893, vol. cv. p. 144.

[2] Prof. Billroth, quoted by Mr. Butlin (*loc. infra cit.*, p. 118), considers that facial paralysis from the pressure of a parotid growth is a sign that this is probably a carcinoma, for the sarcomata and other tumours rarely produce paralysis by pressure, although paralysis frequently follows operation for their removal.

[3] The more adherent, discoloured—viz. reddish-purple—are the integuments, the more unfavourable is the prognosis.

rhage, which is often free, even at this early stage, entirely arrested. The surface of the growth, in its capsule, if one be present, having been completely exposed extirpation is begun below and behind, not from above downwards. This course allows of securing the external carotid or of putting a temporary ligature on the common carotid (*vide infra*), and further, as pointed out by M. Berard:[1] (1) The blood flows away from the wound, and not over the instruments of the surgeon. (2) The same vessels do not need to be tied more than once. Next, the growth is freed at the sides and above. This step is comparatively easy over the parotid, but adhesions to or infiltration of the sterno-mastoid will be difficult to deal with. There should be no hesitation in removing the upper part of the muscle. Every vessel is carefully secured, and oozing is checked by firm pressure while the surgeon is engaged with some other part of the growth. Gradually, as the growth is pulled in different directions and freed by blunt dissection—a strong pair of blunt-pointed curved scissors, used both closed and opened, will be found very useful—the growth comes forward more and more, and is finally only attached above the styloid process and pharynx. Here any bands of fascia, or what looks like fascia, must be carefully examined and ligatured if needful; the upper part of the external carotid or its terminal branches must be found and ligatured if possible, before they are divided. There must be no hurrying at this stage, and the wound must be bloodless while any deep dissection is going on.

In addition to the free oozing, and the presence of important vessels, other difficulties which may present themselves are the breaking down of a soft growth, thus baffling attempts at complete extirpation, and the strong processes of fibrous tissue which, passing normally from the parotid to some important adjacent structures—viz. the digastric, the internal pterygoid, and the carotid sheath—are now liable to be either increased in density, or softened by extension of the growth. Where the surgeon is uncertain as to complete extirpation, diathermy (*q.v.*) is especially likely to be useful, and in these and similar cases where the complete extirpation of the deeper parts of the growth is doubtful, arrangements should be made beforehand to have the necessary apparatus and assistance at hand, in case the need of employing them should arise. Should the apparatus not be available the actual cautery, zinc chloride paste, or sulphur may be tried. If any bleeding persist low down, Spencer-Wells forceps should be left on for thirty-six hours. Drainage from the deepest part of the wound is always to be employed. Two points require special attention here—viz. the amount of facial paralysis which may be expected,[2] and the hæmorrhage.

Facial Paralysis. While in the case of a smaller growth, if the nerve has only been bruised, or, when divided, if the ends have been placed in contiguity, union may take place, and the paralysis gradually disappear,[3] in the case of really malignant growths the question of future deformity must be set aside, and the nerve divided as soon as seen.

[1] *Maladies de la Glande Parotide*, p. 240.

[2] If the surgeon, especially in less serious cases, when making any deep incision that is needful, can manage not to go above the level of a line drawn horizontally three-quarters of an inch below the lobule of the ear, he will avoid any serious interference with the trunk of the facial nerve, and thus escape the risk of permanent paralysis.

[3] This gradual improvement is alluded to, with a case in point, in Mr Jacobson's article, *loc. supra cit.* Mr Butlin (*Operative Treatment of Malignant Disease*, p. 120) suggests nerve suture.

Best Modes of meeting Hæmorrhage. The chief vessels which will be met with are the superficial temporal, transverse facial, occipital, posterior auricular, internal maxillary, and external carotid. The external jugular vein and the large communicating branches between it and the internal jugular are sure to be cut, while the internal jugular vein is almost certain to be seen in the bottom of the wound.

It must be remembered that not only will all the above vessels be liable to be much enlarged, but numerous other unnamed anastomoses will be present.

The common carotid has several times been tied prior to this operation. Ligature of the external carotid, with all the accessible branches, is greatly to be preferred (*q.v.*). If ligature of the common carotid is to be made use of here, it should be reserved for those cases in which the surgeon decides to attack a very soft and vascular growth, as here the vessels may be very numerous and difficult to isolate, and ligatures may not hold. In such a case, instead of tying the common carotid and thus exposing the patient to the risks of brain mischief, it would be better to pass a loop of chromic catgut ligature around the vessel, loosely tied, and to ask an assistant to keep up tension on this whenever bleeding takes place. This method seems to have been first used by M. Roux, and later by Mr. Rivington[1] and Sir F. Treves.[2] (*See* section on "Ligature of the Common Carotid.")

In dealing with any large veins, the risk of the entrance of air should be prevented by making finger-pressure on the cardiac side, or by securing them with double ligatures before they are cut.

If the wound has become infected—and sometimes in these operations near the mouth and nose it is impossible to keep the bandages from shifting—the surgeon must always be prepared for the accident of secondary hæmorrhage. And on account of the same risk the actual cautery should never be used at the bottom of a very deep wound near to any suspicious tissues, if it can possibly be avoided.

OPERATIVE TREATMENT OF NÆVI[3]

The first question which usually arises is whether these growths should be operated on at all, or whether they may be safely left to themselves. While there is a distinct tendency for nævi, after a longer or shorter time, to undergo a fibroid change, spontaneous disappearance is too rare to be confidently reckoned upon. In private practice, where a nævus is not extending,[4] where it is in neither a dangerous nor a conspicuous place, it is justifiable to watch the nævus, remembering that the times of teething and of puberty may bring about atrophy or increase, and that the former, while often spontaneous, is most likely to follow one of the exanthemata. But where a nævus has any of the cavernous element

[1] *Med.-Chir. Trans.*, vol. lxix. p. 72.

[2] *Lancet*, January 21, 1888.

[3] This is a convenient place to consider this subject on account of their frequency and great importance on the face.

[4] "In certain cases the surgeon can, with some degree of certainty, foretell the progress of the nævus. If it is uniformly compressible, soft, and highly vascular, approaching to a bright red colour, especially at the margins, it is fairly safe to predict that it will increase in size" (Mr. Waterhouse, *Clin. Journ.*, August 25, 1897). Mr. Waterhouse also advises that the surgeon should hold his hand in all nævi which are not increasing, in infants. Most of such cases, however, are suitable for non-operative methods of treatment.

about it, when it occupies a dangerous site, one where irritation of any kind is likely to bring about hæmorrhage—*e.g.* scalp, lips, tongue, palate, genitals, rectum, fingers, or toes—or where the site is a conspicuous one no time should be lost in effecting a cure. While admitting that, after a year, there is a distinct tendency for a nævus to become stationary, and often to degenerate ultimately, treatment, operative or non-operative, should be advised in nearly all cases, for the following reasons: (1) During its growing and stationary stage the nævus is always a source of anxiety, and often of disfigurement. (2) This growing stage commonly lasts for the first year. When a nævus appears to be stationary, or even cicatrising at its centre, it may be spreading at its periphery. (3) There is often great difficulty in persuading a mother to put up with any deformity that is remediable in her child. (4) In early life nævi are usually small, and easily and safely cured. (5) The spontaneous cure of a large nævus may leave, by puckering or redundant folds of the skin, more deformity than that of an operation. Before describing the various modes of treatment it may be pointed out: (*a*) that there is no method suited to all cases; (*b*) that it is very easy, by using heroic means and doing too much, to cause needless scarring; (*c*) that during the cure of large nævi in early life the patients are liable to pyrexial attacks and grave malaise. These are not at all uncommon during the cure of large nævi, even though asepsis be maintained.

Non-Operative Methods of Treatment. These, especially radium and the application of solid CO_2, have in recent years been most extensively and successfully employed.

(1) **Solid CO_2.** This is especially useful in the treatment of the very common small capillary nævi, which occur on the head or face. It may safely be employed when the eyelids are involved. The CO_2 "snow" is compressed in a tube to form a rod-like pencil. This is firmly pressed against the nævus for about fifteen to twenty seconds. A boracic-acid ointment dressing is then applied. The treatment will probably have to be repeated on two or three occasions. The application is practically painless.

(2) **Radium.** This may also be employed for capillary nævi, especially when they are extensive. Its action is more penetrating than that of CO_2, and hence it may be used for cavernous nævi. It is also more effective than CO_2 in the treatment of extensive "port-wine stains." It gives an excellent scar, but the treatment is more prolonged than with CO_2, and it is of course more expensive.

(3) **Application of Caustics,** *e.g.* sodium ethylate and nitric acid. These may be used for cutaneous nævi. Ethylate of sodium, introduced by the late Sir B. W. Richardson, is the one generally used as being least painful. It should be applied daily for two or three days; a crust then forms; when this drops off, the nævus will be found to be cured if the application has been sufficient. Nitric acid is much more powerful; careless use of it may produce most odious scars. Whatever caustic is used, it is well to smear the skin around with vaseline, and the pointed wood or glass rod used should carry only just enough of the acid, and none to drop about.

(4) **Collodion.** This may be tried in tiny cutaneous nævi in infants. These can, however, be better treated otherwise. In nearly all other nævi it is a placebo, but not always a harmless one, as it wastes time.

(5) **Vaccination.** This is not to be recommended. It often fails to cure the nævus, and the resulting scar may be very disfiguring.

OPERATIVE METHODS OF TREATMENT

(1) **Excision.** This method may be employed for nearly all subcutaneous and mixed nævi, save those on the face, and for many large cutaneous ones where the scar will be hidden. It is a rapid method; healing by primary union may be expected, and there is no slough to separate, as is the case with the cautery or ligature, and no repetition is

required, as with electrolysis. Two points require notice: one is the risk of hæmorrhage. This is met by working rapidly, by judiciously applied finger-pressure, by keeping wide of the nævus (if the incisions are made outside the nævus the hæmorrhage is not serious, save in large nævi in infants). The late Mr. J. N. Davies-Colley recommended, in cases where severe bleeding might be expected, that two needles be passed, beneath the base of the nævus, at right angles to each other, and twisted around and below them a fine drainage tube clamped and thus kept tight by Spencer-Wells forceps; below all, two or three silver sutures are passed deeply. After the nævus has been removed, the needles and drainage tube are withdrawn, and, before bleeding can occur, the sutures are quickly twisted up. The other point is the advisability of leaving any nævoid skin in the excision of a large mixed nævus. While the greater part of the diseased skin should always be removed, narrow strips left on either side will, usually, slowly take on a natural colour. The wound is carefully united with sutures of fine silkworm gut or horsehair. Usually no drainage is required. Where, after excision of large nævi on parts concealed, such as the trunk and limbs, it is impossible to bring the edges of the wound together, skin-grafting by Thiersch's method (*q.v.*) may be employed. Caution must be exercised in the excision of subcutaneous nævi over the abdomen in infants or little children. In these cases there will be an additional need for strict asepsis, for, at this age, the abdominal wall is extremely thin, and, if suppuration occur, a fatal peritonitis may result. In some instances of deep-seated extensive nævi of the side of the face, excision can only be used in conjunction with other methods, such as electrolysis. In such cases excision should, whenever possible, be employed first, before the parts are altered by the electrolysis. One more occasion when excision will, sometimes, be found useful, is when a nævus has been cured by some other means and an ugly scar left, *e.g.* at the root of the nose. If it be possible to get the edges together and to secure primary union, excision will, here, greatly improve matters.

(2) **Electrolysis.** This method is less employed than formerly owing to the improved results obtained by other methods of treatment such as radium and solid CO_2. It has, however, the great advantage of leaving a minimum of scar, and what scar there is, is of good colour and does not tend to contract. Other advantages are that there is no bleeding, no danger, and little or no pain after the operation. The chief disadvantage is that it requires several sittings—on an average, four or five—and, as an interval of six weeks should elapse between the sittings, the treatment is spread over a considerable time. For this reason the method is not suited to hospital patients. With patients in a better rank of life, the following should be insisted upon: (1) That, while electrolysis is not expeditious, it is the slow, gradual fading of the nævus which gives the best after-result. (2) That the chief object of the operator is to stop the growth, and then to wait patiently, unless the nævus redevelops, or its subsidence is much delayed. Electrolysis is best suited to those nævi which are unsuited to excision, and where the cautery will leave a conspicuous scar, *e.g.* upon the face, and especially upon the eyelids and nose.

Dr. H. Lewis Jones, who has had large experience at St. Bartholomew's Hospital, thus describes his methods in the *St. Bartholomew's Hospital Reports*, vol. xxx, p. 206. He considers the unipolar method the most useful.

"Needles of platinum having been connected with the negative pole, the circuit

is completed through the patient's body by means of a wet moistened pad attached to the positive pole and placed underneath the patient's back or hips. Small currents are employed and the nævus is treated gradually.[1] The reason why this plan is preferred is because it gives the operator one set of needles only to manage; the density of the current in the nævus is more easily distributed; the changes produced at each of the needles is alike, and there is little or no bleeding when they are withdrawn. Further, the systematic use of the same pole makes it easier to recognise the appearances which indicate that enough has been done so as to stop the electrolytic action before the stage of complete destruction and sloughing. The objections to the unipolar arrangement of needles are that the current traverses the body of the child, who may therefore be affected by electric shocks, and the positive pad, if not carefully managed, may produce an undesired electrolysis in the wrong place. The first of these objections is not serious unless the nævus be situated on the head, and even then with proper care it becomes slight, if one remembers that the needles should be inserted and removed singly and gradually, and the full strength of the current turned on after the insertion of the needles, and turned off before they are all removed. The other danger—that of electrolysis at the seat of the positive pad—can be guarded against by strict attention to the pad and conducting wire; both must be completely covered by moist material, as the smallest portion of uncovered metal will produce destructive effects at the place where it touches the skin."

The bipolar method, in which both poles are inserted into the nævus, is carried out by Dr. Jones by means of his fork electrodes, in which two to five needles can be arranged, firmly, parallel to one another, thus easily controlled and evenly distributing their action on the tissues. If the needles are used in the ordinary way, care must be taken to keep them parallel, not to allow their points to come in contact, thus producing needless shock, and to keep them at regular distances from each other, from the centre to the periphery of the nævus, so that the whole of the nævus, centre and periphery alike, may be acted upon. If the needle-points converge to, and thus the current is concentrated in, the centre of the nævus, sloughing is likely here, while the periphery will escape. As to the strength of current used, Dr. Lewis Jones advises as follows: "The best way of specifying the current is to take into consideration the number of needles used, and to say that for every inch of needle in the nævus, twenty to thirty milliamperes is sufficient. Thus, if four negative needles are inserted to a quarter of an inch apiece, the total current may be twenty or thirty milliamperes." The needles used may be of platinum, one advantage of which is that they may be attached to either pole. The only objection to them is the difficulty of rendering them really sharp. If steel or copper needles are used they must be attached to the positive pole. The needles should be isolated with vulcanite for a full half of their length, otherwise sloughing will occur at the point of their puncture. Before use the needles should be boiled. When introduced their points must not be allowed to approach the surface of the nævus too closely, or sloughing, and, later on, sepsis, will occur. The progress of electrolysis is best judged by the induration which takes place, also by any discoloration at the points of entrance of the needles. A greyish spreading zone here indicates that it is time to withdraw and re-insert the needle. Blackening at any part denotes that sloughing will ensue there. Before the needles are withdrawn the current should be shut off, but not abruptly.

[1] It may be taken as a principle of the electrolytic treatment that the current should not be pushed to such an extent as to cause the nævus to slough. It follows as a rider to this that electrolysis can very seldom be used so as to get rid of a nævus at one operation, unless it is quite a small one, for where this is attempted the result is almost certain to be a slough, and should be regarded as an unfavourable termination. If the nævus is very small, say under a fifth of an inch in diameter, it may be completely destroyed in one sitting.

The only dressing needed is a little antiseptic wool or gauze, kept on with collodion till the punctures are healed.

(3) **The Cautery.** Paquelin's cautery is usually employed, the large blade at a cherry-red heat being carefully wiped over a cutaneous nævus, and the fine point used for the subcutaneous ones. This is made to penetrate the skin at one spot, and then made to traverse the nævus in several directions from the one puncture. It is an effectual method, but has the disadvantage of leaving large and unsightly scars. Thus the black sinus or sinuses left after the operation with a red margin of scorched skin suppurate and heal tediously, with much disfigurement in exposed places. Furthermore, while the slough is being detached, the health of the infant or little child often suffers considerably. A small-sized Paquelin's cautery is greatly to be preferred, but best of all is an electric cautery with fine platinum points. If, in hospital practice the surgeon arranges for his nævus cases to attend on one day, there should be no difficulty about the apparatus being in working order. The amount of scarring is far less than with the Paquelin's cautery. No anæsthetic is required with either apparatus in infants, the pain being momentary. Attention may here be drawn to a most useful warning by Mr. Waterhouse. "In mixed nævi it is necessary to procure destruction of the subcutaneous portion of the growth, and the cure of the cutaneous part as a rule follows. Times without number have I seen cases in which the treatment adopted has been destruction of the skin portion with caustics. This has resulted in ugly scarring, and the subcutaneous portion of the growth has not been in any way influenced for good." A very simple form of cautery for those stellate patches which appear on girls' faces long after infancy, "spider nævi," is supplied by a needle heated or dipped in nitric acid. An anæsthetic should be given. Another excellent means of treating small nævi is to make a puncture with a tenotome, and apply for a few seconds a fine-pointed stick of silver nitrate.

(4) **Subcutaneous Discission.** This method of obliterating a nævus without scarring was introduced by Dr. Marshall Hall. A cataract needle or fine tenotome is passed from a point about a line from the margin of the nævus to the opposite extreme edge of the growth. The needle is then withdrawn almost to its point of entrance and pushed again through the nævus at about one-sixteenth of an inch from the line of the first puncture, and so on till the lines of puncture take a fan-like shape. The number of times which the needle is passed will vary, according to the size of the nævus, from ten to forty. Each passage must be just removed from the last. Should the needle penetrate the skin, pressure must be applied. This method is best adapted to subcutaneous or mixed nævi of moderate size.

(5) **Ligature.** This method, though formerly often employed, has been practically given up, owing to its painfulness, its production of a slough and large scar, and the great chance that part of the strangled mass may escape obliteration.

(6) **Injection.** This again is practically an obsolete method of treatment. Several cases suddenly and instantaneously fatal from thrombosis have occurred. It should certainly never be employed unless the nævus is secured with ring-forceps or by means of temporary ligatures. A preparation of iron, iodine, or pure carbolic acid has been used.

Port-Wine Stain. This troublesome form of cutaneous nævus is best treated by radium. Should this be impracticable, the careful use of

caustics, linear scarification, or the platinum cautery at a white heat, may be tried. The latter should barely touch the surface of the stain. Whichever method is used care must be taken not to destroy too much *e.g.* no more than the epidermis and superficial layer of the rete mucosum —in the cases where the stain is thinnest and most diffuse. Cicatrisation will do the rest. The maintenance of asepsis is of great importance.

Large Hairy and Pigmented Moles. The methods at hand in these very troublesome cases are excision followed by grafting, electrolysis, and the use of caustics or solid CO_2. Where they descend from the forehead and encircle the eye, every precaution must be taken not to destroy the tarsal plates. Where a large isolated patch occupies one cheek, excision and grafting, either by Thiersch's or Wolfe's method, may be tried.

CHAPTER XVIII

EXCISION OF THE EYEBALL

THE general surgeon may at any time be called upon to perform this operation. It should always be practised upon the dead subject, and for these reasons is described here. Indications :

(i) New growths, *e.g.* glioma of the retina, melanotic sarcoma of the uveal tract.

(ii) In the following cases of injury and its results :

(*a*) The eyeball ruptured and collapsed after a blow.

(*b*) If, though the wound be small, it lie in the dangerous region, and have already set up irido-cyclitis.

(*c*) When lens, iris, and vitreous have been extruded, the eyeball is filled with blood, and there is no perception of light. In cases where the lens is extruded beneath the conjunctiva, which is intact, an attempt should be made to save the eye.

(*d*) A large jagged, foreign body in the eye, *e.g.* a bit of metal, not removable without inevitable disorganisation.

(*e*) If the wound lying wholly or partly in the dangerous region, be so large and so complicated with injury to deeper parts that no hope of useful sight remains.

(*f*) Where there is a wound in the dangerous region complicated with traumatic cataract.

(*g*) Where a small foreign body, *e.g.* a shot glancing in cover-shooting not removable by an electro-magnet, gradually sets up inflammation and shrinking of the eye.

(*h*) Where traumatic cataract has been caused by a wound which is wholly corneal, and therefore out of the dangerous area, and yet severe iritis and pan-ophthalmitis come on in spite of treatment.

(iii) As part of an operation for rodent ulcer which has extensively involved the conjunctiva

(iv) Occasionally in the course of excision of the superior maxilla where the growth has invaded the orbit.

(v) As part of an operation for the removal of orbital tumours, *e.g.* a glioma or sarcoma.

Operation. The chief object is to remove the globe alone, whenever this is possible, leaving the muscles to coalesce and form a stump on which the artificial eye may rest and be movable. As much conjunctiva as possible should be left. The surgeon, standing in front, having inserted a spring speculum between the lids, snips with blunt-pointed scissors through the ocular conjunctiva close to the cornea and all round it, using small toothed forceps to lift the conjunctiva, and leaving enough at one side to hold on by the forceps during the next step. This is to open freely Tenon's capsule, and catching up each rectus tendon (beginning

usually with the external rectus) with a strabismus hook, to divide them close to the sclerotic, leaving the cut end of the external rectus long, in order to draw the eyeball forcibly inwards. The superior and inferior rectus are then cut, and the speculum pressed back into the cavity of the orbit so as to make the eyeball start forwards. The scissors, blunt-pointed and slightly curved, are now passed back to feel for the optic nerve, which may be known by its toughness and thickness, and which is now severed with one clean cut. The eyeball being drawn forwards with a finger, the oblique muscles and any remaining soft parts are to be cut close to the globe. The hæmorrhage, though temporary, may be troublesome and should be controlled by irrigation with hot saline solution and by firm pressure for a few minutes. The socket should not be plugged, but sterilised gauze is applied outside the lids, and firm pressure secured by bandaging over a pad of absorbent wool.

If the eyeball is collapsed the operation may be rendered much more difficult owing to the trouble that may be experienced in securing the tendons of the muscles with the strabismus hook.

In the case of a new growth, *e.g.* glioma, the optic nerve must be divided as far back as possible. The scissors, slightly curved and long enough to reach to the back of the orbit, are introduced on the inner side, and the nerve either cut as far back as is possible before the globe is removed, or, after this is done, the nerve is dissected out and a fresh section made.

Owing to the early stage at which dissemination of intra-ocular sarcomata takes place, and to the tendency of these growths to creep backwards along the optic nerve towards the interior of the cranium, the prognosis very largely depends upon the earliness of the extirpation. On this account it should be remembered that the earliest symptoms of these growths, viz. impairment of sight from partial detachment of the retina by the pressure of the growth behind it, should be most carefully tested in suspicious cases, this impairment of sight being not usually noticed by the patient, save accidentally on closing the sound eye, unless the growth originates near the yellow spot. If later evidence is waited for, such as evidence of tension and pain, dissemination or recurrence is most probable, while the growth will very likely have perforated the eye, and the more severe operation of clearing out the orbit will be required. The following questions will very likely arise: If there is evidence of general dissemination of the disease, is it expedient to remove the eye, or, if this be insufficient, to clear out the orbit as well? In most cases the answer will be in the affirmative, in order to save the patient pain and the misery of the protruding and ulcerating mass.

If the disease has recurred, is it any use again to attack it? The answer will mainly depend on the amount and depth of the recurrence, and on the completeness of the first operation. Thus, if the eye only was removed at first, it may be wise to clear the orbit out thoroughly.

In a few most distressing cases in children it is well known that both eyes are attacked. The question of operating on the second eye must now be faced. Mr. Treacher Collins [1] has recorded four cases, in each of which three years had passed since the enucleation of the second eye and the patients were alive, with no sign of recurrence. Mr. Lawson held that if both eyes are affected, both should be excised, providing that the sight has already been destroyed. He had, on many occasions, removed the

[1] *Trans. Ophth. Soc.*, vol. xvi. p. 142.

second eye to procure temporary relief from the excessive pain induced by the over-distended globe, and when there had not been the slightest prospect of curing the disease. In each case the operation gave immediate and perfect relief.

Evisceration : Mules' Operation. In this operation the entire contents of the eyeball are removed from the interior of the sclerotic, which is left, and into which a ball of glass, celluloid, or ivory is inserted in the latter operation. This operation is said to provide a better socket for an artificial eye, and, owing to the attachments of the muscles not having been divided, much more movement is possible. A possible disadvantage is the occurrence of sympathetic inflammation. The indications will be similar to those for excision (excluding growths), but it is said to be specially desirable in cases of suppuration of the eyeball where excision may lead to infection of the sheath of the optic nerve and thus to meningitis.

The Operation. The patient having been anæsthetised, the ball is transfixed by a Beer's knife, the points of entrance and exit being just without the corneo-sclerotic junction. By cutting upwards a flap of cornea and sclerotic is obtained. The free edge of the flap is then seized, and the cornea is entirely removed by means of sharp scissors. The contents are then eviscerated by a sharp spoon. Care must be taken to remove the entire uveal tract so that the inside of the cavity should be quite white. It is then irrigated with dilute perchloride of mercury lotion.

In Mules' operation the globe must be aseptic. Evisceration is first performed as directed above, and then a loosely fitting celluloid ball is introduced into the sclerotic. The cavity is then closed by a few catgut stitches inserted into the sclerotic and the conjunctiva is then drawn across by a few sutures of gossamer gut or silk.

Clearing out the Contents, or Exenteration of the Orbit.

In November 1903 a man, aged 38, who had the eyeball removed for sarcoma elsewhere, was admitted under Mr. Jacobson for persistence of the disease. The left orbit was occupied by a fungating, bleeding, sloughy mass; the eyelids were not involved, and no infiltration of the glands could be made out. An incision having been made all round the orbital margin down to the bone, the periosteum was carefully stripped up by means of an elevator from the entire interior of the cavity back to its apex. The optic foramen was enlarged with a small gouge, and then with fine, blunt-pointed scissors pushed in as far as possible, the optic nerve was divided. The entire mass then came away with its coat of periosteum. The section of the nerve appeared quite healthy. The bones did not appear to be involved. The frontal sinus was explored and found to be free from disease. The cavity was packed with strips of sterilised gauze wrung out from pure formalin. These were removed in thirty-six hours, leaving the dry, black, odourless sloughs so characteristic after the use of formalin. The recovery was without interruption save for severe pain during the first forty-eight hours. The patient was kept under observation for nearly two years, and there was no reappearance of the disease and the patient was able to continue his work as a shepherd. In September 1905 the opposite eye was attacked, the patient becoming blind and dying in two months with paraplegia and convulsive attacks. There was no reappearance of disease on the left side. The deformity was, of course, considerable; but when the malignity of sarcoma of the eyeball, its speedy reappearance after the first operation, and the interval of nearly two years in which the patient remained well are considered, the result may be considered satisfactory.

Intradural Growths of the Optic Nerve Itself.

Mr. H. P. Bennett, Surgeon to the Newcastle-on-Tyne Eye Infirmary, reports one of these rare cases.[1] The patient was a boy, aged 2. From the perfect mobility

[1] *Brit. Med. Journ.*, 1905, vol. i, p. 1041.

of the eye and its projection directly forwards. Mr. Bennett had no doubt that he had to deal with a tumour situated within the muscular cone, and from the early loss of sight, with probably a growth of the optic nerve. The eye was removed with about 1·3 cm. of apparently normal nerve attached to it. On inserting a finger into the orbit, a large growth could be felt extending right down into the optic foramen. In order to remove the whole of this mass a small gouge was inserted into the apex of the orbit, and the whole of the growth was removed with 1 cm. of healthy nerve at the posterior end; in fact, the nerve was partly torn away at or very near the chiasma. The growth was a fibroma. The patient was well about six months later.

Temporary Resection of the External Orbital Wall. Kronlein, in order to avoid the sacrifice of healthy eyes, and to enlarge the very limited field between the eyeball and the outer wall of the orbit, was the first to propose the above method as a means of obtaining access to the structures behind the eyeball. Donnella has collected [1] forty-five cases in which this operation was performed and has analysed the results. The conditions calling for it were sarcoma, angioma, cysts, endothelioma, neuroma, adenoma, osteoma, growths of the optic nerve and sheath, injury pulsating exophthalmos, and retro-bulbar suppuration.

The Operation. A curved incision is made with its convexity forwards in the temporal region, commencing at the anterior part of the temporal crest, 1 cm. above the upper margin of the orbit, extending along the outer orbital margin almost as far as the outer canthus and ending on the zygomatic arch midway between the outer canthus and the auditory meatus. It is carried down through the skin, aponeurosis and muscles, but, along the orbital margin, only divides the periosteum. The periosteum is next separated with a rugine from the outer orbital wall as far back as the spheno-maxillary fissure below and a few mm. behind the spheno-malar suture above, and it is partly retracted along with the orbital contents. The exposed outer wall is now divided along the three following lines: (1) Above, from the external angular process of the frontal bone horizontally backwards. (2) Posteriorly, from the posterior end of this incision obliquely into the spheno-maxillary fissure. (3) Below, from the base of the orbital process of the malar bone horizontally backwards to the anterior end of the spheno-maxillary fissure. The bony fragment with all its adherent soft parts is displaced outwards and backwards, the orbital periosteum is incised horizontally, the external rectus easily distinguished and the retro-ocular space well exposed. At the conclusion of the operation the orbital periosteum is sutured, the bone replaced, and the wound sutured. Of the forty-five cases collected by Donnella, one patient died from an invasion of the cranial cavity soon after the operation. In six others it was necessary completely to remove the contents of the orbit. In the remaining thirty-eight no atrophy of the eyeball followed, even when it was necessary to divide the optic nerve. In many cases vision was much improved. The only inconvenient effects are said to be temporary anæsthesia of the cornea, diminution of the mobility of the eyeball, and external strabismus.

[1] *Revue Méd. de la Suisse Romande*, 1902, vol. xxii. p. 833.

CHAPTER XIX

OPERATIONS ON THE FRONTAL SINUSES[1]

Chief Points in the Surgical Anatomy. These are of great importance, for it must never be forgotten that while operative interference with the maxillary antrum is a safe proceeding, a similar step in the case of the frontal sinus is a very different matter; owing to the close proximity of the meninges and the communication of these sinuses with the ethmoid and nose, the risk of fatal infection, especially osteitis and meningitis, is always present.

Extent. The variable extent of these sinuses in the upward, outward, and backward direction is well known. The last mentioned, or the depth, is the most important from the surgeon's point of view. Logan Turner gives the following as averages. Height, an inch and a quarter; breadth, one inch; depth, three-quarters of an inch. When the sinuses are asymmetrical, one may extend across the middle line, reducing its fellow to a mere slit. The septum, complete in health, is often perforated in disease of any standing. Thus, where both sinuses are diseased and communicating, discharge may appear in the nose on one side only (Tilley). While the posterior wall, thin and brittle, and marked posteriorly by the frontal convolutions, contains no diploe, in the anterior wall this tissue, though slight in amount, is sufficiently present to be the seat of infective osteitis. The floor of the sinus at its inner and posterior part is formed by the anterior ethmoidal cells. The bone here is delicate, readily giving way. From this fact and the close contiguity of the openings of other sinuses, *i.e.* the anterior ethmoidal and the antrum, to that of the frontal in the middle meatus, infection readily spreads from one to the other. The upper opening of the naso-frontal duct lies at the back and inner part of the inferior wall of the sinus. It is on this part of the sinus, *i.e.* that just above the internal angular process, that the surgeon should especially direct his attention. The duct passes through the anterior ethmoidal cells. Its direction is downwards and backwards. Slightly curved backwards, it may be tortuous; sometimes a mere slit represents the upper opening. Apart from the results of disease, difficulties may arise in the passage of a probe along the duct owing to the way it may be encroached upon by the anterior ethmoidal cells, and its varying length according as it opens directly into the upper part of the middle meatus, or farther down, in the groove known as the hiatus semilunaris, in common with the openings of the anterior ethmoidal cells and the antrum. The latter is the more common of the two, and may account

[1] Operations on the frontal sinuses are described here as the incision required is situated on the face. The frontal sinuses are, however, accessory nasal air sinuses, as are also the antrum of Highmore and the ethmoidal air-cells. Operations on these latter are described at pp. 431 and 461.

for the frequency with which the antrum is also involved. The site of the opening into the middle meatus is denoted on the surface by the level of the inner canthus (Gollee).

Chief Indications for Operation.[1] In acute cases these will be chiefly pain and severe constitutional disturbance which are not relieved by intranasal treatment.[2] In some cases, in addition to very severe pain, there will be œdema and redness of the soft tissues, suggesting that the pus is making its way forwards through the anterior wall of the sinus.

In chronic cases the indications will be pain, evidence of retained infective material, and altered health, bodily and mental, from the constant swallowing and breathing of such material and the resulting toxæmia. It will be assumed that intranasal methods have been tried and have failed. In chronic cases,[3] pain, so long as the duct is patent, is not usually a prominent symptom. Dr. Milligan [4] goes so far as to say of these cases: "Localised pain, which is such a valuable symptom in the diagnosis of deep-seated suppuration, is usually conspicuous by its absence. It is true that pressure over the floor of the sinus, which is its thinnest wall, does at times produce marked pain, but an almost equal amount of discomfort is not uncommon when similar pressure is made on the floor of the opposite sinus. The finger must be introduced well under the supra-orbital arch, and pressure made upwards and inwards." When the surgeon is in doubt as to the need of an operation, the chief point for him to weigh is whether adequate drainage exists. Where the fronto-nasal duct remains patent, and operation is deferred, patients must be made clearly to understand the need for attending regularly to report their condition and to allow of the removal of polypi or granulation masses which arise here, as elsewhere, in the course of long-continued suppuration. In such cases, the patients must also be warned of the risks of fresh attacks, *e.g.* of influenza, in interfering with the escape of discharge, and of resulting cerebral complications, as in the more familiar instance of imperfect drainage through an ulcerated membrana tympani in otitis media.

Operation is strongly indicated where the discharge is profuse, where the sinus is distended without escape of discharge from the nose, and especially when there has been any threatening of cerebral trouble, and where the antrum is involved as well. Two other indications are the presence of an external fistula due to the pus having made its way through the anterior wall and burst externally, and the possibility that the patient may later on be remote from surgical assistance. Another point that

[1] For further information on this subject reference should be made to a discussion on "The present position of the treatment of purulent discharge from the frontal sinuses" before the Laryngological Section of the Royal Society of Medicine, opened by Dr. Watson-Williams (*Proc. Roy. Soc. Med., Laryng. Sec.*, June 1911, p. 127). The indications for operation and the relative value of the different methods are here fully discussed. In his opening remarks Dr. Watson-Williams gives the following indications for a radical operation: (1) The continuance of a purulent discharge, despite intranasal and other treatment, sufficient to cause grave inconvenience or markedly impaired health. (2) Persistence of headache, or of mental depression, or other nervous phenomena due to frontal sinus disease, especially in neurasthenic patients. (3) Recurrent facial erysipelas, orbital or external cellulitis, caries of the sinus walls, the formation of a fistulous opening, and any symptoms of intracranial complications secondary to the sinus.

[2] For particulars of this the reader is referred to a special work on diseases of the nose.

[3] Skiagraphy is often of very great assistance in confirming the diagnosis of chronic suppuration in the frontal sinus as well as in the other accessory nasal sinuses. Dr. Tilley points out that an X-ray examination may also show certain important anatomical details which may be of great service during the operation.

[4] *Loc. infra cit.*

should have weight is that the longer operation is deferred the more prolonged will be the after-treatment, and the greater the risk of deformity.

Operation. (Figs. 162, 163.) This will vary according as the case is acute or chronic, and whether complicated with disease elsewhere.

Owing to the risk of infective troubles alluded to below, every care should be taken in the preliminary sterilisation. Not only are the eyebrows to be shaved and skin thoroughly cleansed, but all the parts adjacent to the field of operation are to be rendered as sterile as possible. Before opening the sinus, any polypi should be removed from the nose, and to facilitate [1]-ainage the anterior end of the middle turbinated bone should be rem[illegible] (*see* p. 455).

The mouth and teeth (more particularly if the antrum is also infected) will require attention.

(*a*) *In Acute Cases.* Ether [1] having been given and the posterior nares blocked by a plug of sterilised lint secured with tape, an incision is made curving from within outwards, commencing above the site of the internal palpebral ligament, *i.e.* a little below the inner end of the eyebrow (Figs. 162, 163). The incision should be immediately below the line of the eyebrow and extend to the junction of its middle and outer thirds. At its inner parts it should pass down to the bone at once, the outer part being made more superficially at first, especially in slighter cases, so as to spare the supra-orbital nerve if possible.

The incision is on no account to pass below the supra-orbital ridge, which is always to be preserved. The periosteum having been cleanly divided,[2] the soft parts are raised [3] with an elevator. The bone is then removed with gouge or chisel and mallet, commencing on the supra-orbital margin vertically above the inner canthus. No undue force is to be used with the mallet; the eye may be protected with a sterilised pad. The sinus having been opened, its extent is ascertained with a probe, and the opening enlarged chiefly in an upward and outward direction. The amount of bleeding during this stage varies; if considerable, it is best met by removing the bone as rapidly as is consistent with safety, and then by firm plugging. Suitable dossils of sterilised gauze and adrenalin solution (1 in 1000) should be at hand for this purpose, with smaller ones for cleansing the recesses of the sinus. As the bone is removed, the mucous membrane, normally thin and bluish in colour, now more livid red, thickened and friable, will protrude into the opening. When opened, muco-pus, pus,[4] granulation-polypi, or exposed bone will be met with according to the duration of the case. On this depend the further steps

[1] This operation is one which it is probably safer to rely upon ether throughout. H. Fetterolf, of Philadelphia, has drawn attention (*Amer. Med.*, March 19, 1904) to a case in which cardiac inhibition took place reflexly from irritation of the peripheral fibres of the fifth nerve during an operation for chronic empyema of the frontal sinus. Each time that the curette was applied there was a marked diminution in the force and frequency of the pulse, together with distinct cyanosis. The path of the impulse is through the sensory branches of the fifth to the fourth ventricle, and so to the vagus.

[2] Dr. H. Tilley has found from an examination of 120 skulls that a quarter-inch trephine applied to the lower margin of the frontal bone between the middle line, and one drawn vertically upwards from the internal angular process, will in all cases open the sinus, if one exist.

[3] Especial care must be taken to deal gently with the periosteum in cases where it will be needful to obliterate the sinus. In such cases this membrane plays an important part.

[4] The amount of this in a sinus which has been discharging freely by the nose may be small. While there is no specific organism, the following have from time to time been demonstrated in pus from infected sinuses—streptococci, meningococci, pneumococci, and the bacilli of Pfeiffer and Friedlander (Milligan).

FIG. 162. Kilian's operation for chronic suppuration in the fronto-ethmoidal cells. (Tilley.)[1]

FIG. 163. Cavity of sinus after removal of the anterior wall and of diseased mucous membrane. The dotted line indicates upward extension of the sinus. (Tilley.)

[1] These figures are taken from a paper by Dr. H. Ti[illegible] (*Lancet*, May 21, 1904, p. 1414). Reference may be made to this and another practical paper by the same authority (*Brit. Med. Journ.*, August 30, 1902, p. 582), and one by Dr. R. Milligan (*Brit. Med. Journ.*, January 28, 1905, p. 171), as well as to the discussion opened by Dr. Milligan mentioned on p. 411.

of the operation. If if be a recent one dating to an acute infection from the nose, *e.g.* influenza, and if the sinus is a small one, it will be sufficient to remove the anterior wall sufficiently to admit of cleansing the sinus completely and finding the orifice of the fronto-nasal duct. A drainage tube is passed along this into the nose, the upper end being brought out through the lower and inner margin of the incision, which is never to be closely sutured. These points will now be taken in detail. The anterior wall having been cut away, pus is washed away by syringing with sterile saline solution, and the mucous membrane is gently wiped with dossils of gauze.

The orifice of the fronto-nasal duct is found with the help of a blunt probe and a small drainage tube with lateral windows is passed through it to the nasal fossa. The wound is sutured except where the end of the drainage tube projects.

(*b*) *In chronic cases.* The sinus is opened in a similar way and the cavity thoroughly exposed by removal of its anterior wall. All polypi and the swollen infected membrane must be removed with a small spoon or curette. If the case be of any duration, it will be needful to scrutinise the cavity for any loculi or recesses in which infective material may lurk.

In exploring these with a small spoon, especial care is needed in dealing with the inferior and posterior walls, the former on account of the meninges, the latter chiefly on account of the pulley of the superior oblique (p. 417). If, accidentally, any opening be made in the posterior wall, this must be at once plugged with sterile gauze until the operation is completed. According to Dr. Tilley, diverticula of the main sinus may exist, especially below. Their openings are easily missed. The next step will be to find the fronto-nasal duct at the junction of the posterior and inner walls with a curved probe or small bougie.

The patency of the duct must be restored to ensure a medium-sized drainage tube being passed as above. To enable this to be done, and at the same time to remove parts which are certain now to be involved (p. 410), the anterior ethmoidal cells which lie in front of the probe, acting as a guide in the duct, must be broken through and removed with a small gouge, curette and burrs. To allow this to be done efficiently, it will be well in severe cases to prolong the skin incision carefully downwards, and to detach the periosteum downwards and backwards. Attention must be paid at this stage to the pulley of the superior oblique. If this be detached cleanly and without damage, any after-trouble (*vide infra*) will be slight and temporary. Any interference with vision which may show itself for a few days, is more likely to be caused by inflammatory exudation.

In difficult cases passage of the tube and breaking down of the anterior ethmoidal cells will be facilitated by the introduction of the little finger through the nostril, and the introduction by this route of small, ring-shaped curettes. But it will be safer to do most of the work from above, the probe in the sinus being a guide as to the amount of bone which lies in front of it and which may be safely removed.

When the essential point of free drainage has been secured the operator must decide, in chronic and advanced cases, as to the advisability of removing freely the anterior and the inferior walls of the sinus. He will have explained to the patient that such obliteration is more likely to lead to a certain and less delayed cure, but at the cost of an evident depression. The size of the sinus, as manifested by a probe (the larger the cavity the greater the disfigurement resulting), the age and sex of

the patient, the extent of the disease, and especially the presence of caries will guide the surgeon in coming to a decision. One other indication may be given. In some cases no duct can be found by the probe; in a few, after most careful attempts, the surgeon may fail in securing a new and adequate track for drainage: in these cases the cavity should be obliterated, otherwise caries, reopening of the wound and a persistent sinus are bound to follow. It need scarcely be added that in advanced cases there is additional urgency for attention to the details already given as to the need of removing all diseased tissues, finding any diverticula, and taking every precaution to leave the cavity in as sterile a condition as possible. Before the dressings are applied all recesses of the wound should be again washed out and dried, and any small plug which has been inserted in a possible opening in the posterior wall removed.

Fig. 161. Symonds' frontal sinus cannula.

A drainage-tube should be passed along the fronto-nasal duct into the nasal fossa as advised in the operation for acute trouble. One or two lateral openings should be cut in its upper part and this end should just project through the external wound. It is now syringed through, and the cavity lightly packed with sterile ribbon gauze, one end of which is brought out at the lower angle of the incision by the side of the tube. The outer part of the wound is then carefully sutured with gossamer salmon-gut. Boracic fomentations are usually to be preferred to dry dressings. Finally the plug in the posterior nares is removed.

It is always easier to insist on adequate and prolonged drainage than to ensure its attainment in all cases. In some, the tube causes irritation, in others it soon becomes blocked, and we are all aware that drainage-tubes may be sources of infection. On the other hand, the importance of securing patency of the fronto-nasal duct, to make certain of the cure remaining thorough, is paramount. Irritation and blocking of the tube are best avoided by making a free passage for the tube to lie in; infection by the tube by remembering that keeping the skin about the wound and the nose as sterile as possible is important after as well as before the operation.

Where the disease is bilateral, the scarring will be less if the sinuses are treated by separate incisions. Where this method is employed at one time, the operator must not be hurried when he deals with the second sinus, or the result is certain to be imperfect. A median inverted T-shaped incision may be made use of in men: the scar tends to become much less noticeable with time, but this method gives less room. For this reason especially the other method is preferable, but the patient should always be warned of the possible necessity of the op

Of the other sinuses, disease of the ethmoid and antrum most frequently complicates that of the frontal sinus.[1]

Transillumination, radiographic examination,[2] the amount of suppuration, the number and extent of polypoid masses, and evidence of, or a history of previous dental trouble may all help to elucidate this point. When the surgeon feels assured as to the co-existence of frontal and antral suppuration, he may be in doubt as to which sinus he will deal with first. Dr. Tilley [3] is strongly of opinion that the upper sinuses should be dealt with first, as the pus may be formed above, the antrum merely acting as a reservoir. The surgeon will have an additional reason for following this advice in the fact that by waiting to see if operation on the upper sinuses suffices, he will be better able to deal with other mischief if this prove necessary, than if he had attempted to cope with several sinuses at one time.

Operations on the maxillary antrum are described below (p. 431). Nothing has been said on the subject of the sphenoidal sinuses, since disease in this situation is not a common complication of suppuration in the frontal sinus. For detailed information on the diagnosis and treatment of suppuration in this inaccessible situation, where the mischief is less evident, and where it is necessary to find and enlarge the orifice and remove polypi, granulations and carious bone, the reader is referred to some special work on this branch of surgery.

When frontal sinus suppuration is complicated by extensive disease of the ethmoid, some more radical operation is required to eradicate the whole of the disease. Under these circumstances **Kilian's operation** is indicated. The incision is similar to that described above, but it is prolonged downwards in front of the inner canthus along the nasal process of the superior maxilla. The periosteum is displaced by a rugine and the sinus opened. The whole of its anterior wall down to the supra-orbital ridge is removed, and the floor is then completely cut away by bone forceps so as to allow the orbital fat to bulge upwards and aid in the obliteration of the cavity. Care is taken to preserve the margin of the orbit entire. All diverticula are followed up and all diseased mucous membrane is curetted away as described above. A second opening is now made by removing the upper part of the nasal process of the superior maxilla. This gives a good view of the anterior ethmoidal cells, which are closed in by this process. The disease can then be efficiently treated by sharp spoon curette, or forceps.

It will be seen that in this method a bridge of bone consisting of the supra-orbital margin is preserved between the two openings, and thus excessive deformity is prevented. Drainage will take place into the nasal fossa, and hence the external wound can be completely sutured. In this operation attention must be directed to avoidance of injury to the pulley of the superior oblique muscle or diplopia may result. If desired the floor of the sinus may be left, but this, though simplifying the operation, necessitates longer after-treatment.

[1] It is a matter of comparative rarity to find only one sinus or one group of cells affected; in the vast majority of cases two or more sinuses are involved. Zuckerkandl never found a single case post-mortem in which frontal sinus suppuration was uncomplicated with ethmoidal.

[2] Transillumination, though of great assistance in the diagnosis of pus in the antrum, is of doubtful use in the case of the frontal sinus. The lamp should be placed below the inner third of the supra-orbital arch.

[3] *Lancet*, 1904, vol. i., p. 1416; *Brit. Med. Journ.*, 1902, vol. ii., p. 585.

After-treatment. A varying amount of œdema and ecchymosis in the loose tissues of the eyelid is certain. In acute cases the dressings should be changed on the following day. The drainage-tube should be removed on the second or third day, and after the sinus has been irrigated with some weak antiseptic lotion such as boracic, the tube, which has been resterilised, is replaced. Gauze dressings may be used instead of fomentations when the swelling has subsided. The treatment is repeated daily, and in about two weeks there should be very little pus, so that the tube may be omitted and the external wound allowed to close.

In chronic cases the after-treatment is, necessarily, much more prolonged. At the end of twenty-four or forty-eight hours, according to the state of the parts and the course which the case is running, the gauze drain should be removed. If the condition is favourable, it need not be replaced, a strip only being now left in the lower angle of the wound to promote free drainage. When it is removed, the wound must be carefully irrigated, and the nose and mouth must also be carefully kept clean. The first changing of the drainage tube should be left, if possible, until the third day, and is much facilitated by having a loop of silk attached to its upper end. It should always be drawn from above downwards through the nostril. The drainage tube must be replaced and cannot be dispensed with until the discharge is scanty and serous looking. This often requires a period of four or five weeks. In one case of chronic disease, in a patient of sixty-five, with a huge right sinus, typical egg-shell crackling, and downward protrusion of the eye-ball, it was seven weeks before the wound was closed, the drainage tube being continued for a month. A feature of interest in this case was the fact that the sinuses communicated by an aperture as large as a sixpence. This allowed of the left sinus, much less affected, being dealt with without a second incision. When the fomentations are omitted, firm pressure with sterilised gauze or pads and a tight bandage will be found helpful.

Possible Sequelæ after Operations on the Frontal Sinuses. The chief of these are: (1) *Infective Trouble.* In spite of all care, septic osteomyelitis, lighting up into fresh activity of quiescent mischief in adjacent parts, meningitis and cerebral abscess, are all grave possibilities to be borne in mind. To avoid these serious complications, which are almost invariably fatal, it is necessary to have removed the whole of the disease and to provide adequate drainage both by the nose and through the external wound. Should severe pain, swelling, pyrexia, or other symptoms suggesting retained pus make their appearance after the operation, the stitches should be removed and free drainage provided. Should symptoms still continue the wound must be thoroughly explored.

(2) *Persistence of the Disease.* This may be due to an incomplete operation, or to mischief in the opposite sinus, or in the ethmoid, antrum, &c.

(3) *Disfigurement.* This, chiefly marked in cases where the disease is extensive, and where the sinus has a large antero-posterior extent, may, if persistent in young subjects, be probably remedied by the injection of paraffin (*q.v.*).

(4) *Diplopia, from Injury to the Pulley of the Superior Oblique.* This is usually temporary, and with other minor sequelæ, such as ecchymosis and altered sensation over the brow, needs no further mention.

(5) *Persistence of an External Sinus.* This is due to some focus of disease having been overlooked very possibly in the ethmoid cells. Further operation is indicated.

(6) Dr. Milligan has noticed in several cases the development of a *keloid scar* some months after operation. This he attributes to constant action of the fibres of the orbicularis palpebrarum preventing local rest to the tissues. In the same way he considers the movements of the platysma as responsible for the keloid appearance of the scar after operations upon the neck. The ages of the patients and the time occupied in healing are not mentioned, but there is no doubt that, in cases where primary union has been secured, scars in the neck, *e.g.* after partial removal of the thyroid, may take on a keloid condition some time after an operation in those no longer young.

CHAPTER XX

OPERATIONS OF THE JAWS. EXCISION OF THE UPPER JAW, PARTIAL AND COMPLETE. OPERATIONS ON THE ANTRUM OF HIGHMORE. EXCISION OF THE LOWER JAW, PARTIAL AND COMPLETE. OPERATIONS FOR FIXITY OF THE LOWER JAW

OPERATIONS OF THE UPPER JAW

These will include:
(i) Removal, partial or complete, for growths (Figs. 165, 166, 167).
(ii) Operations for naso-pharyngeal fibroma (Figs. 181, 182).
(iii) Operations on the maxillary antrum.

REMOVAL OF THE UPPER JAW, PARTIAL OR COMPLETE

Indications. These include the different growths to which the upper jaw is liable, and opportunity will be taken here to give briefly the chief practical points in connection with these.

(1) **Epulis.** One of the new growths most frequently met with here. Etymologically tumours of the gum these growths vary a good deal. At first, and most frequently, they are simply fibrous, tough, and firm, springing from the periosteum, the peridontal membrane, and the endosteal lining of an alveolus.

Myeloid cells and small spicules of bone are not uncommon. The longer they are left, the more they are irritated, especially with imperfect attempts at removal, the more cellular and vascular do they become.

Very rarely on extracting the tooth, to the alveolus of which the growth is connected, the epulis comes away completely. Much more frequently it is firmly connected to the periosteum and subjacent cancellous tissue, or to the endosteal lining of one or more alveoli. Removal should be early and complete. Shaving off the growth and the gum beneath, and then cauterising any suspicious granulations, is most uncertain and unsatisfactory, especially if the presence of teeth be allowed to interfere with the complete removal of the growth, or if this be connected with stumps, and thus dips deeply into an alveolus. By far the best treatment is to extract a tooth in front and another behind the growth, and then with a narrow saw to notch the bone at these points deeply through the alveoli with cutting-forceps, or, better, a chisel and mallet, a V-shaped or rectangular piece of the bone is then removed. In the case of the mandible this bone must be steadied. The extraction of teeth not only enables the surgeon thoroughly to eradicate the growth, but their removal leads, as pointed out by Mr. Salter,[1] to wasting of the alveolus, and thus to non-recurrence of the growth. The teeth, if sound, and if the patient so desire, should be preserved, and later on, when all is firmly healed, fitted to a plate by a dentist. The deformity is thus rendered imperceptible.

[1] *System of Surgery*, vol. ii. p. 456. Mr. Salter also points out that when an epulis forms on an apparently edentulous part of the jaw, the existence of stumps should always be looked for.

If a patient refuses the only operation which is safe, the surgeon must rest satisfied with shaving off the growth, gouging the subjacent bone, and, if needful, canterising any suspicious patches later on. This course is not only much more tedious and painful, but is also uncertain.

(2) **Fibroma.** These originate either in the periosteum or in the endosteum of the antrum, the connective tissue of the medulla, Haversian canals, vessels, &c. At first firm, dense, and slow-growing, they may, from the frequent irritation inseparable from their site, become vascular, sloughy, and, taking on more rapid growth, tend to invade the numerous fossæ, fissures, and foramina in the neighbourhood of the bone.

They should be attacked early; and while the surgeon may need at this stage to remove only the periosteum and bone from which the tumour springs, especially if it be alveolar in origin, or after opening the antrum to shell out the fibroma completely, he must also be prepared for more radical measures, *e.g.* when the growth is of long standing, of late more rapid, if the patient is at all advanced in years, and especially if the growth is a reappearing one.

(3) **Sarcoma.** These include the spindle, round and myeloid varieties, the fibro-, chondro-, and osteo-sarcomata, and the rarer forms of alveolar sarcoma. While the more slowly growing ones simulate more innocent growths such as epulis, the more rapid ones will tax the surgeon's judgment as to whether any operation is justifiable, and all his skill if removal be attempted. On these subjects the reader is referred to p. 423.

(4) **Carcinomata.** These are usually of the squamous kind, and commence in the alveolar border in the form of ulceration, beginning in syphilitic scars, or the irritation of an ill-fitting tooth-plate. They tend to creep far back, and to invade the palate and tonsil; on this account they should be operated on early. Whenever a sore in this position is suspicious in its characters, and obstinate to treatment, whatever be the age of the patient, the parts affected should be widely and freely extirpated. If the growth has eaten into the antrum, or has travelled back so as to invade the pterygoid region, removal of the whole bone is most likely to benefit the patient. More rarely a squamous epithelioma attacks the jaw from the lip or face. This happens much more often in the case of the lower jaw.

Another epithelial growth met with here is a carcinoma, by no means infrequent, and it is often a difficult matter to distinguish it clinically from a sarcoma. Also the tubular[1] variety (cylindrical or adenoid carcinoma), which begins in the mucous membrane of the antrum or nose. It is marked by rapidity of growth and invasion of the surrounding parts, and is thus of grave prognosis.

According to Prof. Schlatter,[2] carcinomata as compared with sarcomata possess the following characteristics: They usually occur in older patients—the average age in the case of sarcoma is about 35, in that of carcinoma about 55—they are commoner in the upper than the lower jaw, pain is greater at an early date, growth and infiltration are more marked. Involvement of the lymphatic glands is more common in carcinoma, especially in the case of the mandible. In that of the maxilla it is less common, but it is to be remembered that it is the deep glands along the internal maxillary and internal carotid which are affected.

[1] Mr. Heath (*Dict. of Surg.*, vol. i. p. 857) quotes Reclus as calling this form epithélioma térébrant, from its boring or burrowing tendency.

[2] Von Bergmann's *Syst. Pract. Surg.*, *supra cit.*

(5) **Odontomes and Dentigerous Cysts.** Under this heading the commoner odontomes and dental cysts will be alluded to. Of odontomes or growths "composed of dental tissues in varying proportion and in different degrees of development arising from teeth germs, or teeth still in the process of growth" (Bland Sutton), the commonest are the epithelial and the follicular odontomes.[1]

(*a*) The epithelial odontomes (multilocular, cystic epithelial growths of Eve) while occurring as a rule in the mandible, have been observed in the maxilla. They are most frequent about the twentieth year. The structure is that of a fairly firm capsule, containing a collection of various sized cysts separated by their septa and containing brownish mucoid fluid. Microscopically they consist of branching columns of cells, often columnar, often imperfect, the origin of which is as yet uncertain. In some cases it may be from remains of the enamel organ, in others from the gum, and in some it is of endothelial origin. While in many cases, owing to the bony capsule and the early degeneration of the epithelium, these growths have little tendency to spread, where they are of endothelial origin, or where sarcomatous change has set in from irritation, the outlook is much more grave.

(*b*) *Follicular Odontomes or Dentigerous Cysts.* These are formed by a collection of viscid or serous fluid taking place during the development of a tooth nearly always a permanent one, and especially a molar, which has not come through the bone.[2]

There are two varieties of these cysts: one, the commonest, is cystic only, consisting of an outer bony shell of varying thickness, and an inner membranous one. The tooth may be well formed, or a small, shapeless, calcified mass; its crown usually projects into the sac, vertically or horizontally. The following points are of practical importance. These cystic swellings may be taken for solid growths, and this mistake may be avoided by remembering that when such a swelling exists there is usually a history of its having commenced in early life, and that though all the teeth may appear to be present, one will very likely be found to be a temporary one. Furthermore, there is the help derived from puncture with a fine trocar.

In the other variety, usually of longer duration and in older patients, solid growth of a sarcomatous nature is present in addition to the cyst.

(6) **Dental Cysts.** These usually occur in connection with carious teeth or the stumps of teeth. They are met with in either jaw. Suppuration and a sinus, very rare in the case of follicular odontomes, are more common here. Occasionally they are allowed to grow until clinically they resemble new growths. Their painless slow growth and above-given origin should always cause their presence to be suspected.

[1] For further information on odontomes, especially the rarer forms, Mr. Bland Sutton's *Tumours Innocent and Malignant*, p. 47, should be referred to, with its excellent illustrations. The following seven varieties are recognised: (1) Epithelial odontomes, or fibro-cystic disease of the jaw; (2) follicular odontomes; (3) fibrous odontomes; (4) radicular odontomes; (5) cementomes; (6) composite odontomes; (7) malignant odontomes. The excellent and comprehensive *Report on Odontomes*, published by the British Dental Association, 1914, should also be read by those desiring a detailed account of these tumours.

[2] Mr. Salter (*Syst. of Surg.*, vol. ii. p. 469) gives the following three circumstances as capable of producing impaction of a tooth: (1) The tooth may be originally developed too deep in the body of the jaw—thus, though it grow in the right direction, it will never reach the alveolar margin; (2) while it may be sufficiently superficial, it takes an oblique direction of growth, so that it lies covered more or less in the axis of the bone; (3) the position of the tooth and its line of growth may be originally normal, but from arrest of the development of the fang it may fail to reach the alveolar edge.

Treatment. In the case of the epithelial odontomes where the growth has been slow and the cystic element is the chief one, the operation performed within the mouth should be on the lines of that given for epulis (p. 119), aided by the gouge, gouge forceps, and small, really sharp curettes. All diseased tissue, cystic or bony, must be removed. The basilar border can always be left. Where the growth is of longer duration, the patient older, and the amount of solid tissue present greater, the whole thickness of the jaw must be resected; and where it is a case of reappearance of a growth, extensive resection is indicated.

In the case of the follicular odontome or dentigerous cyst, the treatment consists in exposing the surface of the cyst by turning the lip up, incising the mucous membrane and then in cutting away freely (with gouge and chisel, aided by a three-quarter inch trephine if needful) the walls of the cyst, so as to examine its contents, and next digging out the tooth often the most difficult part of the operation. The cavity is then carefully stuffed with strips of aseptic gauze to encourage its granulating from the bottom. If any swelling persist, keeping up deformity, pressure must be trusted to, the Hainsby's truss of old days being here found useful.

In the other variety of dentigerous cysts, where solid growth of a sarcomatous nature is present in addition to the cystic, the surgeon must use his discretion as to opening the cyst, freely scraping out the growth, and then applying strong formalin solution or zinc-chloride paste, or removing the bone itself. If the case is of any duration, if the growth is soft and making rapid progress, the latter course will be the wiser one.

In the case of the dental cyst, treatment is usually simple. It consists in the removal of any teeth or fangs, and then in the thorough curetting of the cyst walls. Whenever it is needful to do this thoroughly, the anterior aspect of the bone must be removed with gouge and chisel to give free access. The cavity, when thoroughly exposed and dealt with, is carefully plugged with sterilised gauze.

(7) **Enchondromata.** These are rare. They seem to commence in adolescence, usually starting from one surface of the bone, *e.g.* the nasal, or from the antrum. They should be removed early and completely, as they grow steadily, involving the nose, orbit, frontal sinuses, and thinning the cranial bones.[1]

(8) **Osteomata.** These are rare also. Two forms occur: (1) Of the nature of an ordinary exostosis. These are usually cancellous, but ivory ones arise from the superior maxilla as well as from the orbit and frontal sinuses. Occasionally they are symmetrical.[2] Their growth is usually slow. If they occur in young subjects they should be attacked while small. The ivory exostoses are occasionally found loose on laying open the antrum, as is sometimes the case with those in the frontal sinuses. (2) Diffuse osteomata. These are intermediate in hardness between cancellous and ivory exostoses. They have often broad, ill-defined bases, and are not infrequently multiple and symmetrical. As they tend to produce hideous deformity, and though slowly, most distressingly, to destroy life, they should be attacked while small. Mr. Pollock[3] states

[1] Good instances of what these enchondromata may come to are given by Mr. Morgan's case, *Guy's Hospital Reports*, 1842; Mr. Heath's *Diseases and Injuries of the Jaws*, p. 237, with an excellent illustration, Fig. 107.

[2] In Mr. Hutchinson's *Clinical Surgery*, vol. i, p. 11, Figs. 3 and 4, will be found admirable illustrations of symmetrical exostoses from the upper jaw.

[3] *Syst. of Surg.*, vol. ii, p. 535.

that in cases where the whole mass is beyond removal, a portion may be cut away with present, if not permanent, benefit. This can only apply to osteomata of purely hypertrophic nature. Where the bony growth is tipped with cartilage, every atom must be removed for the operation to be of any benefit. Well-made osteotomes and drills worked by an electro-motor may be of much service here, the great object being to drill a number of holes in different directions through the growth, and then to cut through the intervening bone with osteotomes and a mallet. One of the chief risks is that of intracranial inflammation, especially if the growth has involved the interior of the skull.

QUESTIONS ARISING BEFORE ATTEMPTING THE REMOVAL OF THE UPPER JAW

(i) Is the growth cystic or solid? (ii) What is the relation of the growth to the jaw? Did it begin on one of the surfaces of the jaw, within the antrum, or behind the jaw? (iii) Is the growth one, whether malignant or not, that it is wise to attempt to remove?

(i) **Is the Growth Cystic or Solid?** Mr. Heath gave a case under his own care in which caseous pus, after suppuration in the antrum, was taken for a solid growth, and the jaw removed. As the diagnosis is evidently most difficult in some cases, the surgeon should, in all cases of doubt, explore first with a trocar and cannula, or gouge or bradawl, removing a portion for histological examination. The X-rays may be of assistance here.

(ii) **What is the Relation of the Growth to the Jaw?** Did it begin on one of the surfaces of the jaw, within the antrum, or behind the jaw?

In some cases it is quite impossible to be sure on this point up to the time when the flaps are reflected or till the jaw itself is removed; even the use of a finger aided by an anæsthetic is insufficient.[1]

The following points may be useful in aiding a decision as to the relation of the growth to the jaw:

If the growth began on the surface of the jaw, *e.g.* the nasal or malar process, there will probably be a history of a lump noticed here first, very likely after a blow, and any evidence of the antrum, nose palate, and orbit being involved, will be deferred till late. On lifting up the cheek, masses of growth will very probably be found creeping down between the cheek and gums, but not altering the line or affecting the structure of the alveolus, unless it commenced in it or just above it.

If the growth began in the antrum, the cheek is more slowly swollen, and the swelling is deeper and less defined. The different walls and boundaries of the cavities, viz. the orbital, nasal, facial, and zygomatic, are expanded steadily and with a varying rapidity, while the palate is depressed, the alveolar border displaced, and the teeth rendered irregular.

If the growth began behind the antrum, *e.g.* in the basilar process of the sphenoid or the spheno- or pterygo-maxillary fossa, in many cases a history will be given of polypi removed from the nose or pharynx some time before, perhaps reappearing soon: the upper jaw is pushed forwards, and in some cases there is but little alteration in its outward shape, but this is by no means constant. Not infrequently the upper jaw will be so altered by pressure, its processes, *e.g.* the malar, so thinned, flattened,

[1] Growths originating in the nasal fossæ and their accessory sinuses often extend most widely and in a most insidious manner. This is owing to the large number of foramina and fissures which open into these spaces. Thus even the cranial cavity may unexpectedly be found to have been invaded through the sphenoidal fissure.

and expanded that it may well be thought that the disease began in the bone itself. And this mistake is the more excusable when it is remembered how easily a growth situated behind the antrum may make its way into this cavity, either by absorbing its walls, or by entering it through the opening into the nose.

Other possible evidence of the existence of a retro-maxillary growth, whether arising in the roof of the naso-pharynx or the above-mentioned fossæ, will be symptoms pointing to the nose, viz. early discomfort and perhaps increased secretion, pain here, or in the orbit and brow; epiphora from blocking of the nasal duct; interference with nasal breathing, epistaxis; possible symptoms of interference with the function and movements of the eyeball; swelling in the temporal region; yet it must be remembered that many of these symptoms will be brought about by a growth within the antrum increasing rapidly.

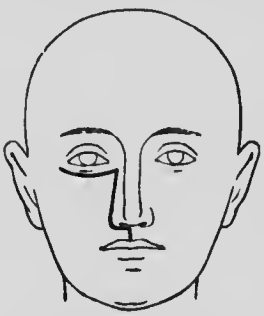


Fig. 165. The incision for excision of the upper jaw.

It is only when the surgeon finds no evidence of the growth beneath the skin, or of its originating on the surface of the bone, no depression of the palate, and no irregularity of the alveolar margin or displacement of the teeth, that he can say that the growth is probably behind the antrum.

(iii) **Is the Growth one, whether Malignant or not, that it is wise to attempt to remove?** While every case must be decided upon separately and while it would be most misleading to lay down hard-and-fast rules, the following are not unworthy of attention:

Favourable Cases. Growths with a duration extending over many months hard well defined, limited to the jaw, with the skin over the growth perhaps thinned from pressure and altered in colour, but still movable over the parts beneath.

Unfavourable Cases. History of a few months' duration; growth soft, vascular, ill defined; integuments involved and fixed; naso-pharynx invaded; extension into orbit or temple, *e.g.* a soft, semi-elastic swelling noticed behind the malar bone in the temporal region; extension to the sub-maxillary and cervical glands; origin of the growth behind the jaw, rather than on it.

Occasionally, a growth unfavourable at first sight from its large size will be found to have protruded on to the face without involving the parts around, and especially those behind. The history must be carefully examined into. If it be doubtful where the growth began, whether it has invaded or only crept towards the nostril, the surgeon will inquire as to the existence of deep-seated pain, stuffiness in the back of the nose, loss of smell, interference with nasal respiration, epistaxis, &c. Again, the existence of any swelling near the inner canthus will point to extension towards the ethmoid and base of the skull.

Complete Removal of Upper Jaw (Figs. 165, 167). The parts having been previously rendered as sterile as possible, the patient is brought carefully[1] under an anæsthetic, and duly propped up, as near

[1] As in excision of the tongue, the assistant to whom the anæsthetic is entrusted is second only in importance to the surgeon. He should watch most carefully for the first signs of flagging of the pulse, and meet this by injection of ether or brandy. Any evidence of blood going down the throat, dyspnœa (as shown by venous stasis of the cheeks), lividity of the lips, or respiration short and fixed, must also be looked out for. Intra-

to the edge of the table as possible, with the head raised and turned over towards the opposite side, and downwards as much as is permissible to facilitate the ready escape of blood from the mouth. The surgeon now takes the opportunity of examining more completely the attachments and limits of the growth, and decides whether, owing to its vascularity, it may be advisable to tie the external carotid or place a temporary ligature on the common trunk (*q.v.*). It will be seen later (p. 431) how unsuccessful this severe operation is in spite of the advance of modern surgery, that a partial factor in the incomplete removal of the disease is the shock and hæmorrhage, which lead to the close of the operation being hurried, and further that the high mortality is mainly due to hæmorrhage in patients whose vitality is often very low, and to aspiration-pneumonia.

German surgeons and this operation seems to continue to be more common with them than it is with us and Dr. J. D. Bryant, of New York, are strongly in favour of preliminary ligature of the external carotid especially in patients exhausted by hæmorrhage and cachexia. Preliminary exposure of the bifurcation of the carotid for ligature of the external alone does not always suffice to admit of a temporary ligature[1] being placed around the common trunk, has the further advantage of exposing any deep-seated glands that might otherwise have escaped notice. Sir F. Treves and Mr. Hutchinson[2] consider that "preliminary ligature of a large artery is not a necessary or desirable proceeding. Should, however, the tumour be extremely vascular, a ligature may be placed round the external carotid." Efficient plugging of the posterior nares is recommended, the division of the bony palate being taken last.

The surroundings of the surgeon will largely aid in a decision on these points. If the apparatus for the intratracheal administration of ether be not available and if it be thought inadvisable or unnecessary to make use of a preliminary ligature of the external carotid and a laryngotomy, he must be aided by efficient assistants ready at all points with sponge-pressure, necessary movement of the patient's head, and with the anæsthetic. He must plug the posterior nares efficiently, removing the plugs before the bony palate is divided, and he must not forget the possibility of infiltrated deep cervical glands.

One more preliminary step needs reference. It has been advised that the operation take place with the head in the dependent position after the external carotid has been tied. This is an extremely inconvenient position for the operator. The Trendelenburg position, as advised by Prof. Keen in excision of the larynx is worth a trial, but might cause much venous congestion of a vascular growth.

The incision which goes by the name of Sir W. Fergusson[3] is then

tracheal insufflation of ether is the most desirable anæsthetic in these cases. If the necessary apparatus and an expert anæsthetist are not available, preliminary laryngotomy and plugging the pharynx are advisable. With regard to a preliminary laryngotomy not a tracheotomy be it noted—it is to be recommended not only because the pharynx can be plugged preventing blood being drawn down to the lungs, but also because it is on this account an important safeguard against the development of aspiration-pneumonia. The laryngotomy tube is removed as soon as the operation is completed.

[1] Crile's clamp may also be employed.

[2] *Manual of Oper. Surg.*, vol. i. p. 694.

[3] First recommended by Dieffenbach. Its advantages are very great, viz. (1) only the terminal branches of the facial nerve are divided; (2) only branches of the facial vessels, not their trunks, are cut; (3) the scar is inconspicuous, as the incision is placed in natural feature-folds.

made through the centre of the upper lip (an assistant controlling the opposite coronary while the one in the flap is commanded by the surgeon himself), round the ala, up along the side of the nose to the inner canthus, and outwards just below the margin of the orbit, as far as the malar prominence. Where the disease is extensive, the incision may have to go farther out; on the other hand, where it is not needful to remove the orbital plate, this part of the incision may be dispensed with more or less. The angular vessels and lateralis nasi will give the most trouble before their bleeding is entirely checked. The flap thus marked out is then reflected and wrapped in sterilised gauze. The haemorrhage is often free, especially in cases of rapidly growing tumours which have thinned the bone. Spencer-Wells forceps are applied to the larger of the vessels: when the flap has been reflected, care being taken not to cut into the growth, these are secured, and an assistant makes pressure upon a number of sterilised pads on holders which must be at hand upon the stump to arrest oozing, while the surgeon divides the bones in the following order, the ala of the nose being first detached from the bony surface, and the periosteum of the floor of the orbit detached from the bony surface and pushed backwards as far as the spheno-maxillary fissure if the whole bone is to be removed; during this step the origin of the inferior oblique is raised with the periosteum, and the eyeball and fat are protected with the copper spatula.

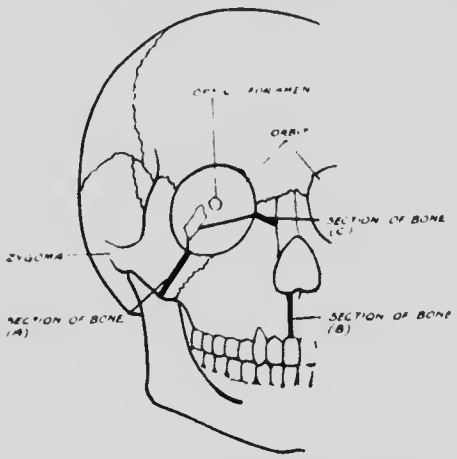


FIG. 166. *C*, Line of saw-cut at the junction of the external and inferior walls of the orbit. This is continued backwards to the spheno-maxillary fissure. *B*, Line of saw-cut through the palatal process. *C*, Line of saw-cut through the nasal process. This is continued back to the spheno-maxillary fissure.

(1) The junction of the superior maxilla with the malar bone is divided. The line for the saw is marked out with the knife upon the bone just in front of the origin of the masseter. With a narrow strong-backed saw (Gant's or Adams' osteotomy saw) this line is converted into a deep groove and the rest of the bone quickly severed with forceps, the left forefinger placed upon the margin of the orbit steadying the instrument used and preventing any damage to the eye. This bone section is practically in a line with the spheno-maxillary fissure (at the lower and outer part of the orbit), and should fall into it. This will preserve the prominence of the cheek. If the malar bone be involved the zygoma must be sawn through. Schlatter advises the use of a Giglis saw (Fig. 128). This delicate instrument inflicts very little damage on the soft parts, and cutting away from the growth is not likely to injure it. It is carried on a half-curved needle through the spheno-maxillary fossa and over the exposed surface of the malar bone.

(2) The nasal process of the superior maxilla is next divided at the level of the highest part of the bony anterior nares, by cutting a saw-groove across it and then placing one blade of the forceps inside the

nostril and the other within the orbit as far as the posterior end of the spheno-maxillary fissure, the soft parts being first a little freed and carefully kept out of the way with the left thumb-nail. This bone section may be also made with a chisel and mallet. In either case there must be no splintering.

(3) The central or a lateral incisor being next extracted—this step is always to be left till now, to save needless bleeding—the mouth is widely opened with a gag, an incision made with a stout scalpel along the middle line of the hard palate up to the teeth and over the anterior aspect of the alveolus into the nostril, and another transversely outwards at the junction of the hard and soft palate, towards the molar teeth on the side affected. The soft palate is then detached with a scalpel or blunt-

A. B.

FIG. 167. A, Removal of upper jaw. (Earlier stage.) Reflection of the flap, and section of the bones. The extraction of an incisor was not needed here. B, Removal of upper jaw. (Later stage.) The flaps are reflected and held aside. The bones have been divided. The upper jaw is being dislocated with the lion forceps while a pair of cutting bone forceps completes the division of the palatine attachments. (Heath.)

pointed scissors, and thus preserved when the bone and growth are wrenched away. The hard palate is next deeply notched with the saw introduced through the nose opposite to the tooth which has been drawn, and severed with long bone forceps, one blade of which is introduced within the nose, and the other into the mouth. If a Giglis saw is used here, it is passed from the nose into the mouth with a curved probe. If a chisel or osteotome be now inserted into the different lines of bone section, the bone is loosened with a series of quick and careful levering movements, while finally, lion-forceps being made to bite firmly into the hard palate and the malar aspect of the bone, in the manner shown in Fig. 167, the bone is detached by a few wrenching—rocking movements upwards and downwards and laterally, the left forefinger detaching any soft parts which retain the bone, and the superior maxillary nerve being cut cleanly with scissors. If the above mentioned sections have been

properly made, the difficulty in detaching the bone next the pterygoid and palatine processes. The introduction of curved cutting bone-forceps behind the tuberosity of the maxilla will help now.

When the bone has been much invaded by disease, or in practising this operation on the dead subject, it is very likely to come away in fragments, being unavoidably crushed down by the forceps. On the removal of the bone, haemorrhage is often free from the palatine and other arteries, especially in a case of rapid growth. A large sterilised pad is at once thrust into the cavity, and pressure efficiently made. If on its withdrawal any vessel still spirts, it is usually easily tied, owing to the large size of the gape. The pterygoid fossæ, the cavity of the nose, and the palate are next examined, the sharp spoon or gouge being applied to remove any remaining portions of disease, or Paquelin's cautery made use of to destroy what cannot be otherwise removed.[1]

If there is any doubt about any part of the growth having been left behind, and if zinc chloride paste or strong formalin is used (p. 122), these had best be inserted on gauze, the strips being brought out at the mouth at the angle and tied together with silk, and so readily removed after a few days. But if the bone has come away with all the growth, if the surface of this is smooth and encapsuled, not ragged or lacerated, and the bleeding is all arrested, the surgeon will do best to insert nothing into the cavity. If oozing is going on, or there is reason to fear intermediary haemorrhage, strips of sterilised gauze should be carefully packed in, and removed later on by the mouth. But it is difficult to keep even these sweet, and the surgeon will do best to dispense with plugging if possible, and to content himself with brushing over the wound with a solution of zinc chloride (gr. xl to ℥j), or Whitehead's varnish (p. 50). The edges of the wound are then brought together with salmon-gut and horsehair sutures. Especial care should be paid to adjusting two points—one, the muco-cutaneous junction of the lip, the other, the angle of the flap near the inner canthus. If suppuration take place here, ectropion will follow. When the edge of the lip is united, the suture should be left long and the lip thus everted, while its mucous surface is carefully stitched with sterilised catgut or horsehair sutures, left long in the latter case. A few strips of sterilised gauze are then laid along the line of incision, with transverse ones across the divided lip, as an additional support here; they are kept in position with [illegible] and collodion.

A few points require further attention. The chief [illegible] are from the orbital plate, and [illegible] also all the attachments of the suspensory part of Tenon's capsule. Lockwood's and the [illegible] which may follow, are alluded to below (footnote, p. 429).

In a favourable case, the surgeon, having divided the [illegible] may be able with saw or chisel to remove the anterior or even the whole of the orbital plate. Where all the bone must be sacrificed, the suggestion of Von Konig may be followed. This is to divide the temporal muscle, half a finger's breadth [illegible] of the anterior border of the coronoid process close to its junction with the horizontal ramus. To give support to the cheek, a strip is carried below and around it towards the nasal wall, and is sutured to the remains of the frontal process of the maxilla. In malignant growths

[1] The high frequency electric current as recommended on p. 396 may also be employed for this purpose.

may proliferate into the orbit without any disturbance of the eyeball. Schlatter[1] advises that whenever cases the patient's consent be obtained to removal of the eyeball.

During the after-treatment the patient should be kept well propped up to facilitate the escape of bloody discharges, which must be prevented from collecting by frequent syringing or (what is better, by the patient himself) often rinsing and gargling the mouth. The wound with some antiseptic solution. Chlorinated, boroglyceride, or potassium-permanganate lotion, one of the spirit of wine, ʒss to a tumbler of water. The wound inside should be, if needful, occasionally brushed over or sponged with hydrogen peroxide solution. The patient should be kept warm and comfortable and a soft tube for the first few days. Especial care is needed to cleanse the mouth after food is taken. If possible, patients should be got out of bed into an armchair within the first week.

In those cases, rare nowadays, where the great gland or the operation being deferred, the mouth always remains open or some days after, but the power over the muscles which close the lower jaw is usually regained. The lost sensation rarely returns, and the resulting deformity is often very slight.[2] Later on, when artificial teeth are soundly fixed, the skill of a dental surgeon is called into requisition to construct a tooth-plate and obturator if needful. The deformity caused by the sinking-in of the cheek may be remedied by the injection of paraffin.

Partial Extirpation of the Upper Jaw. Cases requiring removal of an epithelioma with the alveolar border have been recorded by Gross, Billroth, and others. Sometimes opening up and exploring the antrum with a gouge suffices.

If the surgeon find that the lower portion only of the upper jaw need be removed abundant room will be obtained by splitting the upper lip in the middle line, prolonging this roomy incision into the nostril on the diseased side. By detaching the lip and dissecting up the flap of skin the facial surface of the jaw can be well exposed.

Again, if, after exposing the whole jaw by Sir W. Fergusson's incision, the surgeon find that the orbital plate can be spared, a horizontal saw-cut is made just below the infra-orbital foramen, and the bone cut through with a chisel and a few taps of a mallet.[3]

When the orbital and nasal structures of the upper jaw are involved and the lower alveolar portions are healthy these latter may be thus preserved. A cheek flap being reflected by an incision through the lip and upwards to the inner canthus along the nose, the nasal and malar processes are divided while the eye is duly protected. A horizontal saw-cut is then made above the alveolar process, outwards from the nose, and another carried upwards from the outer end of this, to join the incision through the malar process, being made either with the saw or chisel. The piece

[1] *Loc. supra cit.*

[2] No skin-graft, of course, is removed, even if it appears to be very redundant; it rarely sloughs, save when the struggling has been extreme, or when it has been needful to apply the cautery to the flap. After healing has moulded the skin over it, a hideous fistula is left, which must be closed by the patient if he survives, which he seldom does in these cases; or, if the patient be a woman, a flesh-tinted artificial cheek, supported by spectacles, must be worn. Sir Wm. Cheyne and Mr. Barghard point out that this has the great advantage of allowing the inspection of the cavity, and timely application of any needful cautery or caustics.

[3] The orbital plate should always be left if possible. As Mr. Bruce (*loc. supra cit.*, p. 125) points out, when the floor of the orbit has been removed there often results not only serious disfigurement, but much œdema of the lower lid and an unhealthy condition of the eye itself, which may be destroyed. Paralysis of the lower part of the orbicularis and epiphora from damage to the lachrymal duct are, also, not uncommon sequelæ.

of bone thus mapped out is loosened with a chisel or elevator, and either prised out with the latter instrument, or wrenched downwards and outwards with the lion-forceps.

Several other operations involving partial removal of the upper jaw are given under the treatment of naso-pharyngeal fibroma (p. 469).

Difficulties and Dangers during the Operation. These have been already alluded to. The chief are :

(1) *Shock.*

(2) *Hæmorrhage.*

(3) *Breaking down of the bone in the lion-forceps.*

(4) *Outlying pieces of growth* either in the pterygoid or other fossæ, or in the temporal region, or far back in the roof of the nose.

Possible Causes of Failure. (1) *Prolonged Shock.* Inability to rally. All the usual details, before, during, and after the operation, should be attended to. Feeding with a tube passed by the mouth or by the opposite nostril should be early resorted to, especially in the case of elderly patients, or in those much run down.

(2) *Secondary Hæmorrhage.* If this be severe, resisting the use of ice, &c., the wound must be opened up, and, if no definite bleeding-point be found, firm plugging must be resorted to, either with sterilised gauze, or the same, with the ends in the wound, wrung out of adrenalin chloride (1 in 1000) or turpentine. These steps failing to arrest the hæmorrhage, ligature of the external or the common carotid must be employed.

(3) *Infection of the Wound.* Different forms of this grave complication are likely to set in when the patient is aged or much broken down in health, with impaired viscera, or when, owing to extensive removal of bone, *e.g.* having to saw through the zygoma and loosen the outer wall of the orbit, the surgeon opens up deep planes of cellular tissue, which cannot, from the surroundings, be kept aseptic, most troublesome burrowing in the neck probably following. To cut cellulitis short, free scarification with small incisions should be made use of early so as to unload the parts, and abscesses should be opened at once. Boracic acid fomentations should be early employed.

(4) *Inhalation-pneumonia* is here, as after removal of the tongue, a decided risk. In this case, also, the treatment is mainly preventive, attention being assiduously paid to all the details already given, before, during, and after the operation.

(5) *Inflammation of the Brain or its Membranes.* Sir H. Butlin[1] has shown that the mortality after removal of the upper jaw is nearly 30 per cent. He goes on to remark that, if we are to reduce this mortality, "we must adopt two courses in the after-treatment—first, such means as will render the wounds aseptic ; second, regular and sufficient administration of food."

The experience of German surgeons bears out the above. Schlatter[1] writes : "How little the antiseptic era influenced the prognosis of this operation is shown by a comparison of Rabe's and Kronlein's compilations. The former collated 606 cases of major operations upon the upper jaw between 1827 and 1873, and found a mortality of 18·4 per cent. ; while Kronlein calculated a mortality of 21·5 per cent. from 158 total resections taken from the antiseptic period, 1870 to 1897. Konig estimates the mortality at about 30 per cent.

[1] *Loc. supra cit.*

Kronlein in his most recent communication has shown the cause of failure in the latter cases to be diseases of the air passages, not wound injuries. More than half the deaths after this operation are referable to these complications, especially aspiration during anæsthesia.

(6) *Recurrence.*

With regard to this Sir H. Butlin considers the prospects are very gloomy in cases of malignant disease, only four cases out of sixty-four (in which the result is recorded) being able to be considered relatively successful, *i.e.* having remained cured for three years.

This opinion is again fully borne out by the results of German surgeons. Thus Schlatter writes, at Zurich, he "observed recurrences after an average of 3·9 months in all cases of malignant tumour involving the entire jaw." Kuster recorded no permanent results. In the Erlanger statistics one permanent cure was recorded in seventeen cases. In the Griefswald statistics, of seventeen cases there was not one permanent cure. Estlander found ten reappearances in sixty-two operations. In the Gottingen clinic of seventy-four total resections, with twenty-three deaths, Martens found ten permanent cures. Stein has recently reported, from Von Bergmann's clinic, that of thirteen total resections for carcinoma, between 1890 and 1900, not one of those whose record is obtainable is living at the present time. The prognosis in sarcoma is more favourable than in carcinoma. Out of Mr. Jacobson's five cases of removal of the upper jaw only one was permanently cured. The patient was a young servant-girl; the growth was proved microscopically to be a spheroidal-celled carcinoma. Seven years afterwards the deformity was extremely slight, and owing to the skill of a dentist, mastication and articulation were little interfered with.

OPERATIONS FOR SUPPURATION IN THE ANTRUM OF HIGHMORE

It must be remembered that suppuration in the maxillary sinus, or antrum of Highmore, may be secondary to dental trouble, or be associated with suppuration in the other accessory sinuses of the nose, the prognosis being usually better when the former is the cause. The condition of these cavities therefore must be investigated in all cases of antral suppuration, and conversely when there is suppuration in the frontal sinus or ethmoidal cells it must be remembered that the antrum may have become secondarily affected.

The following operations will be considered: (1) Tapping the antrum through the alveolar process. (2) The radical operation in which the antrum is exposed through the canine fossa. (3) Drainage through the nose.

(1) **Through the Alveolar Process.** This method has the following advantages: (*a*) It drains the cavity at the most dependent part. (*b*) By extraction of the tooth it often removes the cause of the trouble. (*c*) It does not involve any cutting. The operation is a slight one and rapidly performed. It is indicated in all simple uncomplicated cases of short duration.

The disadvantage connected with this operation is, that in many cases, especially those of long duration, it does not effect a cure, as it does not permit of the removal of diseased and polypoid mucous mem-

brane from within the cavity. In other cases the after-treatment is very prolonged, and daily attention to the tube is required.

A tooth has usually to be first extracted, and, as long ago pointed out by Mr. Salter, "the tooth whose fangs are most intimately connected with the antrum is the first permanent molar,[1] and its removal in a case of antral abscess is especially indicated from this circumstance, and from the frail and perishable nature of the tooth itself, which gives it less often than other teeth a long tenure of usefulness." The operation may be carried out under nitrous oxide, which may, if thought desirable, be followed by ether. The puncture is made with an antrum drill, the point of which is introduced into the inner root socket, and is directed upwards and slightly inwards towards the inner canthus of the corresponding eye. The antrum can also be opened from the socket of the second molar or the second bicuspid, in which case the instrument should be inclined slightly more forwards or backwards respectively. The forefinger should be firmly held about one inch from the point of the instrument to prevent it penetrating too deeply. By a combined thrusting and boring movement the antrum is then quickly opened. The drill is then withdrawn, and the size of the opening may be increased by a larger instrument, or by a burr. A solid vulcanite plug, with a flange to prevent it slipping, is fitted into the opening.

The chief points in the after-treatment are to keep the opening patent, to prevent the entrance of food, and to encourage a healthy condition of the lining membrane.

To ensure these ends the cavity must be regularly syringed, the plug being removed for this purpose, and subsequently replaced. By the third day a rubber obturator may be substituted for the vulcanite plug, and later a plug may be fitted to the tooth-plate by a dental surgeon. The cavity should at first be syringed twice a day with lotions of boracic or dilute carbolic acid, sterile saline solution, or potassium permanganate—the lotion itself not being of so much importance as the regularity with which it is used. When the discharge has diminished, syringing once a day will suffice, and when, possibly after many months, no discharge has been noticed for some days, it may be altogether omitted and the plug removed. The opening then usually closes spontaneously, but if this does not occur, by applying caustics such as silver nitrate [2] or pure carbolic acid to the fistulous track.

The Radical Operation. In cases where the suppuration is of long duration, where the interior of the antrum is the seat of caries or where the mucous membrane has undergone a polypoid change, where the cavity acts as a reservoir for pus coming from other sinuses, or where there is a fistulous opening on the face, the above treatment will not be sufficient.

[1] Any other tooth, as Mr. Salter advises, molar, bicuspid, or canine, whose disease is possibly the cause of the abscess, will, of course, be extracted, as absorption round any carious tooth facilitates perforation of the alveolus. Unless the drill is carefully inserted in the right direction the antrum may be missed and the floor of the nasal fossæ perforated.

[2] Dr. H. Tilley (*Brit. Med. Journ.*, August 30, 1902, p. 585) found as the result of alveolar drainage in thirty-four cases, that sixteen were cured of their discharge in from two to eighteen months, fourteen were so relieved of their symptoms that they preferred to continue wearing their tube lest, by its removal, discharge should recur and necessitate further treatment. In all these uncured cases, except one, the headache had disappeared, the discharge had diminished almost to vanishing-point, and the patients were perfectly comfortable. As an antral discharge is so quickly diminished by alveolar drainage and irrigation, Dr. Tilley considered that as a rule the patient should be given a chance of cure or great improvement by this, the simplest mode of treatment.

The radical operation admits of free exposure of the interior of the antrum and removal of the diseased tissues, while a free communication is made with the nasal fossa to allow of permanent drainage. The patient having been anæsthetised, the naso-pharynx is plugged with a sterilised sponge (*see* p. 412), and a second sponge is placed between the cheek and the alveolar process. The cheek is then retracted, and a horizontal incision made through the mucous membrane just above the canine fossa. The bone is now exposed by displacing the soft parts upwards and downwards by a periosteal elevator. By means of a gouge or chisel the antrum is next opened; by means of a burr, or forceps, the opening is freely enlarged so that the little finger can be introduced. The condition of the interior of the cavity is then investigated with the help of a good light from a frontal lamp. All diseased mucous membrane is removed by forceps, scissors, or curette. Any carious patch in the bone also receives attention. Healthy mucous membrane should not be removed for, as in the case of the frontal sinus, owing to the size of the cavity, the object of the surgeon must be to leave the lining membrane in as healthy a condition as possible, not to remove it entirely. Special attention should be directed to the crevices between the projections caused by the roots of the teeth, and to the recesses at the anterior and posterior extremities of the cavity. The operation may be accompanied by extensive oozing, but this may be kept in check by the use of strips of sterilised gauze wrung out of hot sterilised saline solution or hydrogen peroxide lotion. When all diseased tissues have been cleared away, the surgeon must make a free opening into the nasal fossa. A Krause's cannula should be introduced into the nose, and its point pushed through into the antrum just below the anterior end of the middle turbinal.[1] This gives an excellent guide as to where the bone should be removed. The opening is enlarged through the antrum with gouge or punch-forceps. The communication should be as free as possible and should certainly admit of the surgeon's little finger being passed through the antrum into the nasal fossa. The sponge in the naso-pharynx is then withdrawn. No stitches are necessary, for the soft parts fall naturally into position. The subsequent drainage takes place through the opening into the nasal fossa. The antrum will require to be washed out daily until the discharge ceases. A Eustachian catheter, connected with a ball syringe, may be introduced into the cavity through the nasal opening, and it is thus syringed out with hot saline solution or boracic lotion. All discharge should cease in the course of a few weeks.[2]

(3) **Puncture of the Antrum and Drainage through the Nose.** Simple puncture of the antrum may be readily effected for diagnostic purposes by means of Lichtwitz's hollow needle under local anæsthesia. The needle is pushed through the inner wall of the antrum beneath the inferior turbinal. Air is then forced through the needle, and if the antrum contains pus this will be forced through the natural orifice and appear in the region of the meatus.

For purposes of drainage a general anæsthetic should be given, the anterior end of the inferior turbinal be removed if necessary, and Krause's

[1] If the anterior end of the inferior turbinal has not been previously removed this should be done, as described on p. 455, at the beginning of the operation.

[2] In cases of chronic empyema of the maxillary antrum this operation is very successful. Failure may be due to overlooking stumps of teeth within the cavity, and from leaving detached pieces of the carious wall within it. If the pyogenic polypoid mucous membrane be not carefully removed, suppuration may persist.

cannula thrust through into the antrum. The opening thus made is enlarged, through the nasal fossa, by means of punch-forceps. The chief difficulty is to enlarge the opening in a forward direction. By this means free drainage can be secured, more so than by puncture through the alveolar process. It has, however, the disadvantage that the interior of the antrum cannot be inspected, and diseased mucous membrane cannot be satisfactorily and certainly removed. Hence it cannot be described as a radical cure, and if the discharge does not soon cease, the radical operation described above will have to be performed.

FIG. 168. Exploration of the antrum by Krause's cannula after removal of the anterior extremity of the inferior turbinate.

The cavity is regularly washed out through a large Eustachian catheter as described in the after-treatment of the radical operation.[1]

The following opinions of well-known authorities on the *results of operative interference* will be useful to the general surgeon who has to decide as to which method he should adopt. Dr. Lambert Lack, writing of the simpler methods says: "In considering the question of a cure by these means it is safe to say, (1) that in cases of dental origin recent or chronic, a large majority are cured; (2) that in recent cases of nasal origin a majority are cured; (3) that taking all cases together, about 50 per cent. are cured and every case is greatly relieved; (4) that the cure depends to a large extent upon the care with which the patient conducts the after-treatment. If pus reappears in the nose immediately after washing out the antrum, there are such strong probabilities of other cavities being involved that they should at once be explored and treated if found diseased."

Dr. Tilley [2] found as the result of alveolar drainage in thirty-four cases that sixteen were cured of their discharge in from two to eighteen months, fourteen were so relieved of their symptoms that they preferred to continue wearing the tube lest, by its removal, discharge should recur and necessitate further treatment. In all these uncured cases, except one, the headache had disappeared, the discharge had diminished almost to vanishing-point, and the patients were perfectly comfortable. As an antral discharge is so quickly diminished by alveolar drainage and irrigation, Dr. Tilley considered that *as a rule* the patient should be given a chance of cure or great improvement by this, the simplest mode of treatment.

REMOVAL OF THE LOWER JAW, PARTIAL OR COMPLETE

Indications. These are much the same as those already given for removal of the upper jaw (p. 419). Sir H. Butlin [3] has discussed these

[1] The advantages claimed for this operation are that it is simple, quicker, and as effective as the one with the opening from the canine fossa. But, of course, it does not allow any inspection, and only a partial removal, of the diseased contents of the sinus. Still the results obtained are so satisfactory, that it seems advisable to try it in the majority of cases as a necessary first step, even if the radical operation has to be completed later.

[2] *Brit. Med. Journ.*, 1902, vol. ii. p. 585.

[3] *Oper. Treat. of Malig. Dis.*, p. 137.

growths, and has pointed out that here important differences are observable between the central and subperiosteal sarcomata. Thus the central (most often myeloid) sarcomata grow slowly, the periosteal quickly; the former are encapsuled, and even when they make their way into the surrounding structures they do not show that tendency to infiltration which is so marked in the periosteal sarcomata. The central ones are rarely associated with affection of the lymphatic glands, or with secondary growths.

The following operations will be considered:

A. Partial removal of the lower jaw.

B. Complete removal of one half of the lower jaw (Fig. 170).

C. Complete removal of the jaws, upper or lower.

A. **Partial Removal of the Lower Jaw.** This is frequently required in the case of epulis. The steps are the same as those already given at p. 419. The alveolar border should always be removed: in the case of a growth very far back around the lower molars it is advisable to slit the cheek, especially if the growth is becoming doubtful in character, and thus requires thorough extirpation.

The above remarks still more hold good in the case of a growth about the gums, situated far back, in an older patient, and becoming epitheliomatous.

Cases are occasionally met with where, owing to an epithelioma of the lip not having been treated, or to its recurrence, the symphysis of the jaw is infiltrated and requires removal.

The soft parts being reflected by incisions, starting on either side widely of the diseased parts, converging towards the hyoid bone, and the vessels secured, the bone is sawn through in two places, well beyond the level where its softened, spongy state, and the loosened teeth show that it is invaded. The sawn surface left must be carefully scrutinised. The tongue, prevented from falling back by a loop of silk passed through its tip, is now detached by snipping through the mucous membrane, and the muscles attached to the genial tubercles. Any further hæmorrhage being looked to, the sublingual and submaxillary glands are examined, and, together with any enlarged lymphatic glands, removed if needful; flaps are dissected up from the neck to make a new lip (p. 493, Figs. 198–203), and drainage provided, the tubes being brought out below at the lowest level of the region from which the flaps have been dissected up. The adjustment of these to form the new lip will be the more easy in proportion to the amount of bone removed.

Fig. 169. Incision for excision of lower jaw.

So, too, especially in epithelioma in the region of the angle of the jaw directly extending from, or secondary to that of the tongue, the surgeon may be led, in order to relieve his patient's condition, if he cannot cure him, to operate extensively here. Thus, after turning up a horseshoe-shaped flap, with the concavity upwards, and clearing the masseter off the jaw, this bone is divided above the angle, then through the horizontal ramus, and removed, together

with the submaxillary, sublingual, and lymphatic glands, which will probably be enlarged, and also adherent. The hæmorrhage[1] will be free, from the facial and lingual vessels, and veins communicating with the external jugular. Free drainage must be provided.

Removal of part of the horizontal ramus or of the angle may be called for in cases of new growths limited to these parts; and the surgeon may, especially in the case of a woman, ask how far it is worth while to try and remove these from the mouth, detaching the softparts with a raspatory, and sawing the bone in front and behind the growth, as in the case of an epulis, but the section here passing through the whole thickness of the jaw. It may be doubted if the extra trouble and risk of the proceeding are balanced by the absence of a scar, which, in the majority of cases, need not involve the lip, and, if properly placed, will be nearly invisible afterwards.

Fig. 170.

Question of Removing a Portion or the Whole or Half of the Lower Jaw. This matter will have to be decided when the surgeon, having a case of growth before him which involves the horizontal ramus as far back as the angle, is in doubt whether to saw through the vertical ramus or to disarticulate. In the great majority of cases, especially where the patient is no longer young, where the growth is not a central one, where it has been attacked before, the operator had much best place his patient and himself on the safe side and disarticulate. The lower jaw being "a floating bone," this radical step often gives a better prognosis for operation here than in the case of the upper jaw. On the other hand, the lower jaw is so embedded in soft parts, and so near to important parts, *e.g.* pharynx and pterygoid fossæ, that delay may render the extirpation of the growth impossible.

B. **Removal of Half of the Lower Jaw** (Figs. 169, 170). The patient's head and shoulders are raised, his body brought to the edge of the table, and the head moved to the opposite side. The operator stands on the affected side, or operates on either jaw from the right. The parts are again rendered as sterile as possible. A preliminary laryngotomy will rarely be called for, and only when the growth is so vascular as to make plugging of the fauces a wise precaution.[2] As it will be well in most cases to explore the submaxillary region, the incision which

[1] Dr. Addenell Hewson advises that the external carotid should be ligatured before proceeding to removal of the jaw. (*Ann. of Surg.*, 1909, vol. xlix, p. 618.)

[2] The advantages of the intratracheal insufflation of ether in these cases have been already indicated.

begins just below the lip[1] in the centre of the chin, should pass down to the hyoid bone. Hence it is carried laterally well below the mandible along the submaxillary cervical crease (Kocher) to a point a finger's breadth behind and below the angle. The authority just mentioned advocates this level for the lateral part of the incision as sparing the supramaxillary branch of the facial nerve. The incision is carried down to the bone over the chin; over the facial artery it should be only skin-deep. This vessel is next secured between two ligatures. In raising the flap thus marked out, the muscles, where it is safe to do so, are raised with it by a periosteal elevator and the point of the knife, including the small ones in front and the masseter and buccinator behind. Where there is any risk of their being infiltrated the flap must consist of skin and fascia only. Such arteries as the mental and masseteric will now probably need attention. From the inner aspect of the mandible the muscles are next detached, viz. anteriorly the digastric, mylohyoid, genio-hyoid and genio-hyoglossus, and posteriorly the internal pterygoid, until the mucous membrane is reached, but the cavity of the mouth should not be opened at this stage, if possible. The flap that has been raised is wrapped in sterile gauze.

An incisor being extracted if needful, the jaw is divided to one side of the symphysis well in front of the growth, by deeply notching it with the saw[2] before using the bone-forceps or chisel. If it be needful to remove the bone so freely that the symphysis and the genial tubercles are removed also, the tongue must be prevented from falling back upon the aperture of the larynx by means of a loop of stout silk passed through the lip. The bone being divided and pulled outwards, any of the muscles which remain undivided on the inner aspect of the jaw, together with the buccal mucous membranes at its junction with the alveolus, are divided with blunt-pointed scissors. Care must again be taken not to leave behind any infiltrated tissues. In a very few cases, where the nature of the growth admits of it, the submaxillary and sublingual glands may be spared by keeping the knife or scissors close to the bone.

The anterior half of the jaw being now freed, the surgeon, taking it in his left hand, everts it so as to divide the internal pterygoid more freely, and also the inferior dental nerve and vessels. The jaw is next strongly depressed so as to bring down the coronoid process, and the insertion of the temporal muscle. This strong tendon requires complete division, as depression of the bone brings fasciculus after fasciculus into view. If the coronoid process is very long it may hitch against the malar bone or be jammed against it by the bulk of the tumour: in such cases it had better be cut off with bone-forceps, and, after the removal of the growth, dragged down with sequestrum-forceps and removed. After the temporal tendon is thoroughly detached (when this is effected the jaw comes down more easily), strong depression of the jaw is continued so as to bring the condyle within reach, no eversion or rotation outwards of the bone being permissible at this stage of the operation, or the internal

[1] If there are reasons for especial speed, such as the condition of the patient, or if the growth is very large, the red border should be divided, as this facilitates matters much, and the additional deformity is very slight.

[2] When the condition of things admits of it, the jaw should always be divided as far from the symphysis as possible, in order to preserve the anterior belly of the digastric and its insertion, which will thus counteract the tendency of the muscles on the opposite side to draw the chin somewhat over. It is convenient to be provided with a Gant's saw or one with a movable back.

maxillary artery which passes between the neck of the jaw and the internal lateral ligament will be brought into the wound and very likely cut, causing troublesome hæmorrhage. The external pterygoid is next partly torn through with the finger or the director, the capsular ligament is opened in front with the careful use of the knife or scissors, which next, kept close to the bone, divides the lateral ligaments, when the jaw comes away, the final separation being usually effected by the remaining fibres of the external pterygoid being torn through, together with the stylo-maxillary ligament and the periosteum to which it is attached. The knife, if it is required here, should be kept very closely in contact with the posterior border of the ascending ramus. But usually after division of the external lateral ligament the mandible can be pulled away.

If the internal maxillary artery has been divided, which is sometimes excusable in cases of large growths extending far up, it can be readily secured in the large wound.

If the operator finds the vertical part of his incision insufficient, and yet does not like to prolong it for fear of damaging the chief part of the seventh nerve, the soft parts should be well raised by a retractor, after being pushed upwards with a periosteal elevator.

In cases where the jaw has been extensively thinned or eroded by growth, it is very likely to fracture under the depression which is required to bring down the condyle. If this accident occur, removal of the condyle and coronoid process is rendered difficult, as the latter is drawn upwards under the zygoma by the temporal muscle. Their removal will be facilitated by dragging them down with lion-forceps and detaching the temporal tendon with blunt-pointed scissors.

All hæmorrhage being securely arrested, the submaxillary region is investigated, and if needful is thoroughly cleared out. Careful search is made for any remaining infiltration of the parts affected, or for any outlying portions of growth. The flap is then brought down, and adjusted with sutures of silkworm-gut and horsehair, drainage being first provided for by bringing a drainage-tube from the neighbourhood of the condyle through the wound below.

Especial care must be taken in exactly uniting the red line of the lip and suturing the mucous membrane with horsehair left long (p. 428) if this has been divided.

The wound is then dressed, as at p. 428, and the patient here also should be propped up to facilitate escape of the discharges. For the first few days it may be necessary to feed by a nasal tube, aided by rectal enemata and suppositories. The patient should wash his mouth out as frequently as possible as directed at p. 429. The drainage-tube should be shortened so that, as soon as is safe, it ceases to communicate with the cavity of the mouth.

From time to time attention has been drawn to the need of replacing artificially, the removed portion of the jaw,[1] and thus restoring, in a measure, the power of mastication and removing the deformity. C. Martin, a surgeon-dentist, of Lyons, brought forward an artificial jaw made of gutta-percha, in 1889. It is fastened to the remaining portions of the jaw with nails or screws at the close of the operation. A series of perforations allows of the passage of discharges and of irrigating fluids.

It remains in place during the entire period of wound repair. About the third week it is replaced by a permanent artificial jaw provided with

[1] McBurney, *Ann. of Surg.*, July 1894; Pearce Gould, *Lancet*, January 16, 1897, p. 179.

teeth. This and other forms of artificial jaws, some made of aluminium, are figured by Schlatter.[1] An admirable result of what Martin's splint can effect is shown by the illustration of a girl aged 18, in whom, eight years before, Schlatter resected 10 cm. of the lower jaw. Here neither speech nor mastication were impaired.

Difficulties and Possible Mistakes during the Operation.

(1) Slipping back of the tongue, if the symphysis has been removed.

(2) Wound of the pharynx by not keeping the knife close to the bone in separating the soft parts from the angle of the jaw. This interferes with the patient's being able to swallow from the very first.

(3) Fracture of the jaw.

(4) Jamming of the coronoid process.

(5) Rigidity and permanent contraction of the temporal, masseter, &c.

(6) Wound of the internal maxillary vessels.

(7) Outlying growth in the temporal region, or near to the tonsil and large vessels.

C. **Operations for Complete Removal of Both Jaws.**[2] Before leaving the subject of removal of the jaws, a few words may be said of those rare cases which occasionally call for removal of both the upper or the whole of the lower jaw, or both the jaws on the one side.[3] Space does not admit of giving more than brief references to a few cases.

The growths which call for removal of both upper jaws simultaneously fall mainly under the two heads: (*a*) Epithelioma of the palate and alveoli involving one or both of the antra;[4] (*b*) Growths, usually sarcomatous, spring often from the base of the skull or some part of the naso-pharynx, and projecting forwards the jaws with hideous deformity.[5] These cases are much less favourable than the epitheliomata.

In either case the parts are exposed by slitting the centre of the upper lip and then carrying the incision round the nose on either side, Fergusson's incision being made use of as far as needful. In a few cases, in order to get adequate room, it may be needful to make incisions from the angles of the mouth to the malar bones, and raise all the intermediate soft parts as a flap. Wherever it is feasible, as in cases where the growth has begun in the alveolar processes, the infra-orbital plates should be retained. This may be done by sawing through both bones from the nose outwards, and completing the separation of the lower part of the maxillæ from the upper by an osteotome or chisel.

After the full account already given of removal of the upper jaw, no description need be given of these operations for removal of both halves simultaneously. The greater risk of shock, the liability to more profuse hæmorrhage, the probability of finding the growth extending far back into the different fossæ and along the base of the skull, are obvious. Later on, if the patient make a good recovery, the help of a dentist will be much needed in fitting some form of obturator, as articulation is now

[1] *Loc. supra cit.*

[2] It is not always easy to tell the limits of a growth of the jaw. Thus one of these may extend up to the level of the lower part of the ear, bulge forwards close up to the nose, creep low down in the neck, and yet originate in the lower jaw. In deciding to which jaw a growth belongs, attention should be paid to involvement of the floor or roof of the mouth, and the results of masticatory movements.

[3] Mr. Spanton (*Brit. Med. Journ.*, 1885, vol. ii. p. 64) records a case in which first the upper, and, a few months later, the lower jaw on the right side, became the seat of malignant disease. The jaws were removed at an interval of a week. The patient, aged 55, recovered from the operations, but the growth quickly reappeared.

[4] Godlee, *Clin. Soc. Trans.*, vol. xx, p. 260.

[5] J. Lane, January 25, 1862; Dobson, *Brit. Med. Journ.*, October 11, 1873.

far more imperfect. The deformity is also obviously far greater. In fact the operation is only justifiable in a patient of good vitality and with increasing pain from pressure on the nerve foramina.

That such extensive operations are still, occasionally, required, is shown by a case of Dr. Bermays,[1] of St. Louis. Here, in a man, aged 31, a recurrent sarcoma required the removal of both maxillæ and most of the bones of the nose. A preliminary tracheotomy was performed, and Trendelenberg's apparatus employed. The patient made a good recovery, but the disease reappeared ten months later. Excellent photographs illustrate the condition before and after the operation. In two other cases Dr. Bermays had removed both maxillæ.

OPERATIONS TO RELIEVE FIXITY OF THE LOWER JAW. SUTURE OF DISPLACED FIBRO-CARTILAGE (Fig. 171)

The above condition may be due either to changes in the temporo-maxillary articulation resulting in ankylosis, or to cicatricial bands between the jaws, or to both.

Operations. The two usually performed are :

(1) Excision of the condyle, an operation indicated when the mischief is limited to the joint itself.

(2) Esmarch's operation of removing a wedge of bone from the horizontal ramus in front of the cicatrices and masseter ; this operation being preferable to the first when scars are present which interfere with excision of the condyle.

Conditions justifying one of the above Operations. Inability to open the mouth, resisting use of wedges, &c.[2] Fœtor of saliva and breath. Difficulty of speech. Inability to eat solid food.

The above are brought about by the following causes, which will be enumerated together here, though some call for one of the above operations and some for the other, viz. :

(1) Inflammation of the joint set up by a punctured wound,[3] gonorrhœal arthritis, severe contusion,[4] or sprain, osteo-arthritis,[5] or suppurative arthritis, from abscesses burrowing into the joint, *e g.* abscesses connected with otitis media. (2) An unreduced dislocation in which much stiffness remains after attempts at reduction have failed, in a patient healthy and not advanced in life. (3) Cicatrices after sloughing set up by scarlet fever, measles, typhus, cancrum oris, or mercurial stomatitis. (4) Cicatrices after suppuration due to necrosis or alveolar abscess.

The most difficult cases to deal with are those where there has been much previous suppuration, and where the mischief is bilateral.

The earlier any needed operation is performed in young patients the better, owing to the interference with the eruption of the teeth, and the wasting of the muscles, which is sure to follow. Probably in these

[1] *Med. Rec.*, March 28, 1896.

[2] Mechanical apparatus must be used early to do any good. Daily forcible use of levers is usually unsatisfactory, and the use of interdental shields do little more than retard scar-formation.

[3] Cf. Mr. Hilton's case (*Rest and Pain*, p. 114), in which bony ankylosis of this joint and of the upper cervical vertebræ seemed to commence after a punctured wound in the neck.

[4] Mr. Heath (*R. C. S. Lects.*, 1887, vol. ii, p. 114) mentions a case in which ankylosis of the temporo-maxillary joint followed on a kick from a horse on the side of the face. In such cases a fracture may co-exist. W. J. Roe (*Ann. of Surg.*, May 1903) is of opinion that bony ankylosis here invariably results from fracture.

[5] Good illustrations of this condition are given by Mr. Heath (*Brit. Med. Journ.*, 1887, vol. ii, p. 55). The fibro and articular cartilages will probably be wanting.

severe cases the best results follow on bilateral excision of the condyle, with removal of the coronoid process if needful. It has been stated by R. Matas,[1] that if Esmarch's method be made use of on both sides, loss of cont ol of the intervening fragments will follow. Mr. Swain's case (p. 442) proves that this is not always correct. In the worst cases, several operations and the most persevering after-treatment will be required, if a satisfactory result is to follow.

Excision of the Condyle (Fig. 171). This operation is indicated when the mischief is limited to the joint itself, as may be the case in the first two conditions given above. It may be performed as follows :

An incision about an inch and a half long is made on a level with the tragus along the lower border of the zygoma. The parotid and branches of the facial nerve being drawn down, the masseter fibres are cleared away from their insertion with a narrow elevator and the joint exposed. The neck of the condyle is now sawn through with a fine saw, or divided with an osteotome, and the condyle turned out with an elevator, the external pterygoid being detached. The libro-cartilage is left behind. The periosteum should not be preserved. The bone, which must not be splintered, should then be further pared down ; and the operation will very likely need repeating on the opposite side before sufficiently free movement is regained. Care must be taken in prising out the condyle, in the use of gouges, &c., not to open the cranial cavity. The use of a small drain will usually be advisable. While the patient is still under the anæsthetic, the mouth should be opened with a gag to a full inch at least, more if possible. The use of hard wood wedges or cones grooved transversely to give resting-places for the teeth, should be methodically employed. This step should be frequently repeated with the aid of nitrous oxide or ether if needful. The case must be watched most carefully owing to the frequency with which relapses take place.

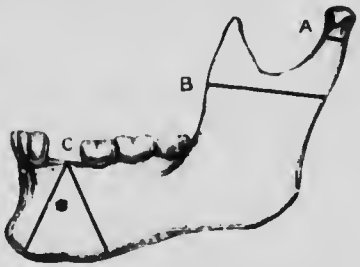


Fig. 171. A. Excision of condyle. B. Excision of coronoid and condyloid process. C. Esmarch's modified operation. This must always be in front of all cicatrix tissue. It happens to correspond here to an edentulous part of the jaw.

Esmarch's Operation (Fig. 171). This operation, which is suited to those cases where the fixity is brought about by cicatrices within the mouth rather than by mischief limited to the joint, consisted at first in simple division of the mandible. Removal of a wedge-like piece of bone, in other words, a cuneiform osteotomy, in front of all scars, is to be preferred.

Division of the bands inside the mouth is absolutely futile, and attempts to cover the wounds made by excision of scars with flaps of mucous membrane or skin are difficult, bloody, and disappointing. The most recent of these is the plan of Von Mikulicz, who drew forward a flap from the masseter, and fixed it to the edges of the gap between the fragments with sutures.

An incision two or two and a quarter inches long is made along the lower border of the jaw in front of the masseter and cicatrices. This incision should go down to the bone : the facial artery will probably need securing. As the soft parts are raised, any muscular fibres met with on

[1] *Journ. Amer. Med. Assoc.*, November 28, 1903.

either aspect should be carefully detached. A triangular wedge of bone, of sufficient size, is then removed with a narrow saw, *e.g.* Gigli's or Gant's. The section should be made as cleanly as possible, to avoid risk of necrosis, and the periosteum should be removed with the bone. The wedge should measure at the very least an inch and a quarter below and three-quarters of an inch above, and it must be taken from a part entirely in front of any cicatricial tissue.

If possible, its apex should correspond to an edentulous gap in the alveolar process. If the dental artery bleed freely, the foramen should be plugged with a tiny sterilised wooden plug, or the bone crushed in around the bleeding-point.

Some surgeons, who prefer a cuneiform osteotomy to excision of the condyle, advise removal of the bone at the angle of the jaw, not in front of it. Here an angular skin incision is made. Such a course would only be permissible where no cicatricial tissue is present. To prevent a return of the ankylosis some Continental surgeons have inserted a flap of muscle, *e.g.* temporal in the case of the condyle, and masseter in that of Esmarch's operation, securing it in place with sterilised catgut. We owe this step to the ingenuity of French surgeons, who first made use of it by inserting a flap from the triceps after excision of the elbow. It is a needless complication if only sufficient bone is removed in every case.

Owing to the tendency to relapse,[1] passive and active movement should be made use of early, and at first, if needful, with the aid of an anaesthetic.

The operation should be performed early in cases where cicatrisation after severe ulceration is leading to increasing fixity of the jaw, ultimately needing operative interference.

Mr. Swain, of Plymouth, published a most successful case,[2] in which he operated on both sides simultaneously, by a modification of Esmarch's operation.

The subperiosteal method preserves the attachment of the masseter and internal pterygoid to the inner surface of the angle, thus keeping intact the two elevator muscles. If a sufficiently large wedge is removed the danger of relapse is very remote.

The jaws had been closed, after scarlet fever, for thirteen years. An incision about an inch and a half long was made just at the angle of one jaw, and then on the other side, parallel with the line of the jaws, the point of the angle being at the centre of the incision. The knife was carried at once down to the bone. With a raspatory the whole of the periosteum on the outer and inner surface of the angle of the jaw was lifted from the bone, together with the insertions of the masseter and internal pterygoid. A narrow saw was then applied, and a triangular piece of bone removed, including the angle of the jaw, and measuring at its base about one inch.

Dr. Howard Lilienthal, of New York, has recorded a successful case of bilateral temporo-maxillary ankylosis treated by excision of the joints. The condyle was exposed by making an incision along the zygoma and a second vertical incision $1\frac{1}{2}$ inches long from the posterior end of the first downwards towards the angle of the jaw. The zygoma was divided in two places by a Gigli saw and an osteoplastic flap turned downwards. The joint was thus exposed and the condyle excised. The flap was then replaced, sutures for the divided zygoma not being required.

[1] This relapse is more likely if the wedge is not removed well in front of all cicatrices. Thus, Mr. Heath (*Dis. and Inj. of the Jaws*, p. 332) found, two years after Esmarch's operation for complete closure of the jaws, that the interval between the left molars had diminished from $\frac{5}{8}$ to $\frac{1}{8}$ inch, and that between the lateral incisors from $\frac{3}{8}$ to $\frac{1}{4}$ inch.

[2] *Lancet*, 1894, vol. ii, p. 189. Mr. Swain collected in this paper 19 other cases of operation for closure of the jaws, of which 12 were cases of removal of the condyle or portions of the neck. In few of the former was the result comparable with that obtained by Mr. Swain in his case.

CHAPTER XXI

PLASTIC OPERATIONS FOR REPAIR OF THE NOSE

THESE operations will be considered under the following headings: (A) Those for "**saddle-nose**" where the bridge is lost; (B) those for **complete**, and (C) those for **partial restoration.** The injection of paraffin will be found described on p. 452.

Indications. When the patient is healthy and of good vitality; when the cause of the destruction, viz. lupus, gunshot or other injury, syphilitic ulceration, congenital or acquired, new growth (*e.g.* epithelioma or rodent ulcer) necessitating removal, is not only checked but soundly healed.[1]

Thus, when lupus has been cured, and still more in the case of syphilitic ulceration, it will be well to wait six months at least after the disappearance of the disease.

A. **Operation for Saddle-Nose.**[2] This partial rhinoplasty will be taken first and by itself, as it is one of the most frequently indicated, and as it is one which gives the best results. The condition presents itself in varying degrees of deformity. In a typical case the entire bridge is deeply depressed, while the cartilaginous portion with the subjacent part of the septum is tipped upwards and forwards by cicatricial contraction, the nostrils looking forwards instead of downwards. It may follow syphilis acquired or congenital, depressed fracture, or suppuration and necrosis after injury. That due to depressed fracture is obviously likely to give the best results. Whatever the cause, healing must be complete before any operation is attempted. Operative steps here will probably be largely replaced by the use of paraffin. The operator has two indications before him: (1) to replace and to retain in its new position the cartilaginous part of the nose; (2) to restore the bridge.[3] The following account is given in detail, as this operation will be found to give the best basis of the methods for complete rhinoplasty. Most of these have now only an historical value, and do not give permanent results. The credit of the success of the operation for saddle-nose must be given in the first and chief place to König. His method has been improved by different operators, *e.g.* Israel and Watson Cheyne.

The parts concerned in the operation are rendered as sterile as possible. By a curved transverse incision at the deepest part of the depression,

[1] In Sir W. MacCormac's case, quoted below, the tip and ala of the nose had sloughed in infancy, after the injection of a large naevus with the liquor ferri perchloratis.

[2] On this subject a paper by Dr. John B. Roberts, of Philadelphia (*Ann. of Surg.*, 1910, vol. li, p. 173) may be consulted. It gives much useful information on the operative correction of syphilitic and other deformities of the nose.

[3] Dr. Stephen H. Watts has described a case of successful rhinoplasty by means of transplanting a finger (*Ann. of Surg.*, 1910, vol. li, p. 191). Dr. Leonard Freeman has described a method of correcting saddle-nose by inserting a celluloid plate (*Ann. of Surg.*, 1907, vol. xlvi, p. 206).

which enters the nasal cavity and is carried with sufficient freedom through all adhesions and what is left of the bony framework (with a fine saw or a chisel), and through the cartilaginous septum sufficiently to liberate the soft parts of the nose below, these are replaced so that there is no tendency for them to spring back into the place where the tip of the nose should naturally be. In cases where the skin over the upper two-thirds of the nose is sound and sufficient, a vertical incision is made from the root of the nose down its centre to where the curved transverse incision was made. At the upper end of this vertical incision two slightly curved ones with the convexity upwards are carried outward for about an inch at first, and by this means two lateral flaps are raised off the centre of the nose. They should not be raised more widely at this stage, as this step would cause needless and troublesome haemorrhage.

The bridge to the nose is then made by taking a flap from the forehead. Two incisions going down to the bone, beginning about half an inch above the root of the nose, and each about one-eighth of an inch from the middle line, are carried upwards to the roots of the hair if needful. A transverse cut of similar depth joins the upper ends of these incisions. With a narrow chisel introduced first at the sides and then above, and sloped sufficiently, the flap of skin and external table of the frontal bone is raised from the diploe. When the lower end of the flap is reached the bone is broken across here. König now inverts the flap before transplanting it, so that the shell of bone forms the outer and the skin the inner surface of the nose, and brings down a skin flap in the usual way from one side of the forehead, which is placed on the raw surface of the first flap. This method may be required where the soft parts over the bridge of the nose are much altered; it obviously entails much more scarring than that of Israel and Watson Cheyne, where the second flap is taken, as described below, from the nose itself. The skin upon the deeper surface of the flap is shaved off where this is needful in order to cause it to adhere to the remaining tissues of the bridge, which are also, in their turn, refreshed. In either case the narrow flap from the forehead must be long enough for its free edge to be stitched with fine sterilised catgut to the tip of the nose in its normal position without any tension whatever. This is sometimes difficult to ensure when the hairs grow low down upon the forehead. If, to secure the above object, the two incisions on the forehead are prolonged downwards, care must be taken not to imperil the vascularity of the flap.

The two lateral flaps which were raised sufficiently in order to allow the frontal strip to be placed in position on the bridge of the nose are now carefully raised by curving outwards the two incisions at their upper extremities.

Troublesome bleeding is often met with as the flaps are raised. When sufficiently raised they are united with sterilised horsehair and very fine salmon-gut sutures in the middle line over the raw surface of the median frontal strip which has been reflected downwards.

The incision in the forehead is sutured and should leave a linear scar. In about a month's time the base of the reflected frontal strip is divided, and any redundancy and folds remaining are removed by suturing the divided base into place after small elliptical portions of skin have been removed.

Sir Watson Cheyne recommends that a long splinter of rabbit's femur be used to keep the tip of the nose in position.

The following account of this most important step is taken from Sir Watson Cheyne's paper [1]:

"The patient, aged 18, had received a severe injury to the bridge of his nose (? fracture) when twelve months old, this being followed by suppuration from the nose, and, during the next few months, by discharge of portions of the nasal bones. The result was loss of the bony bridge. There was practically no bony bridge present; some rough bone, no doubt of periosteal origin, could be felt covering the space between the two maxillæ in the situation of the nasal bones. There was, fortunately, very little tilting forward of the tip of the nose, and it was not necessary at the operation to cut into the nasal cavity to rectify this deformity. The patient having been anæsthetised, a curved incision with the convexity to the right was made, beginning above rather to the left of the middle line at the root of the nose, and terminating below rather to the left of the middle line about half an inch below the commencement of the cartilage of the nose; the convexity of the curve at its centre extended on to the cheek. The incision at the upper part went down to the bone, and at the lower part to the nasal cartilage. The flap was then turned over to the left, an attempt being made to peel off the periosteum from the nasal bones, which, however, failed owing to the great irregularity of the new bone. While the bleeding was being arrested by pressure, a rabbit was killed by chloroform, immersed in bichloride of mercury solution (1 in 2000) to fix the hair, and rapidly skinned by one of the dressers. One of the thighs being then disarticulated at the hip, the soft parts over the femur were detached, the periosteum being left, and with a pair of cutting pliers the bone was split up longitudinally into several fragments. The wound being now uncovered, a fragment about two inches in length was first inserted into the nasal cartilage at the lower part, pushing down the tip of the nose, and then wedged against the frontal bone at its upper part. Four or five smaller fragments were now laid around this till the necessary height for the bridge was obtained. The skin flap was then replaced, but before it could be made to meet it was necessary to undermine it well towards the left side. The wound healed by first intention, but ten days after the operation a little glairy fluid was let out at the upper part. The result, nine months later, was excellent."

B. **Operations for complete Restoration.** Several operations have been described so as to suit the varying conditions met with, but it is increasingly rare to meet with cases requiring complete restoration of the nose. The first three of the following will be found most useful:

(1) Methods by double or superimposed flaps, based upon that of König.

(2) Keegan's operation (Fig. 172).

(3) Syme's, from the cheeks (Figs. 173).

(4) The Indian or frontal.

(5) The Italian or Tagliacotian.

Before deciding which operation he will make use of in restoring the nose, the surgeon will investigate the following points: How far is the bony framework of the nose destroyed? If the cartilages, septum, vomer, ethmoid, and nasal bones are very deficient, however well made the single flap, and however skilfully it is adjusted, it will tend, after looking extremely well at first, to sink down to the level of the cheeks. The final result of complete rhinoplasty is rarely satisfactory. In Tillman's words, "The nose is at first very good, but it soon shrinks. The art of rhinoplasty consists in making a nose with a good profile, long, high, and pointed; but this, as a permanent result, is seldom attained." If he proposes to take flaps from the cheeks, the surgeon must examine how far these are plentiful, and free from old scars. So, too, if the forehead is to furnish the flaps, how far it is a capacious one and free from hairs.

(1) **Methods by Double or Superimposed Flaps**, based upon that of König. Owing to the ultimate disappointment which is certain with the single flap, an operation based on the method which has been given

[1] *Clin. Soc. Trans.*, 1899, vol. xxxiii, p. 218.

in detail above is always to be preferred. The central skin and bone forehead flap must be cut much broader, Rotter says 3·5 cm. broad. It should be turned down at its base so that the skin lies internally. After three or four weeks it is skin-grafted, or covered with a flap taken laterally from the forehead. If the superficial surface be excessively bony the bone is divided longitudinally on either side, with a fine sharp saw, so that the central part forms the bridge and the lateral only supports it. But, as a rule, the bone splinters too easily for this step to be feasible. As the deep surface of the flap is turned forwards any bone that exfoliates is easily removed.

A columella must be made subsequently (p. 449). This should always be as narrow as possible, otherwise breathing will be interfered with.

A. B.

FIG. 172. Keegan's method of rhinoplasty. A. Incisions on nose. B. Outline of incision on forehead.

Many other details will be gathered from the account of the methods which follow.

(2) **Keegan's Method of Rhinoplasty.** This method has been introduced[1] by Surgeon-Major Keegan, whose name is so well known in relation with lithotrity. As Residency-Surgeon for many years at Indore he had ample opportunities of performing rhinoplasty—slicing off the soft parts of the nose being a very common mutilation in India, especially by the hands of jealous husbands. Such cases are most favourable for operative measures, the patients being young and healthy, and the bridge of the nose left. It will be seen that superimposed flaps are used. "The patient having been fully anæsthetised, the cavities on both sides of the septum are plugged with pledgets of wool, to which sutures are attached. The operation is begun by carrying two converging incisions from two points slightly external to the roots of the alæ nasi to two points about three-quarters of an inch apart on the bridge of the nose, where a pair of spectacles would rest. These two points are now joined by a horizontal incision. This horizontal incision is bisected, and a perpendicular incision is drawn downwards from the point of bisection nearly as far as where the nasal bones join on to the cartilage of the nose. In other

[1] *Lancet*, 1894, vol. i, p. 419.

words, this perpendicular incision follows the course of junctura of the nasal bones, but is not carried down as far as their inferior borders. The skin and tissues are now dissected from off the nasal bones from above downwards in two flaps, ABCD and EFGH, as in the appended diagram (Fig. 172A). The two inferior borders of the flaps, viz. CD and GH, are not interfered with, and constitute the attachment of the flaps to the structures and tissues which clothe the inferior borders of the nasal bones where they join on to the cartilage of the nose. If these two flaps are reflected downwards so that their raw surfaces look forwards and their cutaneous surfaces look backwards, it will be found that they overlap in the centre. The surgeon has, therefore, a redundancy which he can utilise a little later on, when he has raised the flap from the forehead. He now proceeds to do this. A piece of brown paper rendered adhesive, corresponding in outline with the flap (Fig. 172B) considered suitable to the case in hand, is stuck firmly on to the forehead in a slanting direction. And then a very sharp knife is run round the border of the paper. The paper is now removed, and the flap is quickly raised from the forehead. This flap should embrace all the tissues down to the periosteum, and should be subjected to as little handling as possible. The sides of the gap now left in the forehead are approximated as quickly as possible with horsehair sutures, and it is surprising how small a raw surface is left behind[1] on the forehead if the approximation of the sides of the gap be judiciously and expeditiously carried out. Attention is now directed to preparing a nidus or bed for the reception of the columna, and this does not require any description. The two flaps ABCD and EFGH, which

A B.

Fig. 173.—Syme's method of rhinoplasty. A. Shape of flaps from the cheeks. B. Mode of adjustment.

have been already raised from off the nasal bones, are now reflected downwards, and, as they overlap in the centre, two triangular shaped pieces are cut away, and placed in the middle of the gap left in the forehead, in order to expedite the healing of the frontal scar. The forehead flap is now brought down over the nasal bones and rests inferiorly on the two reflected nasal flaps, and the nostrils of the newly formed nose are therefore lined inside with the skin of the reflected nasal flaps. The free inferior margins of the forehead flap and the nasal flap are now brought together by horsehair sutures. The columnar portion of the forehead flap is now fixed in the bed prepared for it by sutures, and the two original incisions drawn from the root of the alæ nasi on either side to the bridge of the nose are now deepened and bevelled off for the reception of the sides or lateral margins of the forehead flap. The lateral margins of the forehead flap are most accurately attached, by means of horsehair sutures, to the bed prepared for them. Two pieces of drainage-tubing are inserted in the newly formed nostrils. If the root or pedicle of the new nose is sufficiently broad and is not dragged upon, and the angular artery has not been wounded, then all will go well and there need be no fear of sloughing. I allow a fortnight to elapse before dividing the root of the new nose, and in doing so I cut a wedge-shaped slice out of the root, so that the new nose may not be parrot-shaped. As the inside of each nostril is clothed with skin, the drainage-tubes may be discarded after ten days.

(3) **Syme's, from the Cheeks** (Fig. 173). This method is described by its inventor in his *Observations in Clinical Surgery*, p. 56. Besides doing away with a more conspicuous scar, it is claimed that this method enables a nose thus constructed to have its sensations in correspondence with the part from which it was derived. To counterbalance the above is the future branding of the flaps.

[1] Any such raw surface would be grafted.

The following drawings show the shape of the flaps and the manner of their adjustment.

New flaps of the shape given in Fig. 173A are marked out on the cheeks with their conjoint pedicle above at the root of the nose, between the two inner canthi, extending so far downwards and outwards upon the cheek as to secure sufficient ampleness for the new nose, according to careful measurements already taken. The old nose being got ready by careful paring, the flaps thus marked out are dissected up and united in the middle line by three or four sutures, while the outer margins are fixed on each side to the raw surface at a proper distance from the nasal orifice. Bell[1] advises that if any part of the old septum remain, it should be made very useful as a fixed point, a straight needle being thrust through one flap close to its outer lower edge, then through the septum, and out at a corresponding point of the other flap. The edges of the wounds left in the cheeks can generally be partially united by sutures of silver wire or fishing-gut; and the triangular portion, which must be left to heal by granulation, proves an advantage, as by its depression it enhances the apparent height and prominence of the new organ. The cavity of the new nose should, as long as is needful, be kept at first gently supported and distended by drainage-tubes drawn over pieces of catheter, through which the patient can breathe.

(4) **The Frontal or Indian Method.**[2] This method has been used when the soft parts of the cheeks are insufficient, when they are too cicatricial, or when an operation making use of them has failed. Its chief objections are the large frontal scar, and the liability of the single flap, though abundant and prominent at first, to shrink and fall in later on.

A piece of thin gutta-percha or leather, sterilised by sufficient immersion in 1 in 20 carbolic acid, is so cut that when folded it is of suitable shape and size for the new organ; it is then [illegible] opened out, upon the forehead, and the dimensions marked out with an aniline pencil or tincture of iodine. The flap thus drawn should be of pyriform shape, and, owing to the retraction of the skin, should measure a quarter of an inch more than the model in every direction. The average dimensions of the flap were thus given by Sir J. E. Erichsen:[3] "When the whole nose requires restoration, it is usually necessary to make it about two and a half to three inches long, and from three to three and a quarter inches wide at its broadest part."

For the frontal flap thus mapped out a bed is now prepared by paring the old nose into a raw triangular surface; in doing this the knife must be used obliquely, cutting from without inwards towards the middle line, so as to leave a grooved surface sloping inwards. The warning of Erichsen[4] should here be remembered, not to remove the parts too widely, lest the cheeks later on retract and flatten out the nose. The bleeding being arrested by sponge-pressure, torsion, leaving on Spencer Wells's forceps (but not in this case by ligature), and covering over the raw surface with sterilised lint and hot boracic-acid lotion, the frontal flap previously marked out may now be raised. This is done by running a scalpel down to the periosteum, along the traced line, taking care that the pedicle be sufficiently long to bear a little twisting and sufficiently broad and thick to secure the presence of one, if not both, of the frontal arteries. To avoid any risk of stoppage of its blood-supply and sloughing it is well to place the incision for the pedicle a little obliquely, with one side descending a little lower than the other, viz. on the side to which the flap is to be twisted. Where the level of the hairy scalp admits of it, this flap should lie a little obliquely, the tension being thus lessened. Where necessary, the flap may be taken transversely above one or other eyebrow; but the objection to this is, that the retraction of the scar upon the forehead draws the corresponding eyebrow upwards (Stimson). The frontal flap, however placed, is now raised from below upwards, so that the necessary haemorrhage is rendered as little embarrassing as possible, and with no more handling, or pinching with forceps, than is unavoidable. The knife should be kept away from the flap towards the periosteum, and used in the same plane throughout, without any scoring whatever. The haemorrhage, free at first, is readily arrested by forci-pressure (leaving on Spencer-Wells forceps for a while), or by sponge-pressure. The flap being sufficiently raised to hang freely and without tension, is then twisted slightly to one side (that on which the pedicle has been cut longest), and brought down and adjusted to the pared edges

[1] *Manual of Surgical Operations*, fourth edition, p. 176.
[2] Introduced into European surgery by Carpue in 1816.
[3] *Surg.*, vol. II, p. 608.
[4] *Loc. supra cit.*, p. 1391.

below by means of numerous fine sutures of salmon-gut, fine silver wire, and horse-hair, all being introduced with very small needles.

If the condition of the forehead has admitted of taking a columella from there, an appropriate groove must also have been cut in the upper part of the median line of the lip, and the two carefully adjusted. If no columella can be taken from the forehead, the upper lip must furnish it, either now, if the patient's condition admits of it, or later on, when the pedicle of the frontal flap is divided. If no columella is made now, the flap, when attached, must be supported by gently introducing appropriate sized plugs of iodoform gauze wrung out of lysol lotion. If a columella is made, two bits of drainage tube or Jacques' catheter are introduced. The parts, being painted with collodion and iodoform, are well covered in with salicylic wool, but in keeping this in position no pressure must be made with bandages on the new nose.

The forehead wound, on which sponge-pressure has been made, is now partially closed with one or two hare-lip pins and sutures, but in introducing these great care must be taken not to constrict the pedicle of the frontal flap. Now, and later on, healing may be here promoted by skin-grafting by Thiersch's method (p. 42).

The chief points in the after-treatment are not to change the dressings too frequently, to use the utmost gentleness in doing so, to remove the sutures gradually, and to be on guard to prevent the onset of infection or of secondary haemorrhage. The former will be known by a sudden rise of temperature, vomiting or nausea, and is best treated by hot boracic-acid fomentations and by a sharp purge. Haemorrhage may occur, according to Sir J. E. Erichsen,[1] as late as the ninth day. It must be met by careful plugging with aseptic gauze dusted with iodoform or wrung out of adrenalin.

The flap remains œdematous for some time, but, if not going to slough, it will be found warm and sensitive. If too much swelling persist, careful punctiform scarification should be used.

Separation of the root of the flap. Three months after the first operation,[2] *i.e.* not until the flap has finished shrinking, the pedicle is divided with a narrow straight bistoury and cut somewhat wedge-shaped, with the apex upwards, an appropriate resting-place being fashioned for it in the skin beneath, which up to this time has not been touched. A few of the fine sutures already mentioned are then inserted.

If the patient has been feeble, or if the cheeks are very cicatricial, and thus the new blood-supply to the frontal flap be insufficient, some sloughing may take place, but this is rare.

Formation of a new columella. If this was not made at the time of the first operation, it should be done at the same time that the pedicle is divided. It is rare that a forehead is sufficiently high to obtain an adequate columella, and the additional thickness and vascularity of the lip make it much more desirable to take one from here. Two assistants with a finger and thumb at each angle of the mouth controlling the coronary arteries, and at the same time making the parts tense, the surgeon with a straight narrow knife transfixes the root of the lip just to one side of the middle line and cuts straight down through the free border; a similar incision is made on the opposite side of the middle line, and a narrow strip, about a quarter of an inch in width, is thus detached save above. It is well, in a man, to shave off the skin and hair follicles, and the lip being pared, and the remains of the old columella appropriately freshened, the frænum is freely divided, and the new one united to the remains of the old and to the ala by one or two fine sutures. The cut surfaces of the lip are then brought most accurately into apposition with a silver suture opposite to the coronary arteries, and several points of fine salmon-gut and horsehair. A few more are next inserted to further adjust the columna.

(5) **Italian or Tagliacotian Method.** This has been but very rarely made use of in this country owing[3] to the irksomeness which the needful position entails, and the need of a complicated special apparatus.

On the other hand, the absence of any additional scars on the forehead and cheeks, and the abundant flap which can always be obtained, are so important

[1] *Loc. supra cit.* p. 611, is mentioned a case of Lord Lister's, in which haemorrhage took place on the ninth day, the patient losing over a pint of blood.

[2] The time usually given, *i.e.* four to six weeks, so as to allow of establishment of the blood-supply to the flap, is insufficient.

[3] In cases where the destruction is very great, where other methods have failed, where the skin available on the face is much scarred or of doubtful soundness, the Tagliacotian method is especially indicated.

that it may be thought worth while to try this method in female patients who have sufficient time and means, who object to the forehead scar, and who will put up with the inconvenience of cramped constraint for two or three weeks.

Sir W. MacCormac brought a case before the Clinical Society[1] in which this method had answered well in a girl aged 16. The following account is taken from his paper. Means for keeping the patient's arm in the needful position for the requisite period were thus provided:

"A pair of ordinary stout well-fitting stays were first procured, to which were attached two perineal straps, to prevent displacement upwards. A helmet, partly made of leather, was connected with the stays by a leather band running up the centre of the neck and back. A leather armpiece, strengthened by a steel band, was moulded so as to extend from the wrist to the shoulder, where it was buckled to the stays. The wrist and hand were fastened to the helmet by a gauntlet, while the elbow could be fixed steadily in any required position by straps running from it to the stays, and to the sides of the headpiece, so that there was nowhere any undue strain, the pressure being so evenly distributed that each strap was almost slack. This apparatus was next applied for some days beforehand, so that any point of undue pressure might be remedied. The girl was able to sleep soundly in it, and it gave promise of proving perfectly efficient. Meanwhile I modelled on the deficient nose a gutta-percha substitute, and from this was able to project on a flat surface the extent of the deficiency. The first part of the operation was performed thus: A flap was marked out on the inner aspect of the left upper arm, more than double the actual size of the estimated deficiency. The left arm was the one chosen to supply the flap, and the right side of the nose the one first operated on, the septum being fashioned at the same time. The flap was left attached to the upper part of the arm by a broad long pedicle, and so arranged that there should be no traction whatever upon it, whilst the raw surface from which it was taken should be accessible for daily dressing. With the flap I dissected up the subcutaneous fat down to the muscular sheath. Immediate retraction both of the flap and of the denuded part of the arm took place to a large extent, so that the raw surface on the latter was almost co-extensive with the whole inner surface of the girl's arm, the flap appearing quite small in comparison. I now made a slightly curved incision, nearly parallel to the free border of the nose on the right side, and about three lines above it, corresponding, in fact, to where the alar furrow should normally exist. This incision was prolonged some little distance into the cheek in the line of the cheek furrow, whilst the remains of the septum were split open in the median line. This nasal flap could now be turned down so as to become horizontal, or rather a little depressed below the horizontal line, to allow for retraction of the ingrafted piece. A triangular gap, the apex pointing towards the cheek, was thus left exposed on the right lateral aspect of the nose, and into this the triangular-shaped piece from the arm was inserted, and accurately attached by suture, the portion to form the septum being sutured in the groove already formed by splitting the septum. In this way there was no paring of edges, nor was a single particle of nose tissue sacrificed, whilst by having so large a line of attachment, being almost surrounded by living tissue, the new flap was much more likely to adhere satisfactorily in the first instance, and from its freer blood-supply less prone perhaps to subsequent contraction. Union took place in great part by first intention, some suppuration setting in on the eighth day. Healing was not complete for nearly three weeks. At this date the operation was completed by detaching the flap from the arm, cutting this so as to give it a triangular shape, and preparing the left side of the nose to receive it in a manner precisely similar to the right side. The perfect vitality of the now completely severed tissue of the arm was made apparent by copious hæmorrhage, and healing was complete in a fortnight. After the first forty-eight hours scarcely any inconvenience was felt from the apparatus, save for a slight excoriation on one shoulder. The result was good, but it was expected that further contraction would improve the aspect of the nose, the new organ being fully large."

Grafting bone.[2] *e.g.* that of the rabbit, so as to restore the bony bridge. This method, made use of by Sir Watson Cheyne,[3] with great

[1] *Clin. Soc. Trans.*, vol. x. p. 181. Three figures are given of the patient before and after the operation, and of the apparatus used.

[2] Hoxie and others have replaced the bony frame-work, causing the freshened tip of the left forefinger to heal into the vivified upper angle of the nasal defect. Fifteen weeks later the finger was amputated in the middle of the upper phalanx.

[3] *Clin. Soc. Trans.*, vol. xxxiii. 1899, p. 218.

success in a case of rhinoplasty, will probably be much used in the future for reforming the bony framework of the nose, either in place of taking bone and periosteum in the frontal flap, or in cases where this method has failed. It has been described at p. 445.

Causes of Failure after Complete Rhinoplasty :

(1) Gangrene and sloughing.

(2) Secondary hæmorrhage.

(3) Infection of the wound, erysipelas, &c.

(4) Shrinking and consequent shapelessness of the new nose.

(5) Destruction of the new nose by recurrence of the old disease.

C. **Operations for Partial Restoration of the Nose.** These are very numerous, and have usually been designed for special cases. A few only will be alluded to here.

(i) In cases where the lower third of the nose is left untouched and the central portion especially destroyed. Small square flaps are raised

Fig. 174. Rhinoplasty. Single lateral flap. (Stimson.)

Fig. 175. Rhinoplasty. Denonville's method. (Stimson.)

from the sides of the nose and cheeks, to which a small flap from the forehead may be added, and united in the middle line.

(ii) *Single Lateral Flap.* This may be taken in many different ways. (*a*) From the cheek, at the side of and below the nose. This flap may be raised horizontally, the pedicle lying outwards on the cheek. This is merely a modification of Syme's operation. It has given excellent results after operations for lupus, rodent ulcer, and epithelioma, where the cheeks are fairly full and rich in fat (Fig. 174).

(*b*) From the opposite side (Langenbeck). Here the flaps are taken vertically. The apex of the flap is left attached to the inner angle of the eye, on the same side as the deficiency, while the base comes from the ala of the sound side (Fig. 174 B).

(*c*) *M. Denonviller's Method.* A border that has already cicatrised is made use of so as to prevent subsequent narrowing. A triangular flap is marked out by incisions shown in Fig. 175, the pedicle being internal. The flap, having been carefully raised with a strip of cartilage in its lower margin, is displaced downwards into position, and retained there by the V-shaped wound being sutured in the shape of an inverted Λ.

In all the above methods, if cartilage is not included in the free border which is to form the new ala, the flaps should be cut long enough to allow of turning this border upon itself and thus giving a thicker and more natural appearance to it, and in all, care must be taken that the new ala

is patent, and there is no after-displacement of the upper lip or lower eyelid.

(*d*) *M. Weber's Method.* The flap is taken from the upper lip: on account of the hair follicles this plan is best suited to women. An oval flap is taken, usually from the centre of the lip, with its pedicle left attached close to the columella and its free margin reaching to the prolabium. The flap, which consists only of part of the thickness of the lip, is turned up, and stitched to the remains of the ala, which have been refreshed. The wound in the lip is closed or grafted. In three or four weeks this pedicle is divided, and may be so united to the inner surface of the flap as to give it a thicker and rounded margin.

Subcutaneous Injection of Sterilised Paraffin, especially as a means of correcting saddle-nose. This method was first introduced by Gersuny of Vienna in 1899. The following details are largely taken from the writings of Dr. Walker Downie,[1] Mr. Stephen Paget,[2] and Dr. Milligan of Manchester.[3] Mr. Paget has operated on twenty-six cases; the results shown in many of the photographs which accompany his and other papers on this subject are admirable.

Sterilised paraffin with a melting-point of 110° F. to 115° F. is used. If the melting-point be only 104° F. it tends to set in the needle, if it be as high as 125° F. to 135° F. it is very difficult to prevent its diffusion, while this degree of heat may do damage to the tissues; finally, too, liquid paraffin may escape after the needle is withdrawn. Mr. Paget having tried many forms of needle, prefers that of Eckstein. The syringe and the proximal half of the needle are jacketed with india-rubber, the syringe is easily worked with one hand, and there is a screw-nut on the piston which prevents the paraffin going in with a jerk, and it cannot inject too much paraffin. The skin is duly sterilised. A general anæsthetic is usually required, especially on the first occasion. The paraffin and syringes—it is best always to have two syringes, in case one gets out of order—are kept in a water-bath 6° or 7° above the melting-point. The skin is nicked for the needle; about 6 c.c. of the paraffin are taken up, and the syringe held in the water-bath while the screw-nut is adjusted; then the needle is dipped for a second or two into boiling water. It should not be passed through the flame of a spirit lamp, for this method stains the paraffin in it. To prevent diffusion into the eyelids and forehead, an assistant should make strong pressure with his finger and thumbs, meeting in a ring, especially over the lateral aspects of the nasal bones near the inner canthi. Dr. Milligan has used a thin strip of lead moulded around the area of operation; on this pressure is made. The needle is quickly driven into the subcutaneous tissues, its point being well driven down towards the tip of the nose, from above, or introduced a little to one side of the middle line, below the point where the bridge ought to be and directed upwards. The injection should be made at about the rate of one cm. every ten seconds. It is better to inject too little than too much paraffin, a second or a third injection being made later, if needful. The needle should not be entirely withdrawn until the amount of paraffin required is injected and the moulding carried out. This is carried out by the left hand; the insertion of a little finger in the nostril is sometimes a help. The paraffin begins to set in less

[1] *Brit. Med. Journ.*, vol. viii., 1902, and *Clin. Soc. Trans.*, vol. xxxvi. p. 128.
[2] *Ibid.*, January 3, 1903.
[3] *Med. Chron.*, 1902, vol. iv. p. 333.

that a minute, but remains doughy for about a quarter of an hour. The moulding and squeezing the nose into a good shape must be done pretty vigorously, and must not cease till the paraffin is unimpressionable. The puncture is closed with collodion, and iced boracic lotion applied for a few hours. The immediate effect of the injection is to make the surrounding skin pale as well as tense. This pallor soon passes off. Pain is not, as a rule, much complained of. If no anaesthetic is given, there must be no movement when the puncture is made. As to the permanency of the results, Dr. Milligan states that cases carefully watched for over a year, have shown no tendency to alter to any appreciable extent. Even if, after some years, absorption should take place, repetition of the injection would always be possible. Difficulties in effecting much improvement will chiefly arise in the following cases (Paget): Where the skin is adherent, as after scarring due to syphilis, in cases chiefly congenital. Here the subcutaneous use of a tenotome may help. Connell,[1] in the case of very tight tissues, loosens them a few days before with a tenotome; at the time of the injection he uses sterilised saline solution before the paraffin.

The following are the chief sequelæ which may be more or less disastrous.

(1) Unless sufficient pressure is maintained all round the area injected very disfiguring nodules of paraffin may remain in the adjacent loose cellular tissue. The after-removal of them is a matter of the greatest difficulty from their adhesion to the connective tissue.

(2) Thrombosis of the facial vein and pulmonary embolism have very rarely followed the injection of paraffin. In the *Lancet* for April 9, 1904, a case is published in which the injection of paraffin was followed immediately by blindness of the right eye, probably from embolism of the central artery to the retina.

An injection had been made on two previous occasions without any untoward result. A mixture of paraffin and white vaseline at a temperature of 110° F. was injected from below upwards. At the moment of injection the patient stated that he could not see. A slight ecchymosis on the top of the nose perhaps indicated punc[illegible] of a vein. Twenty-five minutes after the injection it was found that the inf[illegible] ranch of the central artery of the retina was collapsed and empty.

Suppuration is extremely rare after the operation for saddle-nose. That the method of paraffin may be followed after an interval of months or years by very serious suppuration, is shown by Mr. F. C. Wallis.[2] Two cases are recorded in which this method had been employed for prolapse of the uterus and rectum especially. It is pointed out that paraffin, though sterile when introduced, cannot be relied upon to remain so, especially in regions where pyogenic micro-organisms always abound.

Many other instances in which Gersuny's method has been suggested or employed—many of them extravagant—are recorded in the above papers. Amongst the most promising are the filling up of large cavities left after operations on the mastoid bone, elevation of depressed scars, especially about the face, and elevation of the cheek after removal of the upper jaw. Connell[3] gives a good illustration of a case where he succeeded in restoring the tip of a nose (which had been bitten off) by the injection of paraffin.

[1] *Journ. Amer. Med. Assoc.*, September 1903.
[2] *Lancet*, January 28, 1905, p. 221.
[3] *Loc. supra cit.*, Fig. 16, p. 580.

CHAPTER XXII

OPERATIONS ON THE NASAL FOSSÆ. REMOVAL OF FOREIGN BODIES. TURBINECTOMY. OPERATIONS FOR DEFLECTED SEPTUM. REMOVAL OF NASAL POLYPI. OPERATION FOR NASO-PHARYNGEAL FIBROMA AND SARCOMA. REMOVAL OF ADENOIDS AND ENLARGED TONSILS

The Removal of Foreign Bodies from the Nose. Patients with foreign bodies in the nose are usually children, and, on this account, it may be impossible to obtain a history of the insertion of the suspected object.

The existence of a foul blood-stained discharge from one nostril in a child should always suggest to the surgeon the possibility of a foreign body. Occasionally the foreign body may be seen on examination with the nasal speculum, in which case it may be extracted by means of a pair of bent serrated nasal forceps. In a child a general anæsthetic will probably be required, and a finger should also be placed in the naso-pharynx in case the object should be displaced and escape into the naso-pharynx through the posterior nares. A strabismus hook may be used instead of the serrated forceps. Often the presence of blood and pus prevent a satisfactory view of the foreign body. The following method will then generally prove successful. A strong probe, or a probe-pointed director, is introduced along the floor of the nasal fossa until it is well beyond the foreign body. The end of the probe which is held in the hand is then depressed, and at the same time the instrument is drawn forwards through the anterior nares. By this manœuvre the foreign body is dislodged and forced forwards through the nostril. No attempts should be made to dislodge a foreign body by syringing[1] on account of the danger of forcing septic material into the tympanum and thus setting up otitis media.

Turbinectomy. Complete removal of the inferior turbinated bone, at one time a frequent operation, is now very seldom, if ever, carried out, as it is found that complete removal of this bone is followed by an intractable form of rhinitis and chronic inflammatory troubles in the pharynx and larynx. Partial removal of the inferior turbinate—usually the anterior end—and of the middle turbinate are, however, frequently called for.

Indications. (1) When the nasal fossa is obstructed in cases of hypertrophic rhinitis. (2) In conjunction with submucous resection of the nasal septum. (3) As a preliminary to draining the maxillary antrum through the nasal fossa. (4) In the treatment of some of the

[1] Syringing through the posterior nares by means of a special tube attached to a Higginson's syringe is quite safe, and will generally prove successful.

more remote sequelæ of nasal obstruction such as chronic middle ear catarrh, chronic laryngitis, and in some cases of asthma.

Removal of the posterior extremity of the inferior turbinate is indicated in cases of "moriform hypertrophy" of the mucous membrane in this situation. Removal of the anterior end of the middle turbinate is rarely required for hypertrophy. It is, however, frequently called for in the treatment of chronic suppuration in the frontal sinus and in the ethmoidal cells, and in the treatment of nasal polypi.

Removal of the Anterior End of the Inferior Turbinate. This operation may be carried out after the application of cocaine and adrenalin, or under general anæsthesia. In the latter case the nasal fossa should be previously painted with adrenalin to diminish the amount of hæmorrhage. A pair of curved nasal scissors are introduced into the nasal fossa, one blade passing beneath the bone and the other above it. The portion to be removed, usually about the anterior third, is thus divided close to its attachment to the superior maxilla. A strong nasal snare is then inserted and manipulated so that the wire loop encircles the loose portion. This is then tightened and the pedicle is thus cut through. If preferred this may be divided by a pair of punch forceps instead of by the snare.

After-Treatment. It is, as a rule, not necessary to use a plug, but if there is much hæmorrhage a strip of sterile lint impregnated with sterilised vaseline may be lightly packed in and left in situ for the first twenty-four hours. The subsequent treatment consists in daily irrigation with a dilute alkaline lotion containing some mild antiseptic such as boric acid. In cases where the obstruction is caused by an hypertrophy of the mucous membrane alone, a strip of this may be removed from the lower border by the scissors or cutting forceps, the bone itself not being divided.

Removal of the Posterior End of the Inferior Turbinate. A mass of hypertrophied mucous membrane in this situation—"moriform hypertrophy"—may be removed by means of a strong snare which is introduced through the anterior nares. The loop is then manipulated round the mass with the help of a finger in the naso-pharynx. A general anæsthetic is necessary, partly on account of the discomfort of the operator's finger in the naso-pharynx, but also on account of the shrinking of the growth which results from the application of cocaine and adrenalin.

Removal of the Anterior Extremity of the Middle Terminate. This may be carried out in a similar way to that described for the inferior turbinate.

Operations for Deflected Nasal Septum. The older operations have been practically superseded by the operation of **submucous resectiou.**

Indications. (1) To remove an obstruction to nasal breathing. The deflected septum may completely block one nostril, and owing to hypertrophy of the inferior turbinal on the concave side the other nostril may be more or less obstructed. Mouth-breathing with its serious consequences will be the result. (2) In the treatment of the more distant effects of mouth-breathing, when this is caused by the septal deformity. Among these troubles are post-nasal catarrh, chronic inflammatory troubles in the larynx and pharynx, and chronic Eustachian and middle ear catarrh. (3) To gain access to the posterior part of the nasal fossa for the treatment of nasal polypi or sinus disease.

The success of this operation is largely due to the following facts: (1) The deflected portion of the septum is completely removed. (2) The

mucous membrane is not removed or seriously damaged. The small incision required should heal by primary union. (3) The after-treatment, which is not prolonged, is simple and causes but slight inconvenience to the patient. (4) The operation can be carried out under local anæsthesia if this is thought desirable. A general anæsthetic is, however, always indicated in nervous patients. (5) The external appearance of the nose is not altered.

It should be especially noted that there is no falling in of the bridge of the nose, even after a subsequent blow or other injury.

Instruments. The following special instruments (Fig. 177): Ballenger's swivel knife; several blunt raspatories of different curvature; Killian's nasal needle; a large Thudicum's speculum; strong punch forceps and a small gouge and mallet for removing bony spurs from the nasal spine and crest of the superior maxillary. The surgeon should also be provided with a frontal lamp, as a good light is essential.

The Operation. Should it be decided to perform the operation under local anæsthesia, both nasal fossæ should be packed half an hour before the commencement with strips of sterilised lint soaked in a mixture of equal parts of adrenalin (1 in 1000) and cocaine hydrochloride (20 per cent.). On account of the toxic properties of the latter drug it is best not to inject it beneath the mucous membrane. If general anæsthesia be employed, cocaine and adrenalin must still be applied to minimise the amount of bleeding. In this case the application of equal parts of adrenalin (1 in 1000) and cocaine (5 per cent.) in the same way for twenty minutes will suffice.

Before commencing the operation these plugs are removed, but it is well to push a strip of sterilised lint, secured by a piece of silk or cat-gut, to the back of each nasal fossa in order to prevent blood making its way back into the respiratory passages.

A curved incision, about a quarter of an inch behind the junction of the skin and mucous membrane, is made with a small scalpel or tenotomy knife over the displaced septum in the obstructed nostril (Fig. 176 A). The incision, which curves backwards below to the floor of the nose, extends down to, but not through, the cartilage. If the adrenalin has acted satisfactorily there will be little or no bleeding. Should there be much bleeding a further application of this drug should be made before proceeding with the operation. A blunt raspatory is then introduced between the cartilage and the perichondrium (Fig. 176 B); care must be taken that the raspatory is not inserted between the mucous membrane and the perichondrium, for in this case attempts at separation will lead to tearing of the former membrane. When the interval between cartilage and perichondrium is identified, it will be found that the soft layers can be readily separated from the cartilage. The greatest care must be taken not to tear the mucous membrane. At first a straight or slightly curved raspatory may be used. When a spur or sharp bend in the deflection is reached a raspatory with a greater curve may be employed. It is at such places that the mucous membrane is in greatest danger of injury. It will often be desirable to leave these spots until an area of the cartilage has been removed and a better view thus obtained. The muco-perichondrium should be separated from the cartilage to the very back of the deflected portion, above well up into the attic of the nose, and below to the nasal crest of the superior maxilla.

The cartilage must now be cut through in the line of the original incision without injuring the mucous membrane of the opposite nasal fossa. To guard against this accident a finger of the left hand may be placed in the opposite nostril. The interval between the muco-perichondrium and the cartilage on this side must now be sought for and identified. The soft parts are then separated from the cartilage by means of raspatories, as in the case of the convex side, the same care

A. B.

C.

FIG. 176. Submucous Resection of the Nasal Septum.

being taken to avoid injury to the mucous membrane. The large Thudicum's speculum is then introduced through the incision in the mucous membrane, one blade passing between the muco-perichondrium and the convex surface of the cartilage, and the other between the muco-perichondrium of the opposite side and the concave surface of the cartilage (Fig. 176 C).

The swivel knife (Fig. 177), which will cut in any direction, is then applied to the anterior end of the displaced cartilage which is now freely seen between the two blades of the speculum. The knife is first made to cut horizontally backwards, just above the nasal crest. It is then made to cut upwards and finally downwards and forwards, so that a large area of the displaced cartilage is removed.

The septum is now carefully inspected, when other portions of displaced cartilage above, below, or behind the area removed will probably be seen. These are cleared of muco-perichondrium by a raspatory and excised either by the swivel knife or by punch forceps. The long speculum is now withdrawn and the nasal fossæ inspected through the ordinary nasal speculum. This will probably reveal some obstruction due to displacement or overgrowth of the nasal spine and crest, or at the junction of the cartilage and the vomer. With the improved view now obtained after

FIG. 177. Ballenger's swivel knife.

removal of the displaced cartilage, the muco-periosteum can be detached in these situations without tearing. The bone may be removed with strong punch forceps or cutting forceps, or by a small gouge and mallet, the latter being generally required for the nasal spine. This must be persisted in until all the displaced structures have been completely removed. All loose pieces and any semi-detached fragments are then picked out and the space between the two detached layers of muco-perichondrium is cleaned and dried with pledgets of sterilised lint. The large speculum is then withdrawn, and the two layers are allowed to fall together; the small incision is then closed by two or three catgut sutures inserted by the hook-like nasal needle. It will probably now be found necessary to remove the anterior end of the enlarged inferior turbinal which is usually found in the fossa bounded by the concave side of the original deformity (*see* p. 455).

Two pieces of sterilised lint are now rolled up to form two plugs about the size of the little finger. Each is smeared with sterilised vaseline, and one is inserted into each nasal fossa, which is thus lightly plugged.

After-Treatment. The plugs are taken out at the end of forty-eight hours and need not be replaced. Daily irrigation with alkaline boracic lotion is then all that is required.

The patient may be able to breathe through the nose satisfactorily in a few days, but in many cases the full benefit is not experienced until all swelling has subsided, which may be after two or three weeks.

Generally speaking, this operation is not a difficult one, in spite of the small wound through which a large portion of the cartilaginous and bony septum has to be removed. Efficient hæmostasis is of the greatest importance. If the nose is continually flooded with blood the operation may be both tedious and difficult. Careful preliminary treatment with cocaine and adrenalin and the occasional application of the same solution, if necessary during the course of the operation, will usually be successful in controlling hæmorrhage. The presence of the plugs will prevent the formation of a hæmatoma between the two layers of mucous membrane. Should this troublesome complication appear it will be necessary to open up the wound and turn out the clot. The most difficult part of the operation is usually the removal of the bony nasal crest, but this is essential for a completely successful result. Tearing of the mucous membrane must

be avoided by careful and delicate manipulation of the raspatories, and by making sure sure that these are in the interval between the cartilage and the perichondrium.

REMOVAL OF NASAL POLYPI

Before an operation is undertaken on nasal polypi it must always be remembered that they fall into two chief groups: (*a*) those in which they occur alone or with merely a chronic osteitis of the subjacent bones; (*b*) those in which caries of the bones and disease of the accessory sinuses coexist. In these latter cases suppuration—often very profuse—is always present, and there will be evidence of carious bone to the probe or to the finger, when the patient is under a general anæsthetic; the symptoms, especially headache, will be aggravated.

In many cases, no doubt, the obstinacy with which nasal polypi tend to persist and recur is explained by the coexisting bone disease being overlooked. The same tendency does, however, exist in cases of nasal polypi without suppuration or bone disease and with only the usual clear watery discharge. This is due to their occupying sites of difficult access, and to the sensitiveness of the nasal mucous membrane interfering with their complete removal. While the majority of simple polypi can be readily removed under local anæsthesia, a general anæsthetic is advisable in these recurrent cases.

The treatment will depend upon the nature of the case.

A. **Treatment of Simple Nasal Polypi.** It must be remembered that these are invariably attached to the region of the middle meatus, and that the size of the polypus and the nature of the pedicle vary immensely. In some cases there will be one very large polypoid mass occupying the entire nasal fossa, while in others there will be a large number of smaller masses varying in size from a pea to a cherry or even larger. In the latter group, as the more anteriorly situated are removed, others, occupying the posterior part of the fossa, come into view. Their mobility varies considerably. The manipulations necessary to remove those in front may displace others to the upper and back part of the nasal fossa, where they are readily overlooked. Such mobile polypi may often be brought into view and rendered more accessible by making the patient forcibly blow his nose. The posterior rhinoscopic mirror is of great service in detecting polypi which have been displaced backwards into the naso-pharynx.

These simple polypi should be removed by some form of nasal snare. Though the polypi themselves are insensitive, the nasal mucous membrane is by no means so. Anæsthesia may be secured by spraying the nasal fossa with equal parts of adrenalin (1 in 1000) and cocaine (5 per cent.), or better, by plugging the fossa with a strip of ribbon gauze soaked in equal parts of a 20 per cent. solution of cocaine and 1 in 1000 solution of adrenalin or one of its substitutes, such as henisine. The plug should be left in situ for half an hour and removed just before the commencement of the operation.

Krause's, Blake's, and Lack's are the handiest and most useful forms of snare. Blake's is a very convenient form and is best for all ordinary delicate polypi and for those attached high up. Krause's (Fig. 178) is suitable for larger and tougher growths, while Lack's, which is a stronger instrument worked by a screw, can be relied upon to remove the toughest polypi or part of the middle turbinate itself. In any case too fine wire should

not be used, as it soon gets damaged, and moreover it cuts the neck of each polypus through instead of pulling the growth away with its base, and, if possible, a little bone in it. A small ring knife should always be at hand in case there should be any small sessile polypi which cannot be seized by the snare. The patient should sit, facing the surgeon, with his head supported by an assistant or by a head-rest. Good illumination is essential, and this may be secured either by the frontal lamp or by the forehead mirror and reflected light. The anterior nares having

Fig. 178. Krause's nasal polypus snare.

been held open by a full-sized Thudicum's speculum, the wire loop is introduced in the vertical plane between the growth and the septum. It is then made to encircle the polypus by slight movements backwards and forwards, and by rotating the instrument in an upward and outward direction. In this way the loop reaches the pedicle of the polypus, which almost invariably is attached in the region of the middle meatus. The snare is next tightened until a firm grip is secured and the polypus then removed, partly by pulling, and partly by twisting. The pedicle should not be cut through by the loop, as, in this case, the base will be left behind and a recurrence is then almost certain. When the first growth has been removed others will probably come into view. These must be treated in the same way until the fossa is quite clear. During these manipulations one or more polypi may readily be forced back into the naso-pharynx or into the upper and back part of the nasal fossa. Such polypi may be brought forward when the patient blows his nose, and if necessary a finger may be introduced into the naso-pharynx to make sure that this is clear.

Where the middle turbinate is much enlarged, where it is covered with sessile polypi, or when it is found to be carious, it is quite easy to cut it away in two or three pieces with a Meyer's ring knife. When, however, it is thought likely that the bone will require removal, a general anæsthetic will be desirable (*vide infra*). The hæmorrhage, which may be rather free, usually stops spontaneously, or may be checked by sponging with ice-cold water. Plugging should be avoided on account of the danger of retention of septic discharges, which may even lead to meningitis. After twenty-four hours the nasal fossa may be gently irrigated with warm alkaline boracic lotion, and this may be repeated twice daily until the discharge ceases.

The patient should be seen after an interval of four weeks, when the nasal cavity is again inspected and any polypi which escaped removal

on the first occasion, or which have reappeared, are treated in the same way.

B. **Treatment of obstinately Recurring Polypi,** and where caries of the ethmoid is known to be present. A general anæsthetic is desirable for this operation, though, with a view to avoiding excessive hæmorrhage, the nasal fossa should be prepared with adrenalin and cocaine as recommended for the preceding operation. The patient must be in the horizontal position on a couch or operating table, and the nasal fossa must be well illuminated, preferably by a frontal lamp. The special instruments required are Grunwald's nasal punch forceps, Luc's nasal forceps, and Meyer's ring knife.

One blade of the forceps is introduced beneath the middle turbinal and the other between this bone and the septum. A large mass of polypoid tissue and carious ethmoid is thus grasped and is removed by twisting and pulling. The forceps are then again introduced, and further masses of diseased tissue are removed. In this way the ethmoidal cells and even the sphenoidal sinus are opened up. The ring knife or a Volkmann's spoon may be used for removing projecting ridges, and for clearing out cavities which cannot be satisfactorily explored by the forceps. The greatest care must be taken throughout not to injure the cribriform plate, which delicate structure alone intervenes between the cranial cavity and the septic and diseased bone of the nasal fossa. To this end all pushing, scraping, or boring movements in the direction of the roof of the fossa are to be avoided. All pressure from instruments, either forceps, sharp spoon, or ring knife, should be made towards the outer or the inner wall. During such an operation the hæmorrhage, in spite of the preliminary preparation, is likely to be severe. Besides the danger of blood passing back into the naso-pharynx and the larynx, the hæmorrhage will obscure the field of operation. This difficulty may be overcome by allowing the patient's head to hang over the edge of the couch, or better, by a preliminary plugging of the posterior nares. Sir St. Clair Thomson advises that this be carried out in the following manner. "A sterilised sponge, about the size of a tangerine orange, is squeezed very dry and tied round its centre with a piece of tape or a stout silk ligature, leaving two free ends of about twelve inches in length. A soft rubber catheter is passed along the floor of the nose till it appears below the soft palate, when the end is seized with forceps and drawn through the mouth. To this end one of the tapes is made fast, so that when the catheter is withdrawn from the nose, the sponge is pulled up into the post-nasal space; the other end hangs out of the mouth. The two tapes are tied together over the upper lip." The same surgeon recommends, when bleeding obscures the field of operation, plugging with strips of gauze soaked in adrenalin or a 10 per cent. solution of hydrogen peroxide. The plug may be left *in situ* for a few minutes. When the operation is completed the hæmorrhage usually ceases spontaneously when the post-nasal sponge is withdrawn, or, if necessary, the means suggested at p. 460 may be tried. Plugging the nasal fossa should be avoided on account of the danger of sepsis.

Dangers of the Operation. It must be admitted that this operation is by no means free from risks. The chief of these is sepsis. Even apart from injury to the cribriform plate, which has been mentioned above, intracranial complications such as meningitis or cerebral abscess may occur. Hæmorrhage has already been discussed. In addition to this, Sir St. Clair Thomson mentions injury to the os planum of the ethmoid

with emphysema of the eyelids, ecchymosis of the eyelids or even an orbital abscess.

C. **Moure's Operation** and **Rouge's Operation** (*q.v.*). Owing to the improved technique of intranasal operations, these methods are not now likely to be required for polypi or for other simple growths of the nasal fossæ.

OPERATIONS FOR NASO-PHARYNGEAL FIBROMA OR SARCOMA, AND MALIGNANT GROWTHS OF THE NOSE

(Figs. 179–182)

Naso-Pharyngeal Fibroma or Sarcoma. Attachments and Relations. The surgeon should consider these carefully before deciding what operation he will adopt for one of these most dangerous growths.

They will vary according to the duration of the growth. The primary origin is most frequently from the base of the skull, arising in the thick periosteum invested by mucous membrane, which covers in the roof of the nose and top of the pharynx, especially the adjacent parts of the basi-sphenoid and basi-occipital. Less frequently they may arise in the pterygoid fossæ and adjacent plates, or from around the posterior nares. Dr. Sands [1] points out that the region in which a naso-pharyngeal fibroma can originate is one of narrow limits, corresponding with the margins of the posterior nares and the summit of the pharynx. It is thus one that can be satisfactorily explored with the finger, and by this means a growth should be detected in its early stage and removed while small. Where the growth is a sarcoma, owing to the structure of its vessels, and its tendency to ulceration, a preliminary examination may cause severe bleeding.

While the above are the most frequent attachments of the growths, it should always be remembered that when one of these fibromata has existed for some time, when they are sloughy, when previous attempts have been made to remove them—under these conditions the growth is very likely to have taken on secondary attachments. A common instance of these is seen when a growth springing from the base of the skull forms adhesions to the pterygoid fossæ. In advanced cases these growths, when malignant, extend very widely and often insidiously, making their way along the nasal fossæ and extending through the numerous fissures and foramina into the accessory sinuses, adjacent fossæ, and even into the cranial cavity. In such cases it is often impossible to say exactly where the growth started.

If secondary attachments are made out to exist, the next question will be, how far are these intimate and close? How far is the growth not only in contact with, but how far has it actually absorbed bones, such as those of the nose? How far has it got into the antrum, and thus come to resemble closely a growth of the upper jaw? Again, swelling of the cheek, with protrusion of the eye, will point to an operation, osteoplastic or otherwise, on the upper jaw. In the same way extension of the growth into the zygomatic and temporal fossæ will render the prognosis unfavourable. Finally, any symptoms pointing to softening of the base of the skull and implication of the membranes, *e.g.* headache, tendency to coma, convulsions, with evidence of pyrexia, will be conclusive against

[1] "On Naso-Pharyngeal Polypi": Dr. Brown-Sequard's *Arch. of Sci. and Pract. Med.*, No. 6.

any operation, even when most carefully performed. On the other hand, where the evidence only points to the threatening of meningitis, it may be possible to prevent this by an operation.

The site and width of the attachment of these growths having been spoken of, it remains to call attention to one or two practical points in their structure. While usually fibromata at first, and often so throughout their course, they can make their way, like sarcomata, through adjacent bony walls. Metastases are said to be rare. The growths are often very vascular, especially from the character of their veins, which have no sheath, and, therefore, cannot retract when divided, and which often assume the character of cavernous tissue; hence the readiness with which they bleed, even when touched with a probe. Large growths are prone to ulceration on the surface, hence another cause of hæmorrhage, and also of infection. From their tendency to occur in about the decade from 15 to 25, epistaxis and any evidence of nasal obstruction at this age should always call for an early and thorough examination of the naso-pharynx.

Methods of Removal. Several will be given, owing to the great difficulty of exposing the root of the growth. On the whole the best methods . . through the nasal fossæ or through the upper jaw, as these promise to give the best access in the largest number of cases. The three methods first given are rarely to be adopted. They are only suited to small growths, those of the nature of myxo-fibroma—for all varieties of fibroma are present here—those with a distinct and narrow pedicle, which can not only be reached but also commanded (two different things), and cases where no secondary adhesions have been contracted.

(i) **Avulsion.** This method, tearing away with suitably curved forceps introduced either by the nose or by the mouth, aided in either case by a finger passed behind the soft palate, is only suitable to the above cases, and in none is it without danger.

The serious hæmorrhage, and the probable incompleteness of the operation, are always strongly against making use of avulsion. Here, as elsewhere, removal, piecemeal, of a growth is most unsatisfactory, either malignant, or on the high road to become so.

(ii) **Ligature.** This again is only suitable to very few cases, *e.g.* where the pedicle is distinct and fairly thin, and where the growth is not very vascular, *e.g.* a myxo-fibroma, and where it has contracted no adhesions. In less suitable cases, in addition to the probability of return in the root, the infection and the fœtor which accompanies the sloughing process is a most serious drawback. The patient's head being brought a little over the table, so that the blood shall escape readily, the mouth is opened with an efficient gag. A loop of wire sufficiently stout and softened is most carefully adjusted round the attachment of the fibroma, having been passed by the nose, and aided by a finger behind the soft palate. The ecraseur is then fitted on, and the wire tightened very slowly. Spare wire should be at hand. Ether should be given first, and then chloroform by the nostril. Care must be taken in such cases to prevent the growth, when the pedicle is divided, falling upon the larynx.

(iii) **EXCISION BY AN OPERATION INVOLVING REMOVAL OF BONE, OSTEOPLASTIC OR OTHERWISE.** These cases may be divided as follows:

A. Those in which the attack is made through the mouth.

B. Those where the attack is made through the nose.

C. Those in which the attack is made by removing the upper jaw, partially or completely, or by resecting this bone osteoplastically.

A. **Operation for Naso-pharyngeal Fibroma through the mouth.** This operation was strongly advocated by M. Nelaton. It consists in slitting the uvula and soft palate exactly in the middle line from before backwards, then prolonging this incision along the centre of the posterior half of the hard palate, going here down to the bone; from the end of this incision two others are made slightly obliquely outwards towards the teeth, also going down to the bone. The flaps, together with the periosteum, are then detached, so as to form nearly rectangular flaps.[1] Two large holes are next drilled through the hard palate, each well to one side of the middle line, the intervening bone is cut away by placing the ends of cutting-pliers in each of these holes, and, by making lateral cuts back to the free border of the hard palate, a rectangular portion of the posterior half of the bony vault is removed.

The mucous membrane and the periosteum on the upper surface of the bone, which will now be found detached, are divided, and, if it be needful to get more room, more or less of the vomer is cut away. Room being thus obtained, the fibroma is removed and its attachments dealt with. If all the growth is got away satisfactorily, the palate flaps are united in the ordinary way; if further treatment is required, staphylorraphy must be performed later.

Preliminary laryngotomy should be performed, owing to the proximity of the larynx.

The advantages of this operation, when contrasted with removal of the upper jaw, are at first sight considerable.

(1) There is no deformity left on the face; (2) the parts cut through are less important; (3) mastication is not interfered with by removal of the teeth; (4) the operation is said to be less difficult; (5) the hæmorrhage is claimed to be less,[2] no large vessels being cut through; (6) the growth is attacked directly; (7) through the gap thus left the surgeon can again attack the growth, within a few days if he has been unable to complete the operation, or later on if reappearance takes place; (8) the gap can easily be dealt with later on by staphylorraphy, or by wearing an obturator.

The first three advantages are, no doubt, of great value if the growth can be entirely dealt with by this method; the inveterate way in which they reappear, if incompletely dealt with, neither surgeon nor patient would be wise in running great risks for the sake of what one may call rather æsthetic advantages.[3] There is no doubt that, in a few cases, to

[1] This detachment is, as is well known in staphylorraphy, difficult posteriorly, at the junction of the palates, and is best effected by raspatories (p. 509).

[2] This is very doubtful. Bleeding from the divided and partially resected palate will be very near the larynx. Again, if troublesome hæmorrhage take place from the root of the fibroma, it will be more difficult to deal with it by this route than by the nasal or maxillary routes, or by a combination of these. Dr. Sands (*loc. supra cit.*), in removing a fibroma by this method, had surrounded, without difficulty, the pedicle with an ecraseur chain. This breaking, the pedicle, which was stout and firm, was divided with scissors as close to the skull as possible. Copious hæmorrhage followed, and much time was consumed in unsuccessful attempts to secure a large artery which had retracted to the deepest part of the wound, and which was inaccessible to the ligature. The bleeding finally ceased in consequence of the prostration of the patient, who had several alarming attacks of syncope. The growth reappearing, it was removed by the method of Maisonneuve. Though it was not thought prudent to attempt the removal of a small prolongation which ran into the sphenoidal sinus, no reappearance had apparently taken place nine months later.

[3] Attention may here be drawn to the great frequency of these fibromata in males, in

be mentioned a little later, where the polypus is of moderate size, distinctly pedunculated, and attached low down, *e.g.* about the posterior nares, or well forward on the base of the skull, the operation will be easier, the haemorrhage will be less, and the growth will be more directly attacked. The advantage of a future staphyhorraphy is, like those given first, not of sufficient value to recommend this operation if it is wanting in others more important.

Turning to the cases themselves, Dr. Rolán Masse has collected twenty-six treated by this method, twelve having been under the hands of M. Nelaton himself. Of these twenty-six, thirteen are said to have been successful, but it is not stated for how long they were followed up. In one case, in which the after-history is given, a small reappearance took place two years later from the pedicle, and was destroyed. While suited to the cases mentioned above, the method could scarcely be made use of successfully in large polypi, in the case of those with secondary attachments or large sessile bases, or in the case of those which have extended into the pterygoid fossæ, or, in fact, beyond the naso-pharynx. Save by French surgeons, it does not appear to have been much used, from the belief that the space given is too limited.[1]

Dr. Sands [2] points out that, in the majority of cases in which surgeons have operated through the palate, they have had to leave the wound open in order to remove the pedicle later. This step is by no means so easy as might be imagined, and in many cases the surgeon has been driven later to make use of another operation when the patient's condition was less satisfactory. Furthermore, repeated irritation, in the shape of attempts at destruction of the pedicle with caustics, the cautery, &c., is too likely to result in rapid sarcomatous growth.

B. **Operation for Naso-pharyngeal Fibroma through the Nose and for Malignant Growths of the Nose.** Under this heading will be included :

(1) Ollier's operation.
(2) Ronge's operation.
(3) Moure's operation.
(4) Langenbeck's operation.

These operations through the nose are only suitable for cases in which

whom the growth of hair will largely conceal the facial deformity consequent on operations through the upper jaw. In young patients, where the mouth is small and the growth large, this operation will be out of the question.

[1] Mr. Stonham (*Lancet*, January 7, 1888) has recorded a case of naso-pharyngeal fibroma, in which "the soft palate was divided in the middle line, and an attempt made to remove the growth through the mouth; but this plan failing to give sufficient room, the nasal cavity was opened up," and the growth thus successfully removed. Mr. Stonham found that division of the soft palate gave insufficient access to the broad base of the growth; attempts to turn the upper jaw out still gave insufficient access; removal of this bone, the orbital plate being left, was followed by a good result. The sphenoidal sinus was opened and plugged. Mr. Watsham (*Med. Soc. Trans.*, vol. xix, 1896, p. 394), speaking in favour of this operation, said that he had had to deal with growths of this kind on several occasions, and had always succeeded in obtaining adequate exposure by splitting the soft and cutting away the hard palate. He pointed out that these growths, though they may extend into the nose, and even cause the eyeball to protrude, do not usually involve the turbinals or upper jaw; there was consequently, as a rule, no need for turning the jaw outwards to get a good exposure. Mr. Wallis (*ibid.*) also remarked on the excellent exposure which this method afforded him in a case of large naso-pharyngeal growth attached to the internal pterygoid plate. Prof. Annandale (*Lancet*, January 26, 1889) reports three cases in which, after division of the hard and soft palate, the maxillæ were forcibly separated. The gap attained was very limited, only half to one inch. The results are not encouraging.

[2] "On Naso-Pharyngeal Polypi. Dr. Brown Sequard's *Arch. of Sci. and Pract. Med.*, No. 6.

the disease is well within reach. They may also be used in doubtful cases for exploratory purposes. In case of naso-pharyngeal growth, as the room which they give, and the access which they afford will probably be found insufficient, additional room must be obtained by removal of part of one or both maxillæ.

(1) **Ollier's Operation** (Fig. 179). In this method the nasal fossæ are exposed by turning the nose downwards. M. Ollier's incision begins at the edge of the bone, close behind the ala of the nose, and is carried upwards along its side to the highest part of the depression between the eyes, and then across, down to the corresponding point on the other side. The bone is sawn through in the line of the transverse part of the incision, the necessary liberating incisions made in the septum and the side, and the nose turned down. The septum is pressed aside, the growth removed, its base curetted or cauterised, and the nose replaced.

Fig. 179.

(2) **Rouge's Operation.** Owing to the improved methods of operating through the anterior nares this operation is less frequently called for than in former days. It is still occasionally indicated when the surgeon desires to gain free access to the nasal cavities, without an external scar, in the following cases: (1) In inveterately recurring nasal polypi persisting after the steps advised at p. 461. (2) For the removal of large sequestra. (3) For the removal of malignant growths of the nose and the naso-pharynx. (4) In some cases of extensive lupus of the nasal mucous membrane. (5) As a means of exploring the nasal fossæ.

Operation. An anæsthetic having been administered, the surgeon must decide as to what steps he will take to prevent the blood from getting down into the pharynx. This may be done by plugging the posterior nares, or better, by the intratracheal method of anæsthesia (p. 781), or by performing laryngotomy, the pharynx being then plugged with sterilised gauze. A good light is necessary, and this may be secured by the frontal head light.

The upper lip is raised and everted by an assistant, who stands behind the head of the patient, holding it firmly at the angles of the mouth. An incision is then made through the mucous membrane covering the alveolar process, just below the line of reflection to the lip, commencing opposite the first molar tooth on one side and extending to a corresponding position on the other. By means of an elevator the soft parts are separated in an upward direction, so that the orifices of the nasal fossæ are brought into view. The cartilaginous nasal septum is then detached by scissors from the nasal spine of the superior maxilla, and the lower lateral cartilages from the upper jaw, the adjacent parts of the cheek being also freed at the same time, so as to admit of the nose and lips being lifted up sufficiently to explore the nasal cavities. After the hæmorrhage has been checked a strong light can be thrown into the fossæ from the frontal lamp, and the necessary treatment carried out. After any dead bone has been removed, the sharp spoon applied, any growth excised, or any polypi or lupus dealt with, the soft parts are replaced and secured with a few catgut stitches. Care must be taken afterwards to keep the mouth clean, and irrigation of the nasal fossæ will also be required

The great advantages of this operation are that free access to the nasal fossæ is obtained without leaving any scar on the face, and that no special instruments are required.

The following case, recorded by Mr. H. Tilley,[1] is a good example of a large, deeply-seated nasal tumour removed by a modified Rouge's operation. The patient, aged 48, had complained of nasal obstruction with epistaxis and discharge for twelve months. The posterior half of the left nasal fossa was completely filled by a dark red easily bleeding mass of growth. After a preliminary laryngotomy and plugging of the pharynx an incision was made under the lip from the right canine fossa to the left malar process. The anterior half of the septum was detached and the soft parts turned upwards. The removal of the left canine fossa and ascending process of the superior maxilla then enabled the growth to be removed. The soft parts were replaced and kept in position by a few interrupted sutures. The growth was a rapidly increasing soft fibroma growing from the posterior wall of the maxillary antrum.

FIG. 180. The incision through the mucous membrane of the gum in Rouge's operation.

(3) **Moure's Operation.**[2] "This operation gives excellent access to the deeper regions of the nose. Sir St. Clair Thomson[3] says that "this operation is particularly suitable for malignant growths originating in the upper or inner walls of the maxillary sinus, the ethmoidal labyrinth, the deeper regions of the nose, the naso-pharynx, or the sphenoid. It might be required for very vascular naso-pharyngeal fibromata with extensive prolongations. It is very suitable for necrosis—generally syphilitic—of the sphenoid when threatening the base of the brain."

Operation. As in Rouge's operation, the anæsthetic should be administered either through a laryngotomy tube or by the intratracheal method to obviate the danger of the hæmorrhage which may be severe. It is desirable that the interior of the nose should be previously treated with a solution of cocaine and adrenalin. The operation is thus described by Sir St. Clair Thomson.[4]

"An incision is made from the inner border of the eyebrow, along the side of the nose, until it enters the lower margin of the nasal orifice. A second incision, starting from the same spot, above, is next carried round the lower margin of the orbit and outwards as far as the malar eminence. The lobule of the nose is then detached, so that the fleshy parts of the nose can be thrown over to the opposite side, while a triangular flap is turned downwards and outwards. With a raspatory the nasal process of the frontal bone, the nasal bone, the ascending process of the superior maxilla, and the canine fossa, are next exposed. The lachrymal sac is

[1] *Proc. Roy. Soc. Med., Laryng. Sec.*, April 1910, p. 96.
[2] Moure, *Revue hebdomadaire de Laryngologie*, October 4, 1902.
[3] *Diseases of the Nose*, p. 712. [4] *Loc. supra cit.*

carefully defined and retracted. A chisel is first driven through the superior maxilla, close to its junction with the malar bone, but avoiding the infra-orbital nerve, and the section is carried downwards to the canine fossa until it reaches the alveolar border. From the lower extremity of this incision—which of course enters the maxillary sinus—the bone which separates it from the pyriform fossa is broken through with stout forceps. In this way the antro-nasal wall is detached close to the floor of the nose, and can be removed together with the inferior turbinal. The nasal bone itself is next removed, together with part of the lachrymal bone and the nasal process of the frontal. Finally the middle turbinal and lateral mass of the ethmoid are removed with punch forceps. Volkmann's sharp spoon or a ring knife. A gouge, or Killian's eye protector, is then slipped inwards and downwards at the upper part of this opening until it comes in contact with the body of the sphenoid. An assistant holds it closely parallel to the cribriform plate, where it acts as a protector. With a long sharp spoon, acting from above downwards and forwards, the ethmoidal labyrinth can be cleared away with any tumour which may have infiltrated it. The os planum, if not already destroyed, can be removed, so as to obtain access to the orbit. Direct approach is given to the sphenoidal sinus. The septum can be readily resected, but an endeavour should always be made to preserve a strip of cartilage under the bridge of the nose to prevent any external deformity. It is needless to say that great care must be taken while working close to the cribriform plate.

A malignant tumour can then be removed with forceps, sharp spoons, and the fingers, any prolongations being followed into the naso-pharynx, the maxillary sinus, the sphenoidal sinus, the lateral mass of the ethmoid, or even into the pterygo-maxillary fossæ. Success largely depends on the care with which this curettage is carried out. It should be followed by the application of caustics or Paquelin's cautery. Bleeding is generally abundant at first. It can be controlled with tampons and the use of hydrogen peroxide. When the whole of the malignant growth has been removed, hæmorrhage generally stops spontaneously. Firm packing of the wound is therefore unnecessary and is best avoided. The large cavity is filled with one long strip of one-inch ribbon gauze, which is left projecting from the nostril, and the skin incisions are carefully brought together with silkworm-gut sutures. Healing takes place by first intention. There may be a little flattening of the side of the nose, but there is no disfigurement, and a few months afterwards it is difficult to detect any trace of the operation. The strip of gauze is removed in twenty-four to forty-eight hours, and simple intranasal cleansing measures are then instituted."

Sir St. Clair Thomson [1] has recorded two cases which show the value of Moure's operation in the removal of large deep-seated growths from the nasal fossæ. The first patient was a lady, aged 70, from whom he had removed an endothelioma involving the right ethmoid and maxillary antrum. The second was a lady, aged 50, who had a glandular epithelioma in much the same situation, causing swelling of the left cheek and bulging of the canine fossa. There was no recurrence after four months. In neither case was there any disfigurement, and the scar could only be detected with difficulty.

(4) **Von Langenbeck's Operation** (Fig. 181). A curved incision, with the convexity forwards, is made from the inner edge of the eyebrow on to the bridge of the nose, and thence downwards into the naso-labial fold. The flap of skin thus marked out is then dissected up in a backward

[1] *Proc. Roy. Soc. Med.*, Clin. Sec., March 1913.

direction. The nasal cartilage having been severed at its junction with the bone, a short, strong, narrow-bladed finger-saw is inserted into this opening and the nasal process of the upper jaw is sawn through up to the lachrymal sac; the saw is next carried inwards through the roots of the nasal process of the superior maxilla and the nasal bone, and lastly downwards through the nasal bone itself. The removal of this sawn-out lamella, consisting of the nasal process of the upper jaw, part of the lachrymal and the nasal bone, gives space enough for the inspection of the whole interior of the nasal cavity, the posterior nares, and the lower portion of the body of the sphenoid bone.

FIG. 181. v. Langenbeck's operation of resection of the nasal process and nasal bone. (Esmarch and Kowalzig.)

Though, as a rule, no deformity of the face follows on the removal of this piece of bone, Von Langenbeck modified this operation into an osteoplastic one. Thus he sawed through the nasal process covered with the periosteum only, so far as the lachrymal bone, and upwards through the nasal bone; then inserting an elevator, he raised the thin bony flap, which gave away above. At the close of the operation this flap was replaced.

C. **Operations for Naso-pharyngeal Fibroma by removal of the Upper Jaw.** (i) Completely; (ii) Partially: or (iii) By osteoplastic operation on this bone.

(i) **Complete Removal of the Upper Jaw.** This has been already fully described (p. 125).

(ii) **Partial Removal of the Upper Jaw.** These operations are very numerous: one or two will be mentioned as specimens. Of these operations the second is to be preferred. Removal of the entire jaw is not usually needful. The orbital plate can be left. The objections to the osteoplastic method, which are considerable, are given below (p. 172). Removal of the lower portion of the jaw will give a good exposure, especially if the surgeon combines it with a simultaneous attack through the nose, if needful. As the orbital and malar processes are left, the subsequent disfigurement is slight. The skill of the dentist will meet the sacrifice of the alveolar portion.

A. Method of Maisonneuve and Guerin. The essential point is to get room for attacking the fibroma by removal of the lower part of the jaw. The bone is exposed by Fergusson's incision, the hard and soft palate are divided in the middle line, and the latter detached transversely on the side to be operated upon. The hard palate is divided in the middle line by saw and bone-forceps, working from the nose into the mouth. By a transverse section with a narrow-bladed saw introduced into the nose, and made to cut horizontally outwards, the facial aspect of the bone is divided as far as the maxillary tuberosity. This section should pass above the roots of the teeth and below the infra-orbital foramen. The lower part of the jaw is then strongly depressed, and thus detached, consisting of the alveolar and palatine processes, a portion of the body, and a varying amount of the pterygoid processes which usually comes away with it. The fibroma is then extirpated.

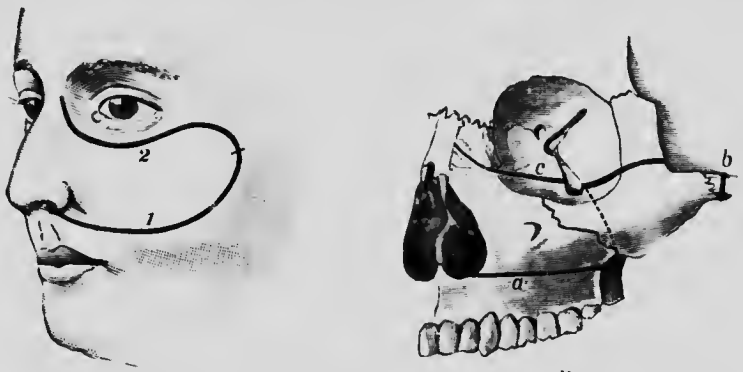
B. Method of Berard. In this the upper, not the lower, part of the jaw is removed, so as to preserve intact the teeth and alveolar process.

(iii) **Osteoplastic Operations on the Upper Jaw.** In this the bone is cut through by various incisions, turned in different directions on some

uncut attachments, as on a hinge, and then fitted down again after the removal of the growth.

Method of Prof. Langenbeck (Fig. 182). This is one of the best known of the above operations. Its object is to get at the fibroma, especially if it be one in the pterygo-maxillary fossa, without interfering with the alveolar and palatine processes or with the orbital plate. While this operation seems well suited to its object, its drawbacks are certainly considerable, for (1) there is the great difficulty of raising so fixed a bone, and again of getting it evenly into place—thus the operation is prolonged and the hæmorrhage very severe; (2) if the upper jaw has to be sawn from behind forwards, this cannot be done easily unless the fossæ at the back of the jaw and the spheno-palatine foramen are much dilated; (3) if the growth has extended into the naso-pharynx, this region will not be well exposed; (4) very disfiguring scars are left, especially objectionable in the case of a female patient.

Two semilunar incisions (1 and 2, Fig. 182), with their convexities downwards, are made across the facial aspect of the upper jaw, the lower running from the ala



A. B.

FIG. 182. A, V. Langenbeck's osteoplastic and temporary resection of the upper jaw. The skin incisions are shown meeting on the zygoma. (Esmarch and Kowalzig.) B. The same operation. The lines for the saw through the zygoma and upper jaw. (Esmarch and Kowalzig.)

of the nose to the middle of the malar bone, the second starting from the nasal process of the frontal and passing just below the orbit to meet the first where this ended.

If needful, owing to the extension of growths backwards, the meeting of these incisions may be carried back along the zygoma (*b*, Fig. 182 B). Each cut is made down to the bone, but the skin is not reflected. To avoid needless loss of blood, the lower skin incision and section of bone are made first, and then the upper division of skin and bone. At the outer end of the lower one the masseter is detached from the zygoma, and if the growth has extended out into the zygomatic fossa it will now come into view on dividing the buccal fascia. Professor Langenbeck found at this stage that by pressing the growth to one side and depressing the lower jaw he could pass his finger through the pterygo-maxillary fissure into the spheno-maxillary fossa, and so on through the spheno-palatine foramen into the nose, all these parts being enlarged by the pressure of the growth. By means of a narrow straight saw introduced the same way the upper jaw was cut through horizontally (*a*, Fig. 182 B) from behind forwards, while a forefinger passed by the mouth kept the tip of the saw from striking against the septum nasi. (If the right upper jaw is operated on, the surgeon will saw outwards from the nose.) The saw was now applied along the upper incision so as to divide the zygoma (*b*, Fig. 182 B), the frontal process of the malar, and the upper jaw (*c*, Fig. 182 B), just below the lachrymal sac.

up to the inner end of the incision. The portion of the upper jaw thus marked out now only remained attached, at its inner part, to the nasal bone, and nasal process of the frontal. Upon these connections, as upon a hinge, the piece of bone was slowly raised by means of an elevator introduced under the malar bone upwards and inwards, until the malar bone was nearly in the middle of the face. The growth was now completely exposed. The operation took an hour, and was attended with much hæmorrhage, most of which stopped spontaneously. The wounds healed well, a tendency of the bone to rise being met by pressure.

The Choice of an Operation for Removal of Naso-Pharyngeal Fibroma. The relative values of several of the above operations have already been briefly given. The surgeon will have to weigh duly the following: on the one hand, the desire to get the growth away with as little mutilation and danger to his patient as possible, and, on the other, the fact that these growths are most certainly malignant in character, and that any partial operation, while probably as difficult and as bloody as one on a larger scale, will, if incomplete, be certain to lead to increased growth in the tumour by the irritation which it causes.

Whatever operation is chosen, it will usually be wise, in order to diminish the risk of hæmorrhage, to perform a preliminary laryngotomy and to plug the fauces with an aseptic sponge. The laryngotomy tube should usually be removed immediately after the operation. The more modern method of intratracheal administration of the anæsthetic may also be employed. Destruction of the root of the fibroma is effected by a powerful curette, or a gouge, or, better still, diathermy may be employed. The risk of reappearance is great if the root be not completely destroyed.

For naso-pharyngeal growths which come early under treatment, in which the growth is of moderate size, with an attachment situated well forward in the roof of the pharynx or within easy reach from the posterior nares, especially one which can be made out to occupy chiefly the region of the nose, such an operation as that of Moure may be made use of.

In cases of greater difficulty, from the longer duration, more extensive attachments, larger size, and, with this last, the certainty of a more extensive base and numerous large sinus-like vessels, the question of deformity and disfigurement must be entirely set aside.[1] In order to secure adequate space for making certain of all the attachments of the tumour, for eradicating these, and, at the same time, satisfactorily meeting the hæmorrhage which is usually inevitable, a freer removal of bone will be required. No doubt, for this purpose, partial or complete removal of the upper jaw should follow the preliminary attack by the nose. Every surgeon who has performed the removal of the upper jaw knows how free is the access which it gives to the back of the nose and to the pharynx. A further advantage, pointed out by Dr. Sands, is the following, that owing to the wide gap left by this operation, reappearance of the disease can be more readily recognised and treated than after any osteoplastic operation.

Dangers and Drawbacks of Osteoplastic and other Operations for Naso-Pharyngeal Fibroma. Many of these have been already given under the head of Removal of the Upper Jaw (p. 430); others, more particularly to be expected here, are:

[1] The reader may again be reminded that these naso-pharyngeal polypi usually occur in males, often in lads or young adults. The growth of hair which can usually be secured in these cases lessens, to a considerable degree, the amount of disfigurement which operations on a larger scale entail.

(1) *Hæmorrhage*, not from large arteries, as the internal maxillary, but from the fact that the very numerous vessels of the growth are embedded in close fibrous tissue and thus cannot retract, and that many of the veins are large and sinus-like. The ways in which this risk should be met have already been indicated. Hæmorrhage from the base of the growth, if persistent, must be arrested by adrenalin chloride, the cautery, or by plugging.

(2) *Meningitis*, from damage to the base of the skull (p. 461), or from inflammation spreading to the membranes of the brain. Mr. Stonham[1] states that "it is a common experience that after removal of these polypi the patient suffers from intense headache, principally referred to the occipital region, but it usually passes off in a few days."

(3) *Necrosis* and *exfoliation*.

(4) *Non-union* of a temporarily resected fragment.

(5) *Reappearance*. The best protection against this risk is either adequate exposure of the growth, especially its base, and then complete destruction of this by a powerful curette or a gouge, or by diathermy.

Operations on the Sphenoidal Sinuses. As in the case of the other accessory sinuses of the nose, the sphenoidal sinus may be the seat of acute or chronic suppuration. This condition is extremely serious on account of the proximity of the cavernous sinuses and the base of the brain, a thin plate of bone alone intervening. The symptoms may be obscure and the diagnosis is often difficult.

Operation. The nasal fossæ must be thoroughly prepared with a solution of cocaine and adrenalin, care being taken that the upper and posterior regions of the nasal cavity are effectively treated. A general anæsthetic is then administered and the middle turbinated bone is removed. If, as is frequently the case, the posterior ethmoidal cells are also diseased, these should be curetted and scraped out, all carious bone and diseased tissue being removed by forceps or the ring knife. With the help of a good light the opening of the sphenoidal sinus will then be seen, or if not identified its position will be indicated by a probe introduced through the anterior nares in a line passing from the anterior nasal spine and crossing the centre of the middle turbinate. Free drainage is then secured by breaking away the whole of the anterior wall of the sinus by means of blunt hooks and Grünwald's forceps. The cavity itself should not be curetted for fear of damaging its roof. The sinus is then lightly packed with a strip of sterile ribbon gauze which is removed in twenty-four hours and the cavity then irrigated daily with warm boracic lotion.

Removal of Pituitary Tumours. These may be mentioned here since in most of the operations which have been designed access has been gained to the sella turcica by the nasal route. Diseases of the pituitary body have attracted a good deal of attention in recent years, and the possibility of the successful operative treatment of tumours in this very inaccessible region has been shown by the work of Horsley, Cushing,[2] Krause, Hirsch[3] and others. Those who desire full information on this most interesting subject are referred to a discussion opened by Professor Schäfer before the Sections of Neurology and Ophthalmology of the Royal Society of Medicine.[4] Here full information will be found as to the structure and functions of the pituitary, and of its diseases and their symptoms, diagnosis, and treatment, with a number of instructive cases. It will suffice to point out here that the most characteristic symptoms of a pituitary tumour are a condition of acromegaly associated with bitemporal hemianopia (blindness in the temporal portions of the visual field owing to atrophy of the nasal half of the retina, the result of pressure on, or involvement by the growth of the optic chiasma). A radiographic examination is often of great use in the diagnosis by showing an enlargement of the sella turcica.

[1] *Loc. supra cit.*

[2] "The Pituitary Body and its Disorders," 1912.

[3] Hirsch, *Archiv. f. Laryngol.*, Berlin, 1912, xxvi, p. 529.

[4] *Proc. Roy. Soc. Med.*, Sec. Neurol. and Ophth., 1913, vol. vi, No. 7. Mr. Thorburn (*Brit. Journ. Surg.*, vol. i, p. 183) has published a detailed account of a case of sellar decompression for a glioma of the pituitary. The trans-nasal route of Schloffer, as modified by v. Eiselsberg, was employed. The patient died of septic meningitis following removal of a portion of the tumour three months later.

Dr. William Hill in the above-quoted discussion mentioned no less than 22 methods which have been employed. In 11 of these the septal route is followed. The Killian-Hirsch method commences with Killian's submucous resection of the septum, followed by resection of the anterior walls and septum of the sphenoidal sinuses and removal of the floor of the sella turcica. Gradam obtains more room by enlarging one anterior narial opening by an anterior incision forwards and upwards, or by vertical fissure of the tip of the nose and columella, followed by the Killian-Hirsch operation, as described in the case quoted below. Halstead and Cushing displace the nose upwards by a sublabial oral incision as in Rouge's operation, and then proceed to the submucous resection. Four of the methods are lateral nasal (or ethmoidal) routes in which the operation resembles Moure's or Langenbeck's, which have been already described. Four of the methods are external rhinotomies with combined septal and ethmoidal resections. In the remaining three the nasal route is not adopted.

The following most interesting case of cyst of the pituitary fossa shown by Mr. C. I. Graham before the Laryngological Section of the Royal Society of Medicine in 1913 is an example of the Killian-Hirsch operation with Mr. Graham's modifications. The patient, a woman aged 37 was admitted to St. Mary's Hospital for failing sight, headaches, drowsiness, slow mental reaction, and incontinence of urine. The right eye was blind and there was optic atrophy, while in the left eye there was vision in the nasal portion of the field. At the operation illumination was obtained by a Nernst light reflected from a frontal mirror. An incision was made commencing at the tip of the nose and was carried to the upper lip, dividing the columella and about $\frac{1}{8}$ in. of the philtrum, keeping accurately in the mid-line. The free edge of the septal cartilage was defined and the skin of the vestibule raised on each side from the septum. Hæmorrhage here caused some difficulty. The mucous membrane was easily raised from the sides of the septum to within 1 in. of the posterior edge. The mucous flaps were held aside by a speculum with narrow 3 in. blades. The mucous membrane over the posterior edge and upper part of the vomer was raised by means of a dental "stopper" which terminates in a single corkscrew turn; the excursion of the instrument along the posterior edge of the vomer was controlled by the left index finger in the post-nasal space. Killian's long nasal speculum with flat blades $\frac{1}{2}$ in. by $4\frac{1}{2}$ in. was then substituted for the smaller instrument, and the vomer was twisted from its attachment to the sphenoid by means of Luc's forceps. To give more room the middle turbinates were forcibly separated by means of a metal glove stretcher, the blades being inserted into the tunnel bounded by the two layers of mucous membrane. The mucous membrane was then elevated from the anterior surface of the sphenoid so that the ostia of the sinuses were clearly seen. The position of the pituitary fossa was found by taking a line which commences at the junction of the ala nasi and upper lip, and runs upwards and backwards towards the junction of the pinna with the side of the head, and this line will be found to pass immediately beneath the outer and lower margin of the orbit. The opening into the pituitary fossa was made by placing a long chisel in the correct line, with the cutting edge against the roof of the sphenoidal sinus, and then cracking the bone by a few gentle taps with a hammer, a mastoid burr with a small head completing the stage. Immediately the bone was removed about ʒij of bloodstained fluid escaped, and when this was removed the dura mater was found to be lying against the opening. After enlarging the opening in the bone the dura mater was incised, but as this gave rise to brisk hæmorrhage on each of two attempts, the operation was concluded by swabbing out the wound with mops soaked in 1 in 4000 aqueous biniodide of mercury lotion and then inserting a suture in the skin wound which was covered with a sealed dressing. The patient was discharged twenty-five days after the operation, with complete relief of all symptoms except the sight, which she thought had improved slightly. Two months later a second operation was performed for a return of symptoms, and the patient died in three days. At the necropsy a malignant growth was found extending into the floor of the fourth ventricle.

The following methods of reaching the pituitary have also been employed. (*a*) By a lateral subtemporal craniotomy as recommended by Cushing; (*b*) by an anterior frontal craniotomy as suggested by Krause. In both these operations, after free removal of bone the frontal lobes are raised until the pituitary is brought into view. (*c*) Kocher suggests that the reflexion of both upper jaws with division of the hard and the soft palate followed by removal of the vomer and of the lower wall of the sphenoidal sinus would lead one down to the point where the pituitary body could be removed from the sella turcica.

These operations have not yet been sufficiently tried to permit of a satisfactory estimate of their relative merits. The advantage of the Killian-Hirsch method would appear to be that infection of the wound is less likely, its disadvantage that the exposure in the deep narrow wound is necessarily incomplete. The ethmoidal route would appear to be very liable to infection of the wound as the nasal fossæ are extensively opened. Kocher's operation, though severe, would provide a good view, though the dangers of infection would be present. The methods of craniotomy, temporal or frontal, could scarcely satisfactorily expose the pituitary, but benefit might result from the decompression thus provided.

REMOVAL OF ADENOIDS AND OF ENLARGED TONSILS

The symptoms produced by enlargement of these structures are so well known that their detailed consideration is not required here. It will be sufficient to point out that the severity of the symptoms rather than the extent of the enlargement should guide the surgeon when recommending operation. It must also be remembered that adenoids may be the cause of "reflex" symptoms such as nocturnal enuresis, convulsions, and laryngismus stridulus.[1] In slight cases, where the surroundings are satisfactory and where attention will be duly paid to carrying out palliative treatment, atrophy may be expected to follow. Nose-breathing, even if systematically carried out, will, however, have no curative effect on established adenoids, any more than it will upon enlarged tonsils. Where the adenoids or enlarged tonsils have caused enlargement of the cervical glands, operation is indicated, but the surgeon should prepare the relations for the possibility of suppuration in the glands after the operation, especially where the vitality is poor, the surroundings unsatisfactory, the glands already tuberculous, or where another member of the family suffers from a like condition of the glands.

Anæsthetic. These operations are carried out by many continental surgeons and by a few in this country without any anæsthetic. Though the operation takes but a short time, yet some deliberation is desirable, and hence general anæsthesia, which will last a few minutes, is strongly indicated. The anæsthetic employed will depend to a large extent on the custom of the operator. Chloroform should, however, except in certain special circumstances when it will be given by a skilled anæsthetist, be avoided. It is distinctly dangerous, and a large number of fatalities have occurred during its use for these small operations. If the patient is over twelve years of age, nitrous oxide gas may be employed. If desired this can be followed by ether. Ethyl chloride is occasionally used for younger children, but it is more satisfactory that the patients shall be anæsthetised with A.C.E. or the C.E. mixture. The anæsthetic should be pushed to such an extent that the corneal reflex is just lost, but the coughing and swallowing reflexes are not abolished.

The removal of adenoids will be first described, then the removal of the tonsils, and finally the operation when both these structures are enlarged.

Removal of Adenoids. The patient should be anæsthetised on a couch or operating table in a good light. The position is of considerable importance. It is best for the head to be turned to the right side, and

[1] It may be here pointed out that several other morbid conditions may give rise to similar symptoms. (1) Diminutive anterior and posterior nares; (2) low pharyngeal vault; (3) paresis of pharyngeal muscles; (4) prominent crest of the vomer; (5) forward projection of the upper three cervical vertebræ, especially the Atlas; (6) retro-pharyngeal abscess; (7) webs; (8) new growths, such as a sarcoma springing from the base of the skull.

the left shoulder to be raised by the nurse. This will be satisfactory both for the operator and the anæsthetist, for the blood will either escape from the nostrils or run down into the hollow of the right cheek. Or the patient lies on his back, with the shoulders a little raised, and the head thrown back, and hanging over the end of the table (Rose's position). In this position the head is supported by an assistant or nurse. It is now but seldom employed, as it has two serious disadvantages: it considerably increases the congestion and so the amount of bleeding, and also, by throwing forward the upper cervical vertebræ, renders access to the naso-pharynx distinctly more difficult. The instrument to use is Gottstein's curette or some modification of this, such as Kirstein's. Sir St. Clair Thomson's modification of this instrument is provided with a cage and teeth to secure the growth when it has been cut away.

The artificial nail, fitting the end of the finger, is now seldom employed. Forceps are useful in some cases for removing masses partially detached by the curette, or when there is a mass of considerable size springing from the lateral pharyngeal wall. The best pattern is Sir St. Clair Thomson's modification of Lowenberg's forceps. This instrument is particularly light and short, making it easy to use the finger at the same time. With these and all modifications of Lowenberg's forceps opening laterally, care must be taken not to damage the orifices of the Eustachian tubes.

The patient having been anæsthetised to the proper degree, the anæsthetist adjusts a gag, either Doyen's or Mason's pattern, and opens the mouth widely, but not to the full extent possible, as this may embarrass the breathing.

The surgeon then depresses the tongue with a spatula or with the left forefinger, and holding the curette firmly in the right hand, introduces it behind the soft palate into the naso-pharynx. Care must be taken that the instrument is in the correct position or the uvula or soft palate may be damaged. The curette may also be easily introduced in the following way: it is inserted over the base of the tongue with the curved portion directed downwards towards the epiglottis. Having reached the back of the pharynx it is rotated through an angle of 180°, and thus slips behind the soft palate. In either case its position must be verified by the forefinger, or by gently drawing the instrument forwards, when it will be felt to impinge against the back of the nasal septum. The handle is now depressed so that the cutting edge is pressed firmly against the anterior part of the roof of the pharynx. The patient's head is now steadied, and a firm sweeping cut made, the cutting end of the curette being made in one continuous movement to pass along the roof and the posterior wall of the naso-pharynx, and to be withdrawn from the mouth. In the majority of cases the detached mass of hypertrophied adenoid tissue will come away with the curette, especially if St. Clair Thomson's instrument is used. The forefinger is then again introduced, and if any adenoid tissue is still felt, one (or more) similar applications of the curette is made. The lateral aspects of the pharynx must be strictly avoided, especially the vicinity of the Eustachian tubes. That all cuts are made in the middle line may be ensured by keeping the shaft of the instrument in line with the incisor teeth. Small masses at the side of the pharynx will atrophy when the main mass has been removed; larger ones may be broken up by the finger, or removed, as may also any loose tags attached to the posterior pharyngeal wall, by St. Clair Thomson's forceps.

The amount of hæmorrhage varies; it is not often severe, and usually

soon ceases spontaneously. The blood escapes from the anterior nares or collects in the hollow of the cheek, whence it may readily be sponged away. Swabbing the back of the throat should be avoided.

Removal of Enlarged Tonsils. This is usually effected by means of the tonsil guillotine. The remarks about anæsthesia made above with reference to the removal of adenoids apply to this operation also. The patient should lie flat on his back with the head slightly extended. As the operator should be well over the patient a couch is better than the ordinary operating table. If the latter be employed the surgeon should be provided with a suitable footstool. When the patient is anæsthetised the anæsthetist or an assistant opens the mouth with a gag, either Doyen's or Mason's, inserted on the left side. The left tonsil should be removed first. The guillotine is introduced well to the back of the pharynx, and, with the help of the left index finger, the enlarged structure is manipulated through the window of the instrument, an assistant meanwhile supporting the tonsil by pressing the soft tissues inwards just behind the angle of the jaw. The window of the guillotine is then firmly pressed against the outer wall of the pharynx, to effect which the shaft may be carried inwards towards the mid-line. With the thumb of the right hand the cutting blade is now pressed home. The tonsil is either cut clean away, or the base is partly cut and partly crushed into a pedicle, which is readily torn through by one or two twisting movements of the instrument. In either case the left index finger should be placed behind the tonsil to assist in its withdrawal and to prevent it falling back into the pharynx. The operator, who looks towards the patient's head during the removal of the left tonsil, now turns round, looking towards the patient's feet, and removes the right tonsil in exactly the same way. There is no need to change the gag to the opposite side.

Directly the second tonsil is removed the patient's left shoulder is raised, so that the blood runs down into the hollow of the right cheek, whence it can be easily sponged away. Hæmorrhage may sometimes be troublesome after removal of the tonsils (*vide infra*).

Removal of Adenoids and Enlarged Tonsils. Both operations are very frequently carried out under the same anæsthetic. The tonsils should first be removed in the way described above. The patient is then turned on his right side and the operation for removal of the adenoids performed.

Enucleation of the Tonsils. The above operation with the guillotine does not completely remove the tonsil. When effectively carried out there is but little tendency for the small remaining portion to give rise to further trouble. There are, however, certain cases in which it is not a satisfactory operation. This is especially the case when the tonsil, though enlarged, does not markedly project: a thin superficial slice taken away is then unlikely to do good. It is also unsatisfactory in the case of small septic tonsils often met with in adults which cannot be cut away with the guillotine. In these cases, especially, enucleation is indicated.

Enucleation. The patient, who should lie on his back with the shoulders slightly raised, is anæsthetised in a good light. The mouth is well opened and the tongue drawn forwards by an assistant either by tongue forceps or by a suture passed through it near the tip. The mucous membrane is then divided along the whole length of the anterior pillar of the fauces, either by means of curved scissors or by one of the

special instruments designed for this purpose. The tonsil is now seized and drawn inwards by a pair of long curved-tooth dissecting forceps. The capsule of the tonsil, a bluish-white membrane, now comes into view. By means of the finger or with the help of the curved scissors, this is separated from the muscular wall of the pharynx, and the tonsil is thus completely removed. There is not usually much hæmorrhage, and the blood can be sponged away with sterilised swabs on appropriate holders by an assistant.

After-treatment. The patient should be kept on one side for some time after the operation, and carefully watched, especially on account of the vomiting of blood, which is almost certain to follow. The hæmorrhage, severe at the time, soon ceases, and very rarely causes anxiety. Occasionally the bleeding is profuse, or may be long continued. In such cases, iced boracic acid to the face, syringing hot water through the anterior nares, the patient being in the position above advocated, or the use of adrenalin chloride, 1 in 1000, must be tried. The child, if delicate, should be kept in bed for two or three days, and in damp or wet weather should not leave the house for a week. For the first twenty-four hours the food should be cold. As a rule, especially in little children, where the parts are so small and delicate, any use of the syringe or Politzer's bag is to be deferred until sufficient time has elapsed to show the result of the operation. Warm boracic acid may be used if the discharge show signs of becoming muco-purulent. The friends should be prepared for the breathing being even worse than usual for the first two or three days. Improvement, especially in the gain in nose-breathing, begins from the fourth to the seventh day. Nose-breathing exercises—a most important part of the after-treatment—should be started on the fourth day. The child should be made to lie on its back with the hands behind the head, for ten minutes, three times a day, and practise breathing deeply through the nose alone. This will cause atrophy of any remaining adenoids and greatly help the clearing-up of symptoms.

Complications and Sequelae. (1) and (2) *Hæmorrhage and Shock.* These have already been mentioned, and it may here again be pointed out that, in addition to deaths under chloroform, there have been fatal results from hæmorrhage. While the bleeding usually ceases quickly of itself, fatal cases have undoubtedly occurred both at the time and a few hours later. In a few this result may have been due to hæmophilia; in others, from the accidental tearing off of pharyngeal mucous membrane, or direct injury to a large blood-vessel, both these accidents being more likely to occur with Lowenberg's forceps. Where the bleeding is excessive the face should be sponged with ice-cold water. When this is not successful the naso-pharynx may, when the bleeding follows an operation for adenoids, be packed with sterilised gauze, which may be wrung out of a solution of adrenalin. If, as is more likely to be the case, the hæmorrhage follows removal of the tonsils, the mouth may be widely opened, the side from which the blood comes ascertained by inspection, and pressure then applied by a sterilised swab on a holder to the bleeding surface inside the mouth while counter-pressure is made from outside behind the angle of the jaw. It has also been recommended that sutures be passed deeply between the pillars of the fauces; while as a last resource, should these methods fail, the external or common carotid may be ligatured. The hæmorrhage in these serious cases usually comes from one of the tonsillar arteries: it is said that the internal carotid may be injured, though as

this is situated behind the tonsil and external to the superior constrictor, it is difficult to see how this can happen. The serious bleeding which would ensue could only be met by immediate pressure as described above and ligature of the common carotid.

(3) *Broncho-Pneumonia* from the entrance of blood into the lungs.

(4) *Infection of the Raw Surface.* This, naturally, cannot be rendered or kept aseptic, and the superficial sloughs which form may closely resemble diphtheritic membrane in appearance.

(5) *Ear Trouble.* In a few cases pain in the ears is complained of, probably due to entrance of blood into the tympanum along the Eustachian tubes. Another rare and more serious aural complication is otitis media from injury to the Eustachian tube, infection of the wound, or unwise use of the nasal douche. If deafness was present before the operation and is not improved ten days after, Politzerisation will be indicated.

(6) It is not very uncommon for some of the cervical glands to become painful and swollen, but, unless the wound has been infected, especially if the patient's vitality is very low, suppuration does not follow.

(7) *Exanthemata.* It is of great importance that after the operation the patient is not exposed to the virus of scarlet fever, diphtheria, or sewer gas.

(8) *Injury to the Tongue.* This may happen when enlarged tonsils are removed by the guillotine, but not in the hands of a skilful or experienced operator..

(9) *Question of Reappearance.* This is regarded by some as frequent. It is, however, distinctly rare when the operation has been properly performed, and the after-treatment efficiently carried out, though parents are liable to take several conditions which may coexist with adenoids for the reappearance of the adenoids themselves. Reappearance or, more correctly, persistence of adenoids, is not uncommon when the operation has been done "against time," either for show, or because the operator is nervous about the anæsthetic. If the adenoids have been properly dealt with, and mouth-breathing persists, some other cause must be sought for. Very likely nose-breathing has not been assiduously practised, or some such condition as enlarged tonsils, deviation of the septum, enlargement of the posterior extremities of the turbinals, hypertrophic rhinitis, or the rarer conditions mentioned at p. 474 may be present and require attention. All such conditions should have been detected at the time of the first anæsthetic, and, if not dealt with then, the patient's friends should have been made aware that more would require to be done.

CHAPTER XXIII

OPERATIONS ON THE LIPS. HARE-LIP AND OTHER PLASTIC OPERATIONS ON THE LIPS

HARE-LIP

Best time for Operation. Any time after the second or third month is to be preferred. For most cases the third to the sixth month is the best. All should be over by the seventh month when dentition begins. While the rule of British surgery is to get the operation over before dentition, many German surgeons defer taking any steps till the child has entered on the second year. Thus, Prof. Billroth [1] announced his practice as follows: "Unless the parents urgently demand an operation as early as possible, I generally prefer to operate on children when they are more than one year old. I always advise this in strong children with complicated hare-lips, especially when the intermaxillary bones are displaced and the hare-lip is double. I have been particularly satisfied with the results of operation, as far as appearance is concerned, on children at rather later periods of life and in adults."

The reasons for deferring the operation, as a rule, till after the second month, are:

(1) The difficulties of getting children with hare-lip to take sufficient food are exaggerated. Very often, unless the palate is cleft in addition, these children can suck well, and are in good condition. When the palate, is also cleft, a serious difficulty may arise from the food passing into the nose, but this may be usually met by careful feeding with a small spoon put well back, if a sucking-bottle with a large teat and a good-sized hole in it fails. This it will very rarely do, if slowly raised so as to give a little milk each time. Sometimes it is be[illegible]ve the child raised when feeding. The mother's milk should [illegible]e drawn and given when possible. When the child really can[illegible] sufficient nourishment, and is marasmic from this cause only, the surgeon may, of course, operate before three or even two months. But a child that is daily wasting is less and less able to meet the strain entailed by the operation and consequent repair. This should be clearly understood by the friends, and also the following fact:

(2) It is not uncommon for children with hare-lip to die soon after birth from causes quite apart from this deformity, viz. diarrhœa, lung trouble, exhaustion. In such, operation is unadvisable. It will not mend matters, and death will be put down to it, and not to the above causes, which would have destroyed the child in any case. In another, smaller, class of cases the operation itself, chiefly from the pain it causes in a weakly child, seems to start a process of fatal wasting,

[1] *Clin. Surg., Syd. Soc.* transl., p. 78.

(3) The operation can be done much more perfectly and artistically on a young child than on a new-born infant, the parts being larger, more fleshy, and more easily handled. Sutures also cut out less readily.

(4) For the first few weeks of life the child has scarcely got over the change from intra-uterine to extra-uterine life, the digestion is not yet, so to speak, in full swing, and a very slight shock may be too much for the low vitality of this period.

(5) The objection that early closure of the hare-lip renders access to the cleft palate more difficult is dealt with at p. 596.

Condition of the Hare-lip. Before operation the following must be inquired into. Is the cleft single or double? If single, is it simple, *i.e.* without involving the nose, and without fissure of the palate? Are the sides equal and acute-angled, or divergent and unequal? Other sources of difficulty are, much flattening of the nose from the septum being adherent and dragged over to the superior maxilla on one side, and the ala of the opposite side being spread out and stretched over the upper part of the fissure. Or the edges of the lip are widely apart, and by no means to be approximated, the alæ being so widely separated that lines let fall vertically through them only just come within the angles of the mouth.

Other more general points will, of course, be remembered as influencing the result of the operation. Amongst these are, the digestive and sleeping power of the infant; its family history; the existence of any weakening condition, such as otorrhœa; if it is in a children's hospital, the possible presence of any cases of infantile diarrhœa, and, by no means least, the good sense and patience of the nurse.

The third of the following operations is the one which is most generally indicated. The first is only of very limited use, while the others may be employed in special cases.

(1) **The Operation for those Cases where the Cleft is Narrow and the sides of the Cleft are equal** (Fig. 183). The child being wrapped in a towel, mummy-wise, to ensure the hands being secured if it "come to" prematurely, chloroform or C.E. is given fully, and the head is held suitably presented to the operator by an assistant, whose hands, at the same time, make pressure upon the facial arteries as they cross the jaw. The lips, and, generally, the alæ also, are now freely separated from the subjacent bones to allow of the margins of the cleft coming together without tension. During this step the knife should be kept very close to the bone, otherwise the hæmorrhage will be free. Some advise the use of a blunt instrument here after the mucous membrane has been incised. Unless this separation of lip and lower nose be thoroughly carried out, the tension on the sutures a little later will be certain to interfere with successful union. To render the separation efficient the knife must sometimes be carried quite up to the infra-orbital foramina, while the alæ nasi must also be thoroughly separated, so that any flattening and distortion of the nostril may be remedied. The bleeding is met by keeping the knife very close to the bones, and after the soft parts are freed, making gentle pressure.

If one pre-maxilla and maxillary bone project inconveniently beyond its fellow, it may now be forced back into place with the finger and thumb,[1] or with non-serrated forceps covered with thin drainage-tube. The bone

[1] If the back of the child's head is firmly supported, the thumb of the surgeon will, usually, quickly fracture back the bone into place.

should be felt to crack when this is done; otherwise, if merely bent back, it springs forward again and causes tension on the flaps.

The edges of the cleft are now pared. This, the most important part of the whole operation, must be done carefully, and thoroughly as well. The surgeon seizes the lower angle of each flap alternately, either with his left forefinger and thumb, or, if the parts are very small and slippery, with tenaculum-forceps, which should not hold the soft parts too near the edge, or they will tear out too soon. The edges being thus made tense, the surgeon, with a narrow-bladed, thin-backed, small knife (scissors are on no account to be used), pares them as widely as possible by two incisions, beginning above at the upper angle of the cleft, curving outwards somewhat as they descend, quite clear of the edges of the fissure, and then, in the lower part, curving inwards again, through the red prolabium. Beginners nearly always make the mistake (Fig. 183) of removing only a thin paring of red surface. The pared surface should be made as wide as possible, especially below, in order that the sutures may hold better and the lip be deeper. In Mr. Owen's words,[1] the object is to carve out as massive pieces as possible, not little flaps. If one margin of the flap is longer than the other, this should be pared first, and after this its fellow, that both may correspond. The hæmorrhage from the coronary arteries is met by seizing them with small Spencer-Wells forceps, which serve to approximate the lips when the first and lowest stitch is inserted.

Fig. 183. (After Whitson, *Edin. Med. Journ.*, 1883, p. 7.) The dotted line shows the cleft widely and freely pared. The dark one shows timid paring close to the prolabium. The advantages of the first incision are—(1) A broader lip. (2) Firmer union, as a greater number of vascular points are cut which will throw loops across. (3) A better grasp for the sutures. (4) A more vertical depth to the lip, the two points, A A, being on a lower level than B, B. The lower ends of the dotted lines should have been shown curved downwards and inwards in the usual way.

The assistant, who steadies the head and keeps pressure on the facial arteries, now, with two fingers, presses the cheeks together, so as to bring the flaps into apposition while the surgeon introduces his sutures. Two or three stout sterilised salmon-gut stitches should first be used, the lower to command the coronary arteries, and passed close to the mucous membrane. This first stitch being passed, and the chief fear of bleeding removed, three or four others of gossamer-gut or horsehair are inserted, one being placed in the free margin of the lip to keep the wound carefully closed here against the entrance of milk, saliva, &c. In adjusting the top stitch care must be taken that it does not too much depress the tip of the nose, if the cleft has been one running up into the nostril.

Another precaution to be taken with the nose is to see that the alæ are symmetrical, and that neither nostril is left a mere chink. The occasional importance of this is shown by the case related at p. 482. All the chief stitches should be inserted with very fine needles, one-quarter of an inch from either side of the cleft. A few more hints may be given with regard to the sutures. They should be used freely, and, in addition to the lowest, which commands the coronary arteries, two should be passed deeply enough to bring the whole thickness of the orbicularis

[1] *Cleft Palate and Hare-lip*, p. 96.

together, and to control the vessels. In tying them there must be no strangling of the tissues; the tension required is to hold the cut surfaces together with allowance for some swelling. In tying them, if their ends be left a little long, their removal will be facilitated.

Hare-lip pins are now practically obsolete. They were useful, no doubt, in promoting close and accurate union where the parts came easily together, but at the expense of the risk of sloughing and scarring even then; with much tension this risk was increased. The sutures already described, and the prevention of tension by free separation of the soft parts from the bone, will meet every need.

The sutures being tied, the nostrils are cleared of any clots, and the following dressing applied: After a sealed dressing of gauze and collodion has been used to cover the wound, a piece of cyanide gauze two layers thick, which has been previously cut to an appropriate size of "butterfly" shape so that one wing can be fixed upon each cheek, while the uniting portion, cut just the width and depth of the lip, passes over the wound. This dressing is secured in place with collodion, and, while it is being adjusted, an assistant holds the cheeks forward, a position which must be maintained until the collodion is firm; or, instead of this, a piece of adhesive strapping cut in a similar shape may be employed.

In the after-treatment, the wound may be looked at on the second or third day, the stout salmon-gut stitches removed on the fourth day, and the others left in much longer. On each occasion the child must be firmly held, and the cheeks most carefully supported, while a similar dressing to that described above is applied.

One point of great importance is scarcely alluded to in most surgical works, and that is, that in some cases of hare-lip death from dyspnœa may take place very soon after the operation. Thus, where the cleft has been a large one, and the upper lip when restored is tight, when it overhangs the lower, if the nostrils are flattened and partially closed by the operation, owing to the tension of the parts, so little breathing-space may be left that temporary interference with respiration may occur, with grave and even fatal results, before the breathing can be accommodated to the altered circumstances, and before the parts dilate and stretch.

The first case that drew Mr. Jacobson's attention to this accident occurred in the early part of 1887, at Guy's Hospital. The patient was an infant, aged three months, having a large cleft with unequal sides and going through the alveolar margin, the two halves of these being on different levels. The projecting alveolus was broken back into position, pared, and stitched with chromic catgut to its fellow. The edges of the cleft were then pared and united. They came together excellently, the wide cleft being replaced by a deep upper lip. One nostril was rather chink-like. About half an hour after, a message came that the child was livid and dying. The child was at once taken to the theatre; the dressing was removed, the tongue carefully drawn forward, and artificial respiration performed. The child quickly recovered, began to cry, though not very vigorously. Three quarters of an hour later its breathing again failed, and, though the house-surgeon at once repeated the artificial respiration, he was unable to resuscitate the child. At the necropsy no clot was found in the fauces, nor anything wrong beyond the suddenly occluded oral passage.

Mr. G. A. Wright of Manchester has also recorded two such cases.[1]

The children here were aged three and five weeks respectively, the hare-lips double; in one, after the operation, the lower lip was drawn in so much as to leave but a small opening, but there was not apparently any dyspnœa. In one case dyspnœa came on suddenly, and, as no relief followed on pulling the tongue

[1] *Abstracts of Cases Treated at the Pendlebury Hospital*, 1885, p. 146. In his *Abstracts* for 1883, Mr. Wright records a case in which, after an operation for hare-lip, there was so much dyspnœa, from the tongue clinging to the roof of the mouth at each inspiration "that it had to be pulled out and fastened by a ligature."

out, tracheotomy and artificial respiration were performed. The child recovered, but a few hours later the breathing failed again, and death ensued. In the second case the child was found dead in the night. "The cause of death was probably valve-action of the lower lip."

The chief objection to this simple operation is, that when cicatrisation is completed there is very likely to be a small, but disfiguring, notch in the border of the lip at the site of the original cleft. This may be pre-

Fig. 184. Operation of Clémot, or Malgaigne.

vented by the (2) **Operation of Clemot or Malgaigne** (Fig. 184). The edges are pared down to, but not beyond, the red line; the flaps thus detached above are turned downwards and kept out of the cleft with a probe. The upper part of the cleft is then sewn together with the sutures already advised, while the projecting is shortened as required with a pair of sharp scissors and united with one or two stitches of gossamer-gut or horsehair. The chief objection to this method is, that, unless great care is taken, a little skin, imperceptible at first, but showing white after a time, may remain below the red line, or as a break in it.

Frequently however, the cleft is very wide, or its edges are markedly un-

Fig. 185. Operation of Mirault.

equal or asymmetrical. Under these circumstances, (3) the **Operation of Mirault** should be performed. This method, which is most generally applicable, gives the best results and is suitable for a far larger group of cases than that first described. By cutting the flaps of sufficient size any subsequent notch in the free border of the lip can be avoided.

The patient having been anæsthetised and placed in the position recommended above, the lip on both sides of the cleft and the alæ nasi are freely separated from the bone to avoid tension. The side of the cleft

which is the more vertical is then selected and an incision is made downwards and outwards from the apex of the cleft to the junction of the skin and mucous membrane so as to leave a flap on this side free above but attached below (Fig. 185). Care must be taken that the knife transfixes the whole thickness of the lip so as to give a good broad raw surface. The other, more sloping side is then freely pared throughout its extent from the apex downwards and outwards.[1] The hæmorrhage is controlled by an assistant compressing the lip on each side by the thumb and forefinger at the angle of the mouth. A silkworm-gut suture, threaded on a small curved cutting needle, is now inserted, passing deeply from the skin nearly to the mucous membrane at the angle of the raw surface of the first flap, which should be just at the junction of the red prolabium with the skin. The suture is then made to traverse the raw surface of the opposite side of the cleft at the corresponding position, *i.e.* at the junction

A. B.

FIG. 186. Edmund Owen's Modification.

of the prolabium and skin. This suture is then tied, the edges of the wound being accurately adjusted. The upper cutaneous portion of the raw surfaces are brought together by means of a few sutures of gossamer-gut. The edges of the red mucous portion are then approximated by sutures of the same material, or of horsehair. The free edge of the lip should, when the suturing is finished, show a slight prominence at the side of the cleft. If this is so, the margin of the lip will probably be level when cicatrisation is completed. If quite level at the end of the operation the scarring is likely to leave a small disfiguring notch. The dressing and after-treatment are similar to those described in the account of the first method.

Mr. Edmund Owen has suggested the following modification of this operation (Fig. 186). The more sloping side is first widely pared. To free the flap which is to be brought across from the other side, the incision is first made, as usual, from A to C, and then outwards. The object of this outward prolongation is to enable the flap to lie level smoothly when it is brought over, *i.e.* without kinking, to which there is otherwise a tendency.

(4) **Method of Nelaton** (Fig. 187). This is adapted to those slight cases in which the cleft does not extend through the whole depth of the lip but terminates at some distance from the nostril. It may also be employed to remedy the unsightly notch left after one of the other operations. An incision resembling a V reversed is made through the whole thickness of the lip, around the upper angle of the cleft. By this means the red edge of the cleft is separated from the two halves of the lip, except at each corner below. This red edge is next turned downwards,

[1] The sides, especially the one which is refreshed throughout its whole extent, should be pared as in Fig. 185—that is, somewhat angularly—so as to promote the adjustment of the flaps, as it were by interlocking.

or reversed so that the ∧-shaped wound becomes diamond-shaped. The raw surfaces are then brought together by the means already described.

(5) **Hagedorn Operation.** This is sufficiently explained by a reference to Fig. 188.

(6) **Konig's Operation** is shown in Fig. 189.

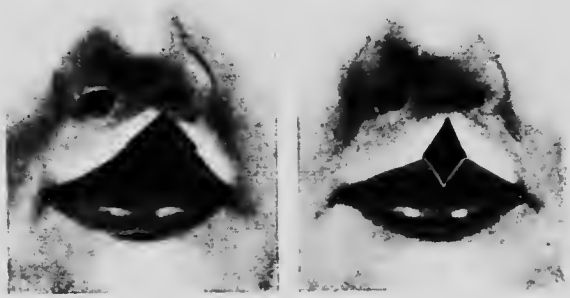


Fig. 187. Nelaton's operation.

Fig. 188. Hagedorn's operation.

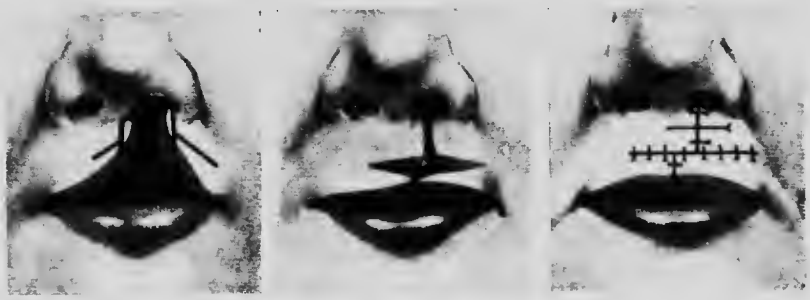


Fig. 189. Konig's operation.

DOUBLE HARE-LIP (Figs. 190, 191)

This is often easier of cure than single hare-lip with very divergent sides and the alveolar margin cleft and its two parts on unequal levels. For in double hare-lip the mischief is often symmetrical, and the sides less divergent. The following varieties may be recognised :

(*a*) When the pre-maxillary bone is *in situ*, and the two clefts are simply and fairly bilateral.

(*b*) When the pre-maxillary bone is separated from the rest of the jaw and projects forwards, in some cases slightly, in others being attached to the vomer and hanging from the tip of the nose.

(*c*) When the pre-maxillary bone is small and ill-developed, and when the clefts are widely gaping.

The first two of these require notice.

(*a*) If the pre-maxillary bone is in position, the skin over it is freed from its attachments behind and pared to a point. The sides of the cleft are next pared from above downwards (as in Fig. 190), and the parts brought together by transfixing the sides and the central flap with salmon-gut sutures, every care being taken to keep the central piece well down. Horsehair and gossamer-gut sutures are also used as well. As the central piece is always shorter than the lip itself, the resulting wound is Y-shaped, and it is the side flaps which meet each other in the middle line below.

Care must be taken to free the central flap right up to and with the tip of the nose, and not to depress the latter too much with the sutures, otherwise the nose will be flattened. As in single-hare-lip, where one side is larger than its fellow, a flap may be freely cut from it to form the prolabium and lower border of the new lip by the method shown in Fig. 190. When both clefts are wide the centre portion may be pared as described above, and flaps turned downwards from the outer side of each cleft as described for Mirault's operation (Fig. 185).

Fig. 190.

(*b*) Cases in which the pre-maxillary bone is separated from the maxillæ, projecting forwards, sometimes being even attached to the very tip of the nose.

The question of removing or leaving the pre-maxillary bone arises here. It is now generally agreed that, with rare exceptions, this should be preserved for the following reasons:(1) if the bone be removed there must be a permanent gap through the hard palate. (2) There must also be a flattening and malposition of the upper lip, in consequence of its having lost its bony support; and from this flattening of the upper jaw it will result that the lip will be very short and tense, and the patient extremely "under-hung," a very unpleasing deformity. To these two more may be added—that (3) the presence of this bone is needful for the preservation of the due width and arch of the bone, and (4) that such an arch will best carry artificial teeth, if any are needed owing to the unsatisfactory eruption of the natural ones.

If the following points be attended to, the pre-maxillary bone, however advanced and firmly attached, can always be replaced and preserved; weakness on the part of the child, which is undoubtedly a matter of grave consideration in cases like this where the loss of blood is considerable, is best met by doing the operation in two stages—in other words, being content to first get this bone replaced, and leaving the uniting of the soft parts till another time.

Where the stalk of attachment of the pre-maxillary bone is slender, and where there is plenty of room between the two maxillæ, it may often be broken back into place by the operator supporting with his left hand the back of the child's head, and then with his right thumb sharply fracturing back the bone. This should be done thoroughly, and, if

needful, by the aid of non-serrated forceps covered with drainage-tube, or bone forceps may be applied to the stalk in front and also behind till it is almost completely cut through. If now it can be replaced, but tends to come forward again, it should be sutured, on one side at least, to the maxillæ with sterilised catgut.

If the maxillary bones on one side or both are in the way, and prevent the replacing of the pre-maxillary bone after it has been detached sufficiently, or if this is too voluminous, its sides must be cut away and the maxillæ also pared till the central piece can be pushed back between them and retained with a suture, as above advised. A severer method—one, therefore, which should only be tried when all other means of replacing the pre-maxillary bone have failed—is to cut a wedge-shaped gap out of the septum nasi and to press or fracture the partially detached bone into the gap. It is absolutely necessary, by some means or other, to get the pre-maxillary bone quite back and to make it stay there, as otherwise

Fig. 191. Hagedorn's operation for double hare-lip.

the soft parts over the projecting bone, or the line of union, which often comes just opposite to it, will be pressed upon and give way.

Hagedorn's Operation is shown in Fig. 191.

Causes of Failure and Death after Hare-lip Operations. Amongst the commonest of these are: (1) *Feeble vitality. Marasmus.* Many infants die after hare-lip operations, but, while the effect of loss of blood and of pain must not be lost sight of, in most of the fatal cases death is due not to the operation, but to feeble vitality. Whether operated not, the majority of these cases would have died in infancy. *morrhage.* This, if serious, is due either to very free separation of the [illegible] in a weakly child, or (a cause much less excusable) to the coronary arteries not having been properly secured. Loss of blood may lead to non-union, but it may also destroy life rapidly by a clot in the fauces and upper aperture of the larynx. One case has been reported in which, after operation, this untoward result would have happened, the child getting increasingly blue and breathless, had it not been for the prompt common sense of the nurse in charge, who removed a large clot with a sponge on a holder. (3) *Bronchitis* and *Broncho-Pneumonia.* (4) *Diarrhœa.* (5) *Asphyxia* (p. 482). (6) *Infection*, especially where the bone has been interfered with in a weakly infant, and under conditions always adverse to aseptic healing.

Repetition of Operation. In the rare cases where primary union fails, all sutures are to be removed and the parts fomented with boracic acid lotion. As soon as all inflammation has subsided, the edges will rapidly

cover themselves with healthy granulations. An anæsthetic should now be given and the parts thoroughly cleansed and dried. They are then carefully approximated with gauze and collodion, over which Meade's strapping should be applied.

A good result will often be obtained in apparently hopeless cases. In many cases a perfect result cannot be secured by one operation. Where parents are likely to be unreasoning and unreasonable, the surgeon should warn them of this.

In cases unfavourable owing to the malformation or to the general condition (p. 480), hare-lips which have been operated on often cause disappointment, however much, up to the third day, they resemble pictures in books. Incomplete closure, below or above, a little inequality in the levels of the halves of the new lip, some flattening and closures of the nostrils—any of these may mar the first operation. The more operations a surgeon does, the more difficult and trying cases will he meet with. He can scarcely do better than remember the words of the great surgeon of Vienna :[1] "Operations on little children do not always succeed as well as could be wished, on account of the diminutive size and softness of the parts. The flaps of the lips cannot always be adapted as exactly as desired, and, even if this be satisfactorily accomplished, the result does not in every case quite come up to expectation, so that, some few years after, further slight proceedings become desirable, in order to improve the appearance." And again, a little later, the same surgeon, speaking of operations on "quite little children," says : "I decline to give any absolute guarantee with regard to the result in such cases."

OTHER PLASTIC OPERATIONS ON THE LIPS AND FACE

(Figs. 192–213)

These are very numerous, especially for the restoration of the lower lip after operations for epithelioma, &c., injuries, ulcerations, and burns. A few of the chief will be described here. It will be convenient if, at this time, some general principles which should govern every operation of plastic surgery, large or small, are considered.

(1) The patient should be in the best possible condition as to general vitality, healthy performance of the chief functions, appetite, &c.

(2) If the deformity has resulted from tubercle or syphilis, a satisfactory condition, both constitutionally and locally, must have been secured by previous treatment.

(3) The parts to be operated upon must be rendered as aseptic as possible. Where the mouth is involved, this and the teeth should be thoroughly cleansed beforehand (p. 532).

(4) Asepsis should be maintained as thoroughly as possible throughout the operation. The knife and cutting instruments employed must be of the sharpest.

(5) The flaps should be taken from healthy parts. As instances of the convenient sites for flaps, the side of the abdomen or region of the hip may be given where the ulcerated surface, *e.g.* after a burn, is on the forearm or back of the hand. Where, in a child especially, the surface is about the knee, the thighs may be crossed in order that the skin may be taken from the opposite limb.[2] Fixity must be maintained by the use of plaster of Paris, with appropriate windows. "Under

[1] Billroth, *Clin. Surg.*, p. 79. [2] Keetley, *Lancet*, March 4, 1905.

no consideration should cicatricial tissue of a pale glossy surface be employed, for when its subcutaneous connections are severed it is almost certain to slough, especially when the result of a burn. If cicatricial tissue exist at the base of a flap, sloughing is quite likely to occur. Cicatricial tissue at the border of a flap is quite certain to die, and its presence there must not be estimated in computing the area of the new flap. When the flap is to be joined on three sides with cicatricial formation, the base must be made large, be highly vascular, and but little twisted, as the vascular supply at the sides will be very little added to by the new association."[1]

(6) Each flap must be cut thick enough, carrying with it the subcutaneous tissue, and large enough; "as a rule, one-sixth larger than the space it has to fill."[2] "Reparative flaps should always be made large enough to allow of at least three lines of shrinkage for each inch of width of their surface."[3] As an instance of the size required, Mr. Keetley gives the case of a child with a large hairy mole on the face. After this was excised and the arm brought up to the head, nearly all the skin on the inner aspect from the shoulder to the elbow was needed for the pedunculated flap employed. The same authority advises the use of a pattern for the flap, cut out of boiled india-rubber sheeting.

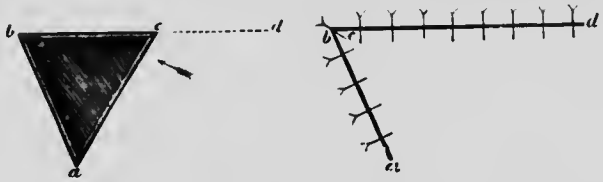


FIG. 192.

(7) There must be no tension whatever on the flaps when they are brought into apposition. Tension is one of the most frequent causes of failure after a plastic operation. The chief aids in securing this most important end are: (*a*) Cutting the flaps sufficiently large. (*b*) Undermining the flap or flaps. Julius Wolff elaborated this method of closing large gaps.[4]

In the case of small wounds it is only necessary to cut between the superficial and the deep fascia. In larger wounds the knife should pass between the deep fascia and the muscles. In either case the undermining must be carried out freely so that the edges of the wound come together without tension. Care must be taken to avoid scoring or unduly lacerating the deep surfaces of the flaps, as this may easily interfere with the blood-supply and so lead to sloughing.

(*c*) By making liberating incisions at a short distance from the wound, lateral or horizontal as required, before inserting the sutures in the lips of the wound. These incisions cause slightly gaping wounds after the defect has been closed, but these usually heal rapidly by aseptic granulation. (*d*) By use of flaps. These may be (*a*) broad and capable of being glided into the new position, (*b*) pedunculated; (*c*) granulating.

(*a*) Fig. 192 shows how a triangular gap may be closed by gliding in a flap raised by a horizontal incision. But in these cases it is preferable to convert the horizontal incision, *cd*, into one curving outwards and

[1] J. D. Bryant, *Oper. Surg.*, vol. i, p. 507
[2] J. D. Bryant, *loc. supra cit.*
[3] Treves, *Oper. Surg.*, vol. ii, p. 3.
[4] *Berl. Klin. Woch.*, 1890, No 6.

downwards. Such an incision better frees the flap, *acd*, which is to be glided, and is likely to leave a less conspicuous scar, as it can often be made to follow a natural sulcus. Where the gap is very large, two such freely curved incisions are made, one on each side of the gap. In the removal of extensive epitheliomata of the lower lip, where a very large triangular gap is left, such freely-made curved flaps will enable the

FIG. 193.

surgeon to close the gap better than those which carry authoritative names and which are shown below.

(*b*) *Flaps with Pedicles.* These may be so fashioned (as in Fig. 193, where a quadrangular gap is being closed) that the flaps are again little more than glided. In other cases the pedunculated flap must be cut in accordance with the principles already enunciated. The pedicle must be as wide as possible. The flap itself must be from two to three times as large as the area which it has to cover. It must be raised as thick as possible, its apparent bulkiness being greatly diminished later. In many cases it will have to be "jumped" over intervening undetached soft parts. The directions given above as to a pattern and the use of plaster of Paris must be remembered. When the pedicle is divided the parts must be carefully steadied and approximated.

FIG. 194. Patient before operation. (Croft.)

(*c*) One more class of flaps must be mentioned, that of granulating flaps.

This method was used with much success, especially in cases of cicatrices after burns, by Mr. J. Croft.[1] Where the gap is a large one, the flaps being necessarily long and somewhat narrow, and therefore possessing but a limited blood-supply, Mr. Croft advised that the flaps be dissected up and left attached at each end, and allowed, together with the wound, to granulate before the flap is moved. Mr. Croft claimed the following advantages for this method, and his claims were made good by the cases which he showed: (1) The risks of sloughing of any part are greatly diminished. Instead of being transplanted when recently drained of blood and reduced in temperature, it is removed when abundantly vascular and full of active, living, plastic matter. (2) The transplantation being made two or three weeks after the first operation, the local effects of shock are avoided or reduced to a minimum.

While Mr. Croft's results abundantly justify a resort to this method, it is a tedious one, nine to twelve months being sometimes needed in a severe case; it is a painful one, as the second stage may have to be repeated; and it draws largely on the reparative powers of the patient.

[1] *Med. Chir. Trans.*, vol. lxxii, 1889, p. 349.

For these reasons most surgeons will prefer to try, first, what can be effected by a very free division of the scar and then careful Thiersch's grafting (p. 43).

FIG. 195. The same patient five years after operation. The dotted lines show the site and extent of the strap of skin which was raised and transplanted. (Croft.)

(8) All hæmorrhage must be thoroughly arrested; any ligatures used must be of the finest.

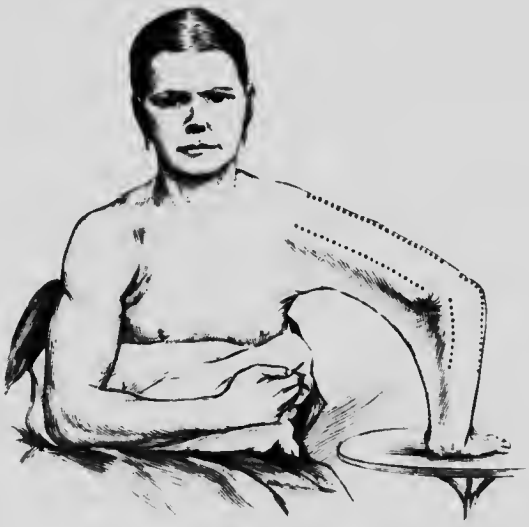


FIG. 196. The patient before operation. The web is well shown. The dotted lines indicate where the strap-like flaps of skin were raised, and their extent. (Croft.)

(9) Each flap "must be gently handled, carefully adjusted, and most tenderly and precisely sutured."[1]

(10) The sutures, of sterilised silkworm-gut and horsehair, must be inserted so as uniformly to distribute the slightest remaining tension.

[1] Treves, *Oper. Surg.*, vol. ii. p. 3.

(11) Asepsis must be carefully maintained during the healing of the wound.

(12) Where restlessness on the part of the patient is to be expected, as in a child with one of the common burn-scars on the neck or upper extremity, some fixed apparatus, *e.g.* plaster of Paris applied after the method used in Fig. 27, should be kept applied, from the first, to the head and neck, upper trunk, and limb, or the flap will begin to ulcerate and irreparable mischief will be done.

Removal of Epithelioma of Lower Lip. Restoration of Lip. Figs. 198-201 have been retained partly on account of the eminent names

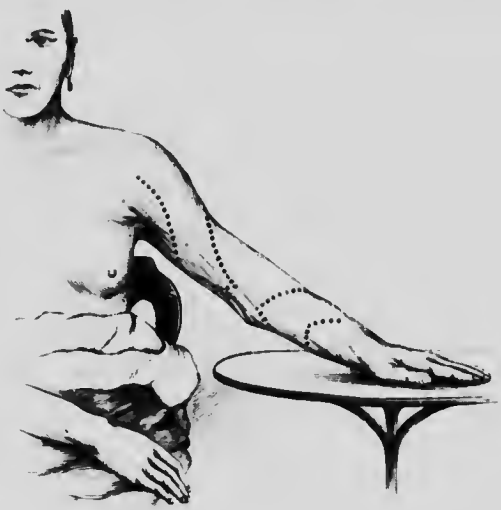


Fig. 197. After operation. The greatly improved position of the limb is manifest. The dotted lines show the situation into which the flaps have settled. (Croft.)

associated with these methods and partly because they are still occasionally of service. In each individual case the situation, extent, and duration of the growth have to be considered as well as the question of secondary deposits in the glands. Hence the method selected will be the one which best meets the necessity of the case in question. Carcinoma, in this situation, is, however, best removed on the lines shown in Fig. 202. There are two dangerous fallacies with regard to this operation: (1) That when occurring on the lip, because at first often warty, and in a dry and exposed position, it is a slow and less important form of carcinoma; (2) it follows that the operation is too often considered a trivial one, one for which the classical V-shaped incision suffices, and, as it is followed by rapid healing, that removal of an epithelioma of the lower lip is, in fact, any one's operation. The simple V-shaped incision is only justifiable in the very straightforward and early cases, and in all cases the limbs of the V should be widely separated so as to pass through healthy tissues well away from the growth. It is surprising how freely the lip can be removed in this way without subsequent inconvenience or deformity. Where, as is most frequent, the disease occupies the neighbourhood of the angle of the mouth, two V-shaped incisions should be employed (Fig. 202); where

the lip is extensively involved, three such incisions (Fig. 202) are called for.[1] Further, in the great majority of cases, owing to the duration of the disease, the lymphatic glands in the submental and submaxillary

Fig. 198. The dotted lines show the operation of Serre, the continuous ones that of Syme. The central part of each runs too near to the growth. The same remark applies to several of the succeeding figures.

Fig. 199.

Fig. 200. V. Langenbeck's method of cheiloplasty. (Tillmanns.)

Fig. 201. Cheiloplasty by the method of Bruns. (Tillmanns.)

As pointed out above (Fig. 198), the incisions in many of these illustrations are drawn much too near to the growth.

regions should be investigated, even though they cannot be felt to be enlarged.[2]

[1] Not only is the actual epithelioma to be remembered, but the adjacent area should also be widely removed owing to the degenerative changes here, and the fact that they lie on the borderland of carcinoma. The knife should pass a full three-quarters of an inch from the actual disease.

[2] This should certainly be a rule in hospital patients owing to their carelessness and the difficulty in keeping them under observation. When the submaxillary or submental group can be felt to be enlarged the deep cervical group should also be removed. See the remarks on infection of the glands in epithelioma of the tongue, and those on removal of epitheliomatous glands in the neck (p. 539).

Restoration of Lower Lip. Let us suppose that the surgeon has operated widely on an epithelioma here, removing it by two or more V-shaped incisions, and that he has to restore the lower lip and cover in the greater part of the chin, on one side at least. *The method of taking flaps from the neck* will be given first as on the whole preferable for reasons given below.

Fig. 202. The above show the way in which an epithelioma of the lower lip, whether involving the centre or one angle of the mouth, should be dealt with.

From the apex of the central V-shaped incision one or two curved incisions are carried as in Fig. 198, only on freer lines, down to the level of the hyoid bone and then backwards and slightly upwards to the angle of the jaw. The following points require attention. The flaps must be cut thick enough to carry the facial artery in order to maintain their nutrition. The bleeding will therefore be very free and abundance of Spencer-Wells forceps must be at hand. Further, as the deeper cellular tissue will be opened up every precaution must be taken before, during, and after the operation to keep the wound as sterile as possible. The flap must be raised evenly and without scoring. The lips of the central V-shaped incision are now brought together in the horizontal position to form the new lip, the cut edge of the mucous membrane being sufficiently freed to enable it to be united to the edge of the skin without tension, by numerous horsehair sutures introduced with very fine needles. The edges of the flap or flaps below are then united vertically, at first with stout silkworm-gut and horsehair. But it must be understood that it is only by cutting the flaps on very free lines that tension will be obviated. Drainage should be employed on either side at the most dependent spots. If tension cannot otherwise be met,[1] the lower edge of each curved incision may be undermined to admit of its coming up to the upper edge. Dry dressings of sterile gauze strips kept in place with collodion for all the upper part of the wound may be employed; and a boracic-acid fomentation for the lower part where the drainage-tubes come out.

In the second method the flaps are taken again by freely curved incisions, but here not from the neck chiefly but mainly *from the cheeks*. The two incisions now start not from the apex of the central V-shaped incision but from those at the angles of the mouth. They are carried straight outwards, at first, to the masseter muscle; here they curve outwards and downwards over the mandible and then forwards in the sub-

[1] Cutting wedge-shaped gaps in the flaps (Dowd, Fig. 203) may relieve tension in and facilitate the fitting of the flaps in place.

maxillary regions nearly as far as the hyoid bone. Where the defect is unusually large, the first part of the incision must go beyond the masseter within an inch or so of the auricle before it is curved downwards. It is only by the freest operating that really large gaps can be closed. It is well to make this part of the incision gradually until the mucous membrane is reached. This must be divided horizontally with one cut of sharp scissors on a level higher than that of the skin. This detail prevents somewhat the retraction of the mucous membrane. As the lower part of the flaps are being raised the mucous membrane is again cut first vertically at the anterior border of the masseter, and again horizontally at the line of its reflection on to the gum. Care must be taken in raising the first part of the flaps not to injure the parotid gland. When the flaps have been sufficiently raised they are glided and pulled inwards so

Fig. 263. Operation for removal of epithelioma and restoration of lower lip. The objection to this method is that it opens up the submaxillary regions only. In order to remove the submental glands the tissues over the chin must be turned down. The after difficulty of keeping these up in place may be met in part by suturing them with buried chromic-gut sutures to the periosteum of the mandible. The wedge-shaped incisions (Dowd footnote p. 494) facilitate the meeting of tension, and fitting the flaps in place.

that the edges of the central V-shaped incision meet in the middle line. The same details with regard to freeing the mucous membrane if needful before uniting it to the skin, preserving the blood-supply and drainage, must be observed as in the method first described. In either case the state of the submaxillary and submental lymphatic glands must be cleared up. In both small triangular gaps may be left at the outer ends of the incision. These are closed by skin-grafts. While in the second method it is easier to provide sufficient mucous membrane for completing the new lip, the first method given is preferable. It avoids the scars on the face, the damage to the lower branches of the facial nerve, and by it, it is easier to keep the facial artery intact.

Regnier's Operation. Here the incisions are fewer and the scarring is less, as a large flap, having its nourishment from either side is under-

mined and glided up over the chin from below. The epithelioma is removed, with the greater part of the lower lip, by an incision curving downwards somewhat from one angle of the mouth to the other, nearly to the chin. All bleeding having been arrested, the cut edge of mucous membrane where it passes at its reflection on to the mandible is freed and stitched carefully to the skin to form the edge of the new lip. A free incision about five inches long is made from side to side in the neck, with its centre at a point three or three and a half inches below the middle of the wound by which the lip has been removed. The tissues between the two incisions above and below the chin are now undermined and the broad strap-like flap with its double pedicle, one on either side, is glided upwards over the chin to keep it in position; its lower margin, that which corresponded to the second incision, is sutured with sterilised catgut to the periosteum over the lower margin of the mandible. When the flap has been thus raised a gap is left in the submental region which will, in part at least, require skin-grafting (p. 42).

The advantages of this operation have been mentioned above. On the other hand, where the chin is prominent it is not an easy matter to undermine thoroughly the tissues which form the broad collar-like flap so as to free them sufficiently, at the same time using the knife on a uniform plane without any scoring. Further, in cases where the glands required removal, the submental and submaxillary regions are not opened up as conveniently as by the other methods.

In some cases where the gap is very extensive, where the patient is young, and where it is especially desirable to avoid scars, it may be preferable to resort to the skin of the arm for the flaps required. Figs. 204 to 206 illustate an excellent result obtained with this method by Dr. S. Watts of the John Hopkins Hospital.[1]

A boy aged 15 was admitted July 6, 1904, having had his lower lip, including the periosteum of the mandible in places, bitten off two days before by a circus pony (Fig. 204). The wound was clean and free from infection. A flap, including skin and fat, 12 cm. wide and 18 cm. long, was dissected up from the right upper arm (Fig. 205). Its under-surface and the raw surface of the arm from which it was taken were covered with grafts from the thighs. All these took well, and in ten days the flap was covered with skin on both sides. Some of the skin on this under-surface was intended to form a substitute for mucous membrane, and, to some extent, prevent contraction. Severe bronchitis delayed further operative proceedings for more than a month. During this delay, the flap, which had become much shortened by the sloughing of its distal extremity, contracted greatly. On August 18 the flap, dissected up somewhat further, in order to lengthen it as much as possible, was sutured by its free extremity to the left side of the wound in the lip. A small portion of the vermilion border, which had been preserved on this side, was sutured along the upper edge of the flap. The arm was held in place by a plaster case for about three weeks. The flap was then severed from the arm. This was done under local anæsthesia in several stages, to allow the circulation to become more perfectly established. At two subsequent operations, at intervals of two or three weeks, the lower and right borders of the flap were trimmed and sutured in position. The admirable final result is shown in Fig. 206.

Replacement of Lip. Reference may here be made to those cases occasionally met with in children where, after burns about the upper neck the lower lip and chin are tied downwards by scar tissue. This is another of those instances where, from the site of the area to be operated upon and the age of the patient, a resort to the skin of the arm for one of the flaps required is indicated.

[1] *Ann. of Surg.*, January 1905, p. 118.

Fig. 204.

Fig. 205.

The following case, under the care of Mr. W. H. Brown, of Leeds,[1] indicates the steps that may be resorted to. The paper is accompanied by photographs which show the admirable result achieved. The child was aged 11. To stop the dribbling from the mouth, a cut was made across the throat from angle of jaw to angle, and the head pushed up into the erect position. To close the wound, about three inches wide, which resulted, two flaps were taken from the shoulders and turned inwards to meet beneath the point of the chin. The result of this operation was to rid the patient of all dribbling. To remedy the eversion of the lip, "as there was no available skin on the neck which seemed likely to be of use, a straight incision was made just below the red border, a stitch put through the red border, and the lip drawn up into a natural position. The right arm was then brought across the face and fixed so as to allow of an ample flap being raised from over the

Fig. 206.

middle of the arm, and then laid into the space below the lip. This flap was left attached to the arm and stitched with silk sutures into its new position. A fortnight later the arm was set free from the face, and the flap was found to be living and healthy. The freed edge was stitched down level and the skin cut." The following practical points in the after-treatment of such cases are emphasised. "One is to keep the child quiet by means of small doses of opium for the first four or five days, increasing the dose about half an hour before the first dressing. When possible, it is best to change the dressing for the first time under an anæsthetic. Difficulty of feeding was in this case got over by means of a tube and funnel. She had all her nourishment for a fortnight by this method. Absolute fixation of the head was secured by using large sand-bags on either side of the head with a strong brow band across the forehead."

Restoration of Mouth. This is sometimes required when extreme narrowing follows on an operation for removal of the lower lip, in which the surgeon has been compelled to trench upon the upper, or on cicatricial healing of ulceration due to burns, lupus, noma, &c.

In cases where the margin of the lip is diseased in its whole extent,

[1] *Brit. Med. Journ.*, January 7, 1905, p. 20.

and where, after removal of the disease, the mouth may become too small, a part of the red margin of the upper lip may be utilised in the restoration of the orifice of the mouth (Fig. 207). Sufficient of the vermilion border is detached from the upper lip to allow of the strip thus made loose being

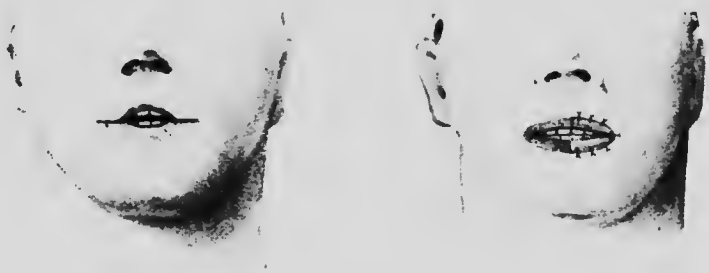
A. B.

FIG. 207. Utilisation of red margin of upper lip for the restoration of the orifice of the mouth. (Esmarch and Kowalzig.)

drawn around the orifice of the mouth and forming an edge for the lower lip without to[illegible].

In other instances the **Method of Dieffenbach** may be employed in these cases (Figs. 208).

This surgeon, so famous for his plastic skill, proceeded somewhat thus: Two lateral incisions are carried from the opening of the mouth through the whole thickness of the cheek, sufficiently far to ensure the new mouth being of proper size. After this the mucous membrane is sufficiently detached (a matter often difficult to secure without causing subsequent



A. B.

FIG. 208. Dieffenbach's method of restoring the size of a contracted mouth. (Esmarch and Kowalzig.)

sloughing, owing to the cicatricial condition of the parts) from the skin to allow of its being stitched as an edging all round the opening of the new mouth. Very sharp knives are especially needed here. The surgeons must particularly aim at securing that the skin and mucous membrane meet exactly at the angles of the new mouth, for if primary union of the skin and mucous membrane be not secured here, recontraction of the new opening will certainly follow. In some cases, instead of dividing the whole thickness of the cheeks by lateral incisions, it is better to dissect off thick triangular flaps of skin and subcutaneous tissue with their bases placed outwards on the cheeks. The scar tissue is next freely divided so as sufficiently to enlarge the mouth. The flaps are then turned

inwards and sutured to the mucous membrane so as to form satisfactory new angles, and prevent any recontraction.

To prevent recontraction Huter has advised the wearing of a dilator made of ebony or hard india-rubber, of the shape of a funnel, with two rims to maintain it in place.

Upper Lip. (i) *Operation of Sédillot by Vertical Flaps* (Fig. 209). Flaps quadrangular in shape are raised by the following incisions: (1) the internal one, starting from a point midway between the angle of the mouth and the lower eyelid, and ending usually at a point on a level with the prominence of the chin; (2) a horizontal one passing outwards from the lower end of the first for half an inch to two inches; and (3) a second vertical incision passing upwards from the outer end of the horizontal one to a point on a level with the ala of the nose. These flaps, comprising the whole thickness of the cheeks, are moved inwards so that their lower extremities meet vertically in the middle line.

(ii) *Operation of Dieffenbach and Chaurel by Vertical Flaps.* Here the flaps are cut in the reverse direction from that of Sédillot. This method is to be preferred

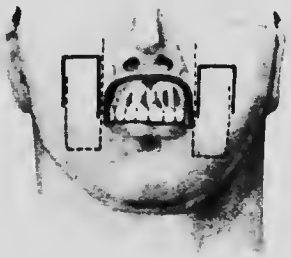


Fig. 209. The dotted lines show the operation of Sédillot, the continuous ones that of Dieffenbach, for making a new upper lip. (After Serre.)

Fig. 210. Restoration of one angle of the mouth. (After Serre.)

as, owing to the base being below, there is less tendency for the new lip to be raised by the contraction of the scar, and thus to expose the upper teeth (Fig. 209).

(iii) *Operation by Lateral Flaps.* Here the flaps are taken laterally from the cheeks. They should be cut of the full depth of the new lip, and at their outer extremities should curve downwards so as to diminish the tension.[1]

(iv) *Serre's Operation for Restoring One Angle of the Mouth.* Fig. 210 shows the steps which would be adapted for restoring one angle of the mouth, which has been distorted by a cicatricial contraction; a similar proceeding being available for a growth in this situation.

Restoration of Defects on the Cheeks (Figs. 211–213). While surgical interference is less frequently called for here than for restoration of the lip, greater difficulties are present. The chief of these are the less mobile condition of the part, the vicinity of the facial nerve and parotid duct, and in many cases the fact that morbid conditions causing cicatricial contraction and fixity are often met with here. The widely different nature of the operative steps required now will be seen when the chief indications for restoration of the cheek are considered, viz. those arising after removal of such growths as epithelioma, and such cases as those after gunshot injury or cancrum oris. In these two last not only is there the deficiency to remedy, but this is probably hide-bound at its periphery, and a varying degree of ankylosis of the jaw is often present as well.

Fortunately these cases are uncommon. Space will only permit mention of two classes of cases. (A) Where there is a large gap and

[1] Dr. Port, of New York, who figures this operation and numerous other methods from Szymanowski (*Handb. d. Chir. Med.*, Braunschweig, 1870), lays stress upon this precaution (*Inter. Encyc. Surg.*, vol. i, p. 489).

little or nothing to be got from the cheek. Such a case results from extensive removal of an epithelioma of the buccal mucous membrane. It is

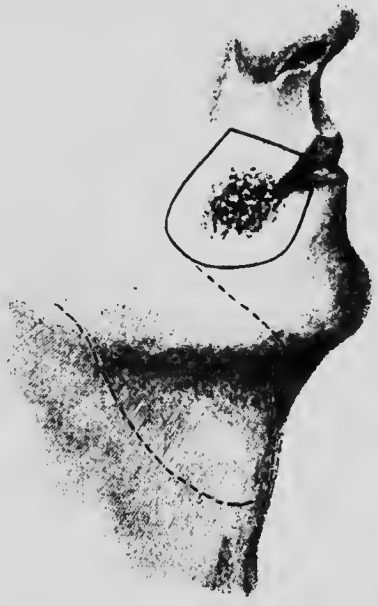


Fig. 211. One method of closing a gap in the cheek by a gap from the neck.

useless in these cases to slit the cheek and then dissect out the epithelioma, leaving the skin. Reappearance of the disease is certain. If any operation is undertaken the whole thickness of the cheek must be widely removed

Fig. 212. Israel's method of closing a gap in the cheek by a flap taken from the neck; this flap may have to reach almost to the clavicle. The flap is reversed, and its outer surface skin-grafted or covered in by a second flap. (Esmarch and Kowalzig.)

The prognosis is always grave, and the gravity increases with the difficulties of the operation the farther back the mucous membrane is involved.

The surgeon who has to fill a large [1] gap in the cheek where the only

[1] Where the gap is a moderate one but too large to admit of being closed by under-

skin left is that fixed above to the malar bone and infra-orbital region and below to the mandible, can take his flap from the forehead or neck. The former skin has the advantage of being hairless, but the resulting deformity is greater. The pedicle of the flap lies here above the root of the nose or the zygoma.[1] If the flap is taken from the neck (Figs. 211 213), the scarring is much less, but the vascularity is not so good, and if the flap contain hairs it must either not be inverted, as hairs will continue to grow into the mouth indefinitely, or, if this is necessary, the pedicle must start well below the jaw so that the flap, which will have to extend nearly to the clavicle, is hairless. A considerable area will thus have to be "jumped" when the flap is sutured in position. At a later stage the pedicle must be divided and the flap trimmed and fitted into its place. The use of double flaps is not recommended, owing to the great interference with soft parts which is entailed in patients whose vitality is often by no means good, and who are not well adapted for prolonged anæsthesia. The surface of the inverted flap should be grafted by Thiersch's method at the time. The wound in the neck will be mainly closed after the edges are undermined, the rest being effected by skin-grafting. As in the case of the lower lip, the question of taking the flap from the arm in suitable cases (p. 498) must be considered.

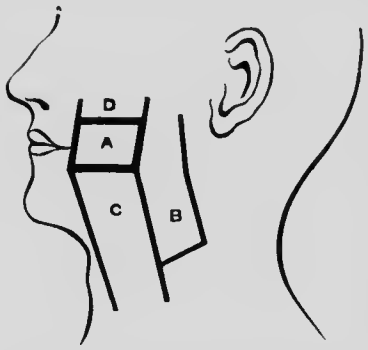


FIG. 213. To show, diagrammatically, one method of closing a defect in the cheek. A, Area involving entire thickness of cheek excised. B, Flap carried up from the neck and inverted so that its cutaneous surface replaced the mucous membrane of the cheek. It was sutured to the gum above and below and adhered readily. C, Flap glided up from the neck to cover the raw surface of B. D, Flap glided downwards for the same purpose. (Haynes.)

(B) In cases where the chief condition calling for repair is not so much a deficiency of skin as cicatricial contraction of the mucous membrane and fixity of the jaw, Gussenbauer's method in two stages should be employed. All cicatricial tissue having been removed and divided and the mouth opened as far as possible, a flap of skin and subcutaneous tissue with its base situated over the masseter, or, if needful, still far back in front of the lobule, is dissected up between this muscle and the gap. It is then turned into the mouth round the anterior edge of the masseter and sutured to the mucous membrane over the internal pterygoid with sterilised catgut on fine curved needles. In about four weeks, when the vascularity of the flap around its edges is assured, the base and posterior part of the flap are dissected up and turned forwards into the remaining part of the gap to form a new angle. It is then grafted or covered with a second flap taken from below the mandible. The objections to double

mining and gliding the edges of the tissues left, a flap may sometimes be taken from the masseteric region with its base near the gap. The flap is turned forwards so that its skin surface looks into the mouth, the raw surface being grafted. This is only applicable to cases where the skin is without hairs. Care must be taken not to injure the parotid gland and duct, and as far as possible, the branches of the facial nerve.

[1] Senn, in a case in which the entire cheek had been removed for epithelioma, turned down a frontal-parietal flap—the patient was the subject of extensive alopecia—so that the skin surface replaced the mucous membrane. A flap from the neck and an additional one from the scalp covered the raw surface and maintained the blood-supply (*Ann. of Surg.*, October 1904, p. 601).

flaps in these cases have been mentioned above. The same assiduous attention will be required as in other cases of fixity of the jaws (p. 112), and Esmarch's modified operation (p. 441) may be required.

In extensive gaps in children, where the confined position is better borne, the flap may be taken from the inner side of the arm, the parts

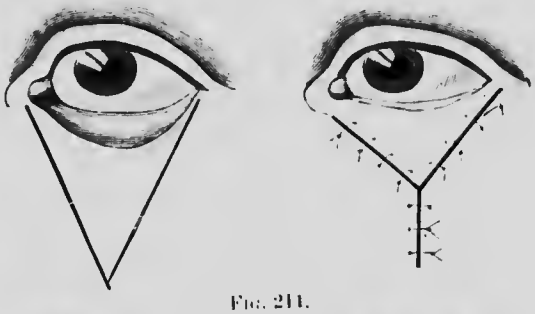


Fig. 214.

Fig. 215.

Fig. 216.

being secured by plaster of Paris (p. 497). In those very rare cases where, after injury or sloughing, the nose, upper lip, lower lids and cheeks have disappeared, a paper by Senn [1] may be consulted. Here a huge flap was taken from the scalp. The operative procedure was divided into about ten stages.

Defects of the Eyelids. Figs. 214, 215 show different methods of curing that troublesome condition known as ectropion. Fig. 216 explains how a growth around the inner canthus may be removed without deformity.

[1] *New York Med. Journ.*, June 20, 1903.

CHAPTER XXIV

OPERATIONS ON THE PALATE

OPERATIONS FOR CLEFT PALATE. REMOVAL OF GROWTHS FROM THE PALATE

OPERATIONS FOR CLEFT PALATE

(1) **Varieties.** The extent of the cleft may vary immensely. Every intermediate stage may be found between a bifid uvula and a complete cleft of both the hard and the soft palate associated with a single or double hare-lip. A cleft of the hard palate without any cleft of the soft palate is rare. The cleft may be narrow or so wide that the palatal processes appear to have developed but slightly. The nasal septum may end freely below or be attached to the palate at one side of the cleft. The results of the deformity are the well-known, nasal, indistinct speech, difficulty in swallowing, and regurgitation of food through the nose. With a complete cleft of the palate and lip an infant is unable to take the breast,[1] a difficulty which, however, can usually be overcome by persevering care and attention. With regard to the voice it may at once be stated that, even when the cleft is neatly closed, the operation is often most disappointing as regards speech. This is due to the fact that the repaired soft palate has lost much of its mobility and hence cannot shut off the naso-pharynx from the buccal cavity. Much depends upon systematic training in improving the speech, which essential part of the after-treatment cannot well be undertaken before the fifth year.

(2) **Age of the patient.**[2] The best age for the operation is still a matter of controversy. Until some fifteen years ago practically all surgeons were agreed that the best time for the operation was about the beginning of the third year. About that date Sir W. Arbuthnot Lane advocated operation in extreme infancy and many surgeons have now adopted his views. Thus Sir W. A. Lane[3] writes: "The best time is the day after birth, or as soon

[1] Cases are very rare in which sufficient food cannot be given by one of the following methods (especially after any coexisting hare-lip has been closed), if only they are perseveringly tried, viz. a small spoon passed well into the back of the mouth; a feeding-bottle with a teat big enough to fill the gap, the teat being perforated underneath for the escape of the milk, only a little being given at a time; an ordinary feeding-bottle with a leaf-like piece of india-rubber attached above the teat, so as to fill up the gap. It is often advisable to take these cases into hospital or a home and put them under the care of a specially trained nurse. The nutrition is usually at once improved, and the mother can be taught to maintain the improvement until the child is about two years old.

[2] The reader should certainly refer to a discussion before the Surgical Section of the Royal Society of Medicine, opened by Sir W. Arbuthnot Lane (*see Proc. Roy. Soc. Med.*, June 1911). The arguments for and against early operation will here be found fully discussed as well as many interesting points about the actual operations and their results. A paper by Mr F. W. Gayler (*Brit. Journ. Surg.*, vol. i, p. 259) may also be consulted. Here the advantages and disadvantages of the flap operation and Langenbeck's operation, and of the early and late operations are carefully and impartially discussed.

[3] *Cleft Palate and Hare-lip*, 1905, p. 42.

after that as possible." Again when opening the discussion on this subject before the surgical section of the Royal Society of Medicine (*see* footnote). "The earliest I have done has been within seven hours of birth. . . . Putting the matter as briefly as possible, early operation saves a large number of lives which would otherwise be lost. Many of the clefts present in those cases can only be closed before the gums are encroached on by the teeth. The sooner the nose is separated off from the mouth the earlier the naso-pharynx is exposed to the influence of the mechanical factors which normally determine the developments of this passage, and of the structures which surround it." The following are, on the other hand, the opinions of other surgeons who have had large experience of operating for this deformity. The late Mr. J. N. Davies Colley [1] stated that when he had the opportunity of choosing the age he preferred fourteen months. Mr. E. Owen [2] gave his opinion that "For a soft palate, the child being in good health, the time for operating is somewhere in the first six months, I think. For a hard and soft palate together it is, I think, in the second year." Mr. G. A. Wright, of Manchester, states: [3] "We are not inclined to attempt closure of a severe case of cleft of both hard and soft palates earlier than the third year at soonest." Mr. R. W. Murray, of Liverpool, prefers, as a general rule, to postpone operating upon the palate until the child is between two and three years of age, and then at one operation to completely close the cleft." [4] American surgeons whose eagerness to make trial of new methods is well known, are not, as a rule, in favour of very early operations, preferring the age of three or four years or later.[5] Finally the opinion of Mr. James Berry in the above-mentioned discussion may be quoted: "The period of choice for the operation he regarded as about two years of age, though there were many cases with narrow clefts which could be advantageously operated upon earlier, some even in the first year of life. It was impossible to mention any age that was suitable for all cleft palate operations; but the difficult ones should be done at about two years of age." The question of the best age for the operation is rendered more difficult owing to the fact that the operation which admittedly gives the best results at the age of two or three years (Langenbeck's operation) is unsuitable, owing to the width of the cleft, in infants, in whom some form of flap operation is necessary.

The arguments in favour of the very early operation are:

(1) That a considerable proportion of the infants born with a cleft palate die before reaching the age of two years, chiefly owing to difficulties connected with nutrition. Surgeons who do not operate until two or three years thus do not operate on the worst cases. On these grounds the early operation is claimed to be a life-saving one.

(2) That in many cases, where the cleft is very wide, an early flap operation affords the only means of closing the cleft.

(3) That an early operation is of importance in the development of the nose, naso-pharynx, and surrounding structures.

Of these arguments the first is by far the most important. The advocates of the late operation, however, deny that difficulty in nutrition

[1] *Trans. Med. Soc.*, vol. xix, p. 70, 1896.
[2] *Ibid.*, p. 68.
[3] Ashby and Wright's *Diseases of Children*, p. 171.
[4] *Brit. Med. Journ.*, vol. i, 1906, p. 245.
[5] *Trans. Phil. Acad. of Surg.*, February 1, 1904; *Ann. of Surg.*, June 1904, p. 1029; *Trans. New York Surg. Soc.*, October 25, 1905; *Ann. Surg.*, January 1906, p. 136.

is a frequent cause of death. Thus Mr. Berry [1] says, "With regard to the question of the early flap operation being a 'life-saving' one, that was a very difficult matter to settle without very careful statistics, which hitherto had never been produced. His strong belief was that the early operation was the very reverse of life-saving. When he saw a young child with a very wide cleft palate and much emaciated, he usually instructed the nurse or mother to feed it carefully and properly until it was better nourished, and then he operated upon it at his own time. If those children were nursed properly he did not find that many of them died. He would be glad to have from those who advocated very early operation some definite statistics as to how many they had done, and how many of the children were alive, not when they left the hospital, but say one year afterwards." Some statistics produced by Mr. C. H. Fagge, who spoke in favour of the early operation, appear to support Mr. Berry's point. Mr. Fagge had operated on thirty-eight infants under one year of age. "One of the thirty-eight died during the palate operation, and two died in the hospital, but the remote mortality was much more alarming, for an effort to trace these patients by correspondence for this meeting showed that fourteen others had died from various causes, of which six were directly or indirectly due to subsequent operations for hare-lip."

The question of the width of the cleft is discussed below, and the possible causes of a fatal result on p. 527.

As is the case in many such controversies the truth is probably intermediate between the two extreme views. It may be granted that a narrow incomplete cleft, involving the soft palate alone, should be closed during infancy. When the cleft is very wide or is complete, the best result will probably be obtained by postponing the operation until the completion of the first dentition, *i.e.* about two years. Should, however, a thorough trial of the methods of feeding mentioned in the footnote on p. 504 not be successful, even after closure of the hare-lip, then the cleft in the palate should certainly be operated upon. Careful observation by the surgeon, and unremitting attention and care by the mother or nurse, are essential in all cases of cleft palate.

(3) **Order of Operation on Lip and Palate.** Another question that has been raised with regard to operations on cases of cleft plate in infants is whether the cleft palate or the hare-lip, which usually complicates the cases, should be taken in hand first. Sir W. Arbuthnot Lane and the other advocates of the early operation on the palate either complete both operations under the same anæsthesia, or leave the hare-lip until the cleft palate is closed. An important argument in favour of this procedure is, that the gap in the lip facilitates the operation for closing the cleft in the palate. If, on the other hand, it is decided not to operate on the palate until the child is two or three years old, the operation on the lip should take place at about the age of two months. If the operation on the palate is postponed for two years the cleft narrows considerably,[2] especially if the hare-lip is operated upon in infancy. These facts are used as arguments in favour of the early and late operations respectively.

(4) **Severity of the Case and Kind of Patient.** It is not so much the extent of the fissure—whether the soft is alone affected, partially or completely, whether that common form in which the cleft involves the

[1] *Loc. supra cit.*

[2] Incomplete clefts, *i.e.* those involving the soft palate and, say, the posterior two-thirds of the hard, do not show this spontaneous narrowing to such an extent as complete clefts, *i.e.* those in which the alveolar process is involved.

soft and a portion of the hard is present, or whether the whole palate is split—that is of importance, as the width of the cleft and the thickness of the tissues which bound it. Sir W. Fergusson was the first who pointed out the influence which the height of the vault of the hard palate has upon an operation for closing a cleft of it. He showed that the higher the vault the more easy is it to dissect down flaps of muco periosteum; while, on the other hand, the less arched the vault, the greater is the difficulty in getting sufficient flaps. Other points of importance are the size of the mouth, a very narrow or small one interfering with the use of the needful instruments; and, finally (a point always to be noted), the length of the palate, for the shorter this is, the more impossible will it be for this to touch the pharynx later on, however perfectly it has been united, and the more marked, consequently, will be the nasal tone of the voice.

Other points of importance, but not connected especially with the cleft, are those which bear upon the general health of the patient—viz. fretfulness, or a sunny temper; coexisting ear disease, or congenital syphilis; whether the child has had the usual illnesses and exanthemata—an attack of whooping cough, scarlet fever, mumps, or measles being likely to interfere with the success of an operation.

(5) **Amount to be Closed at one Sitting.** It is now universally agreed, that unless there are circumstances of peculiar difficulty in the case, the whole cleft should be closed at one operation. When, however, the bringing together of the whole cleft in one operation would necessitate so free a division of the soft parts as to endanger the vitality of the flaps, it is advisable to close first that part of the cleft that can be most easily approximated, whether it be the hard or the soft palate. Thus, if there has been much difficulty in getting the edges of the soft palate together, it is better to leave the anterior part of the hard palate to be closed by a subsequent operation—which can always be done if the posterior part has been closed—rather than to run the risk of spoiling the whole operation by endangering the vitality of the flap. It is far better to make at the first operation a good soft palate than a good hard palate. A hole in the hard palate can always be closed unless extensive sloughing has occurred. It may, on the other hand, be extremely difficult to make a good and efficient soft palate, if the first operation has been followed by a faulty union of this part.

(6) **Preliminary Preparation.** The child should be in the best of health. It is best to keep the patient for some days in the home or hospital before operating, in order that he may become accustomed to the surroundings. Adenoids or enlarged tonsils should be removed several weeks before, any muco-purulent nasal discharge as thoroughly dealt with as possible, and any carious teeth must be attended to as possible sources of infection, and to ensure stability for the gag.

Operation. Langenbeck's operation for a cleft involving both the soft and hard palate is most frequently performed, and thus will be described first.

Langenbeck's Operation. The following special instruments will be required. (*a*) A gag. Smith's gag or some modification of it is very commonly used. It has the disadvantage that the tongue plate is apt to force the tongue back and thus embarrass the breathing. Lane's gag (Fig. 217) is simpler, is easily adjusted and does not slip. If it is used a stout suture should be put through the anterior part of the tongue so that its position is under the control of the operator and the anæsthetist.

(*b*) Cleft palate knives, both double-edged and blunt-pointed. (*c*) Several cleft palate elevators of varying curve and strength. (*d*) Long dissecting forceps, one of which has fine tenaculum or mouse-tooth ends. (*e*) Durham's, or some similar form of cleft palate needle, one curved so as to pass from left to right, and one in the reverse direction: or Lane's small needles with his most ingenious needle-holder may be used. (*f*) Sutures of silkworm-gut, gossamer-gut, and horsehair. Wire sutures are now but rarely employed.

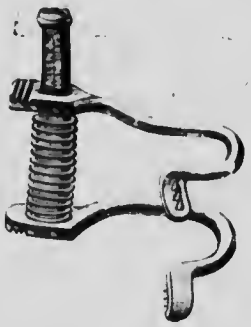


Fig. 217. Lane's cleft palate gag.

The patient's stomach being just empty, so that he shall not vomit during the operation, nor want food immediately after, he is placed on a suitable operating table in a good light. Chloroform or the C.E. mixture is the best anæsthetic. The head is allowed to hang over the end of the table so that it is fully extended on the spine, or the same

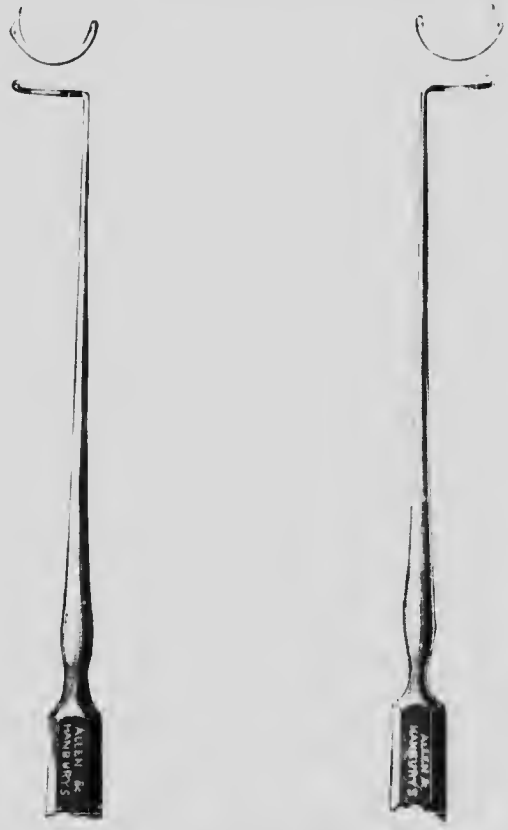


Fig. 218. Durham's cleft palate needles.

position may be secured by a sandbag placed beneath the shoulders. Two points require attention at this stage: (1) The gag should be satis-

factorily adjusted once for all. If Smith's gag be used care must be taken, in fitting the tongue piece, that the base of the tongue is not jammed over the entrance of the larynx. (2) Before commencing the operation the surgeon should assure himself not only that the breathing is regular, but also that the patient is deeply under the influence of the anaesthetic, without abolition of the laryngeal reflex. If this point be secured, without any hurrying at this stage, the subsequent interruptions for the administration of further anaesthetic will be few and brief. The operation may be described in the following stages.

A. **Raising the Muco-periosteum** (Fig. 219). An incision is made, on one side, down to the bone, commencing just behind and internal to the last molar tooth, and is carried forwards, parallel to the alveolar arch, for a distance depending upon the length and width of the cleft. In a short or narrow cleft the incision need not exceed half or three-quarters of an inch, but with a long or wide cleft it may be necessary to extend it as far forwards as the lateral incisor. Care must always be taken to leave a sufficient bridge of tissue in front, or the vitality of the flap may be endangered. Through this incision an elevator, of suitable length and curve, is introduced between the soft parts and the bone, and worked inwards until the extremity appears in the cleft. By movements from without inwards and from before backwards, the muco-periosteum is separated from the bone for the whole length of the cleft; every possible care must be taken to raise the soft tissues evenly and without laceration or button-holing. The chief difficulty will be met with at the anterior end of the bony cleft. If the anterior extremity of the gap reaches as far as a point just behind the incisions, much difficulty may be met with in separating the muco-periosteum here, and the surgeon will do well to be provided with several elevators of different curves. Indeed, it may, in these cases, be better to leave the anterior part of the palate to be closed by a subsequent operation. Again, at the junction of the hard and soft palates, the soft parts are firmly bound down to the former by fibrous tissue. They may best be freed by a pair of curved scissors, one blade being placed under the muco-periosteum, between it and the bone, and the other passed through the cleft, above the soft palate into the naso-pharynx; the fibrous aponeurosis is thus divided close to the bony palate. A third but less important spot where difficulty may be experienced is the attachment of the soft parts in the neighbourhood of the hamular process. Here a curved elevator, a blunt-pointed, narrow, curved knife, or curved scissors — each being kept close to the bone — must be thoroughly used. *The thorough separation of the soft parts, especially at the junction of the hard and soft palate, by relieving all tension on the sutures, and by doing away, probably, with the need of prolonging backwards the lateral incisions, is the key of the operation.* The muco-periosteum having been freed on

FIG. 219. Showing the lateral incisions, and the raising of the muco-periosteum.

one side, that on the opposite side of the cleft is treated in exactly the same manner. While the soft parts are thus separated the hæmorrhage will be free. It, however, can always be controlled and eventually arrested by pressure carefully and firmly applied on the right spot with small sterilised sponges on suitable holders. There must be no unnecessary manipulation of the flaps, and, above all, no bruising of them. Dabbing sponges about needlessly does no good as regards the hæmorrhage, while it is harmful in exciting exudation of mucous and injuring the soft parts. The more the surgeon himself does the sponging the better. He knows how to do it; he sees best where it is required, and his looking to it himself will save additional hands in an already confined space. Sponges on holders should be handed to him, singly, by an assistant, who is kept supplied with them by a nurse. If the blood, in spite of the above precautions, collect in the pharynx, and in spite of careful sponging threaten to obstruct the breathing, the child should be turned right over, and the blood allowed to run out into a basin on the floor. If much blood get into the stomach, it is a certain emetic.

FIG. 220. Paring the edges of the cleft.

B. **Paring the Edges.** The edges of the cleft are then pared in the following manner. The tip of one half of the uvula is firmly grasped by a pair of long dissecting forceps with tenaculum ends. The soft palate is thus made tense and is then transfixed by a sharp double-edged cleft palate knife immediately in front of the forceps, and about one-eighth of an inch from the margin of the cleft. The knife is then made to cut forwards as far as the anterior end of the cleft at the same distance from the edge of the flap. The posterior part of the uvula is then pared by cutting just external to the forceps. The other side of the cleft is next pared in the same manner. The strips which have been cut from the edges of the flaps are now connected alone at the anterior V-shaped end of the cleft. These strips are seized and made tense by the dissecting forceps and the paring of the anterior extremity is complete. It is important that long continuous strips should be removed, as otherwise the paring is likely to be uneven or imperfect. A uniform broad raw edge is essential for success. There will not be much hæmorrhage during the process of paring, and during this and the process of suturing care must be taken to avoid all bruising or crushing of the raw edges, as this will seriously interfere with the subsequent union. The two raised flaps of muco-periosteum should now hang down in the mouth, so that they can be brought together without tension.

Some surgeons prefer to pare the edges before making the lateral incisions and raising the soft parts, but this is largely a matter of individual practice and opinion.

C. **Closure of the Cleft.** The raw edges must now be brought into accurate apposition by sutures of silkworm-gut or of fine gossamer-gut; some surgeons recommend horsehair for the uvula and soft palate. The

first suture should be passed at the junction of the hard and soft palates. The flap to the operator's right hand is made tense by securing the uvula, avoiding the pared surface, with the tenaculum toothed dissecting forceps, and drawing it backwards. A sharp needle, suitably curved, is then by a sudden stab made to transfix the whole thickness of the flap a short distance from its edge. The opposite flap is then made tense in the same manner, and is transfixed by the same needle from the nasal to the buccal surface. A silkworm-gut suture is then threaded and the needle withdrawn, the suture being thus drawn across the cleft. The edge of the flaps should not be held by the forceps for fear of bruising; the needle should always be threaded after the flaps have been transfixed. The suture is not tied at once, but the ends are secured with a pair of clip forceps which may be used instead of the dissecting forceps, for making the anterior part of the flaps tense during the insertion of the sutures in this situation.

Fig. 221. Closing the cleft, showing the sutures in position and the gaping of the lateral incisions.

A second suture is then inserted in the same manner about the middle of the hard palate, and a third about the middle of the soft palate. Other sutures are inserted as required. When three or four are in position they may be tied, care being taken that the edges are everted so that the raw surfaces are brought accurately together. At the anterior end of the hard palate it is usually found, as is sometimes the case through the whole length of the cleft, that the needle cannot be passed in the way described above, without undue tension and pulling on the flaps. When this is so the sutures may be passed in one of the following ways: (*a*) The loop method (Fig. 222). A threaded needle is made to transfix one side of the cleft in the way described above. The loop, which appears in the cleft, is then grasped by a pair of forceps and the needle is withdrawn, leaving the loop of the suture projecting from the nasal aspect of the flap. A second needle, curved in the reverse direction, is then made to transfix the opposite flap from the buccal to the nasal surface. This is also grasped by a pair of forceps and the loop is drawn through the loop of the first suture. The first suture is then withdrawn, bringing the second suture into position across the cleft. (*b*) A curved needle is passed through the edge on one side into the cleft; it is then threaded and withdrawn, and the suture disengaged. A needle with a reverse curve is then passed similarly through the other side and threaded with the end already passed; this is then drawn through the second side by removing the

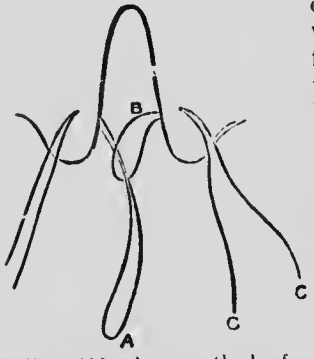


Fig. 222. Loop-method of passing sutures. (Mason.)

needle, the suture being thus brought across the gap. (*c*) The sutures may be passed with Lane's small cleft palate needles and needle-holder. The tip of the right half of the uvula is lightly held with forceps, and the fine needle, threaded with the finest silkworm-gut, is passed from below upwards and brought out into the cleft; the needle is released from the holder and drawn through. It is then readjusted in the holder, the tip of the left half of the uvula is similarly held on the stretch, and the needle passed again into the cleft and brought out from above downwards, transfixing the left half of the uvula.

Attention should be paid to inserting the sutures at a sufficient distance from the edge and a due distance from each other so as to equally distribute amongst themselves any tension that may be present. In passing a suture, the needle-point should be quickly stabbed through at the

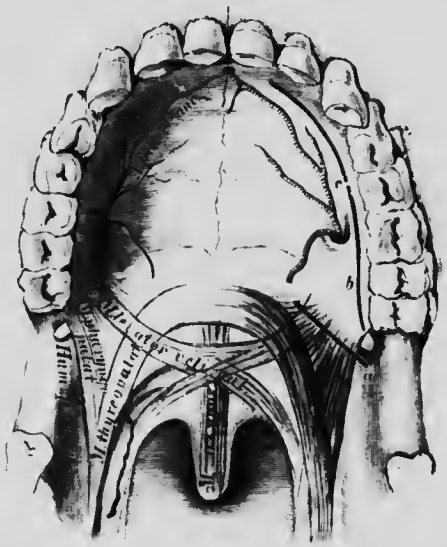


FIG. 223. The chief parts concerned in the operation for cleft palate, the lateral incision *b*, *c* through the mucous membrane, and that for division of the muscles, *a*, are shown (v. Esmarch and Kowalzig). The last incision is largely replaced on the Continent by detaching the hamular process after Billroth's method. The chisel is introduced upwards and inwards, and the dislocation of the process completed with an elevator.

intended spot. The surgeon must make sure that in all cases the edges are everted so that the raw surfaces are brought together.

D. **Relief of Tension.** Should there be any tension when the suturing is completed, the lateral incisions should be prolonged. It will generally be found necessary to continue them backwards just internal to the hamular process. Any hæmorrhage is arrested by firm but gentle pressure.

Operation on the Soft Palate. When the cleft involves the soft palate alone it is usually narrow, and the operation is much simplified. It is carried out on the lines described above in the following stages. (*a*) Paring of the cleft. (*b*) Suture of the raw edges. (*c*) An incision on each side just internal to the hamular process to divide the muscles and to relieve tension.

Operation on the Hard Palate alone. This will be called for in those rare cases where the cleft involves the hard palate only, and in those where

the cleft in the posterior part of the palate has been successfully closed, while the anterior part of the cleft has broken down or its closure not attempted. The operation needs no special description, as it is carried out in the way described above. Lateral incisions will always be required to raise the muco-periosteum from the bone.

The after-treatment and the causes of failure are considered on p. 525.

Davies-Colley's Flap Method for Hard Palate (Figs. 224–226). This was first published by its inventor in the *Brit. Med. Journ.*, October 25,

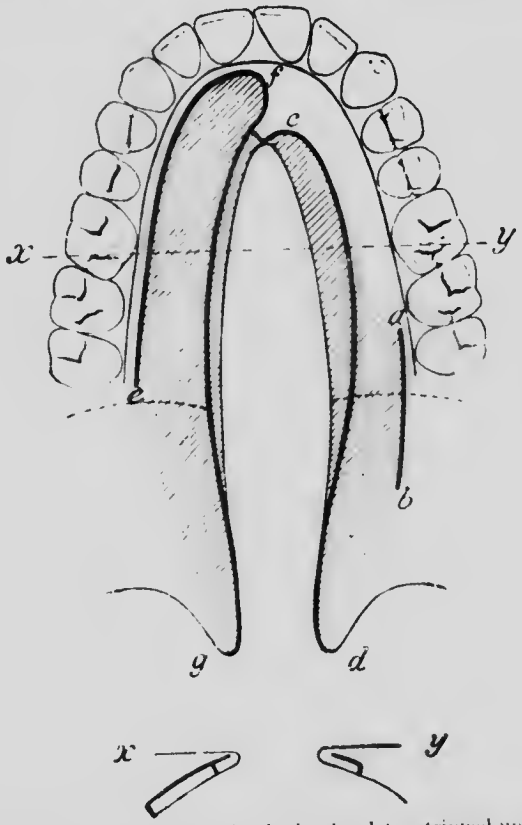


FIG. 224. The shading indicates, in the hard palate, stripped-up periosteum; in the soft palate, the stripping into two planes. The lower figure represents diagrammatically a transverse vertical section through the hard palate along the line *x y*.

1890, and recommended as applicable (1) in infants; (2) in cases where the ordinary operation had failed; and (3) in cases in which the cleft of the hard palate was too wide to be bridged over by the ordinary operation. The late Mr. Davies-Colley afterwards published his method in a modified and extended form.[1] It may be divided into the three following stages:

"*First Stage: that of Incision and Separation of the Muco-periosteum* (Fig. 224). The patient being under an anæsthetic, and the jaws held open by a Smith's gag—(*a*) an incision, *ab*, is made from before backwards about an inch long, with its centre just internal to the last molar

[1] *Trans. Med.-Chir. Soc.*, 1894, vol. lxxvii, p. 236.

tooth. It should go down to the bone in front, and behind it should pierce the soft palate. Through this incision a raspatory is introduced, and the soft parts separated inwards from the posterior half of the hard palate, much as in the ordinary operation, but not to such an extent.

"(B) An incision, *cd*, is carried on the same side from just in front of the cleft, and at a distance of about a quarter of an inch from its margin, backwards to the junction of the hard and soft palate. As it approaches the soft palate the incision should converge to the edge of the cleft, and it

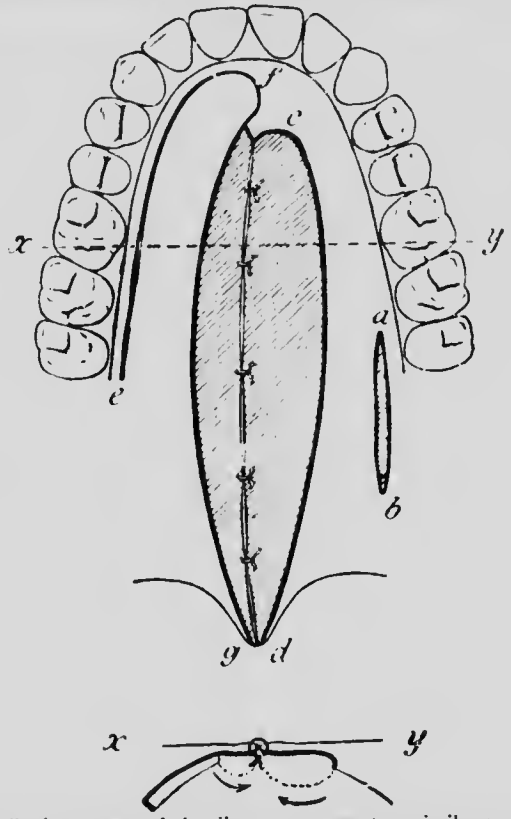


FIG. 225. The lower part of the diagram represents a similar section to that shown in the preceding figure. The arrows indicate the direction in which the muco-periosteum of the margins of the cleft is reflected inwards.

should be continued along the edge of the soft palate in such a way as to split that structure to the depth of about three-eighths of an inch. For this purpose the knife should be lateralised, and as the knife approaches the uvula a forceps will be required to hold the uvula steady while it is being divided. At this part the incision must not be quite so deep, in order to avoid the complete division of the lateral half of the uvula. The soft palate near the cleft will now consist of two planes—a lower one which is continuous with the band of muco-periosteum between the two incisions, *ab* and *cd*, and an upper one attached to the back of the hard palate. The muco-periosteum internal to the incision, *cd*, should be separated inwards from the bone until it is left attached by the soft tissue which covers the margin of the cleft of the hard palate.

"(B) A large flap, *efg*, of somewhat triangular shape, but with the front angle rounded, should be taken from the other side of the palate. One side of the flap, *ef*, runs parallel to and a sixth of an inch from the insertions of the teeth from the last molar to the median incisor; the other, *fg*, runs backwards at a distance of a sixth of an inch from the margin of the cleft of the hard palate, and continuous with a splitting of the soft palate similar to that upon the other side, and reaching as far back as the tip of the uvula. The muco-periosteum of the triangular flap should

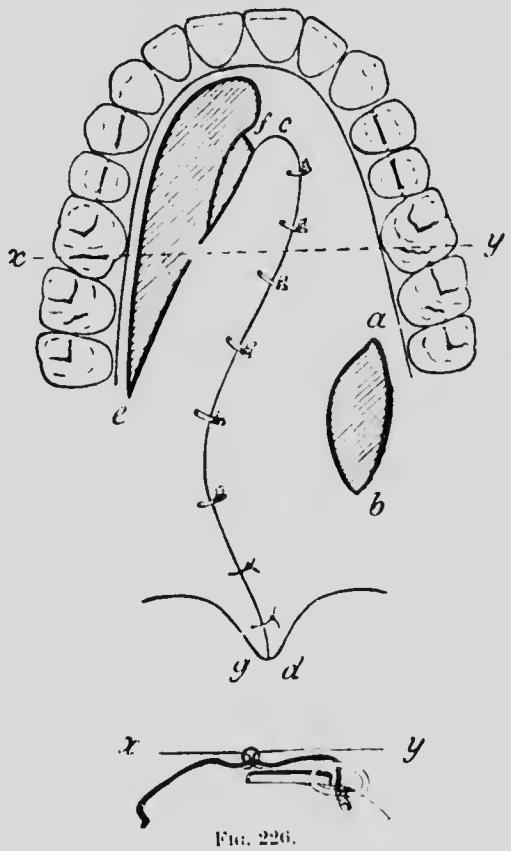


Fig. 226.

also be separated from the hard palate by means of the raspatory, and, finally, that which lies internal to *fg* should be separated inwards, until it is only attached to the margin of the cleft.

"*Second Stage: the Union of the Mesial Flaps and the Upper Planes of the Soft Palate* (Fig. 225). By means of an ordinary palate-needle, with the curve at the end in a plane at right angles to the stem five sutures of silk or catgut are passed through the edges of the flaps internal to *cd* and *fg*, care being taken to turn the flaps inwards so that their mucous covering looks upwards and their raw surface downwards. Continuously with this union the edges of the upper plane of the soft palate on either side must be brought together in the same way. From

four to six sutures are necessary for this stage. When it is completed the whole cleft of the hard and soft palate should be bridged over by a layer of muco-periosteum and soft palate tissue, with the raw surface looking downwards.

"*Third Stage : Union of the Triangular Flap and the Lower Planes of the Soft Palate* (Fig. 226). With the same needle sutures of soft silver wire are now passed in the ordinary way so as to draw over the margin *fg* of the triangular flap to the outer edge of the incision *cd*, on the other side. At the same time the margins of the lower planes of the split soft palate are brought together in the same way. About six wire sutures are necessary, and two silk or horsehair sutures may be used for the approximation of the uvula and the adjacent parts of the soft palate. There will now be a second complete bridge across the cleft, but in this bridge the mucous surface will look downwards, while the raw surface will look upwards and be in contact with the raw surface of the first bridge.

"The incision *ab* gapes widely, and may have to be increased in size, especially at the expense of the muscular tissue of the soft palate, in order to allow the edges to come together without tension.

"The after-treatment is similar to that which is usual after the ordinary operation. An interval of at least three weeks, and sometimes as many as six weeks, should be allowed before removing the sutures of the third stage, while those of the second stage have to be left to come away as they can or to be absorbed.

"There is so little tension, that if primary union should fail, secondary union would probably take its place. For a short time a raw surface is left in the opening made by the gaping of the incision *ab*, and on the other side over the space previously covered by the triangular flap ; but these surfaces soon get covered with granulations, and give rise to no trouble or deformity."

Flap Method of Sir W. Arbuthnot Lane. Sir W. Arbuthnot Lane [1] considers that "The best time for operation is the day after birth, or as soon after that as possible. The newly born child is always healthy, the capacity of its tissues for repair being at the very best, its digestion has not been impaired by experimental and usually most unsatisfactory feeding, and its resisting power reduced correspondingly ; it is apparently uninfluenced by the operation in that it does not cry or show evidences of being in pain ; it is never or hardly ever sick after the anæsthetic, but takes its food within an hour or two of the completion of the operation with apparent enjoyment ; the loss of blood is very slight, being usually much less than in the case of a circumcision, and the risk to life is under ordinary conditions very trivial indeed."

"The general principle on which most of the operations are based is that of raising from the roof of the mouth on one side of the cleft, a flap, which consists of the mucous membrane, submucous tissue and periosteum of the roof of the mouth, and when this flap extends over the alveolus, care is taken to avoid unnecessary damage to the subjacent teeth. This can only be done efficiently very soon after birth. In early infancy it is possible to provide a well vascularised thick flap, which is practically three times as broad as can be obtained when the teeth have begun to encroach materially on the mucous membrane or to perforate it, since the muco-periosteum covering the under and outer surface of the alveolus can be made to form the outer two-thirds of the flap.

[1] *Cleft Palate and Hare-lip*, 1905, p. 42 ; *Clin. Lect.*, p. 15.

"In performing the operation the child is placed under an anæsthetic, a thread is passed through the tip of the tongue by which traction can be efficiently exerted." Sir W. Arbuthnot Lane uses his toothed gags made in pairs. Several sizes should be at hand. His needles and needle-holder are shown in Fig. 227.

"The manner in which the flap is formed from the muco-periosteum on one side and is fixed beneath the separated muco-periosteum lining

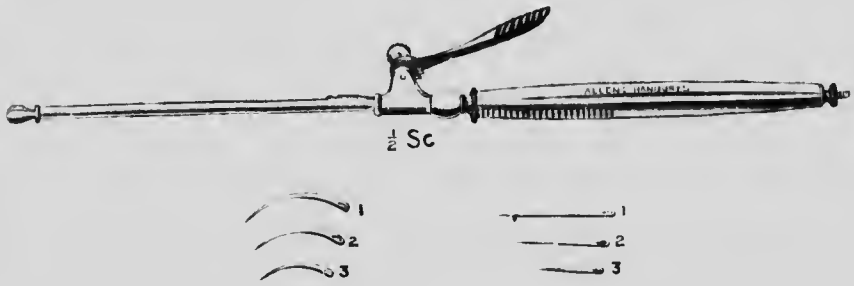


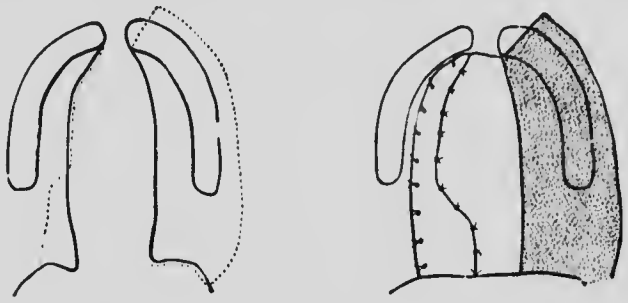
Fig. 227. Lane's needle-holder and needles.

the roof of the mouth on the opposite side is of the cleft in an edentulous infant represented in Figs. 228, 229.

"In the soft palate, the flap which is raised comprises all the soft parts down to the tensor palati, and may be made as extensive as necessary by encroaching on the cheek if there is not enough material in the remains of the soft palate. On the other side of the cleft, the muco-periosteum is divided along its free margin till the soft palate is approached. The extremity of the uvula or its relic is picked up with forceps, and an incision made outwards from it along the free margin of the palate for some distance, and from its outer limit another is carried forwards and inwards along the upper part of the soft palate to reach the posterior limit of the incision running along the free margin of the hard palate. The triangular flap of mucous membrane and submucous tissue intervening between the two incisions described and the margin of the cleft in the soft palate is raised off the subjacent muscles and turned inwards, and the raw surface left by doing so is increased in area by turning outwards a further portion of the mucous membrane covering the soft palate externally. By this means the area of the upper surface of the soft palate, rendered bare by the removal of its mucous covering, is rendered much greater than before. By means of a stout steel elevator introduced between the muco-periosteum and the bone through the incision made along the margin of the cleft, the muco-periosteum is raised from the bone up to the inner margin of the alveolus. The flap whose edge is attached along the margin of the cleft is placed beneath the flap which has been raised from and for a considerable distance beyond the margin of the cleft, and is pinned down by fine curved needles and 0000 Chinese

Fig. 228. Showing the flap raised and fixed in position. In this case the cleft is not of sufficient breadth to render it necessary to strip the alveolus of its covering of mucous membrane. (Lane.)

twist silk in this position by a number of sutures which perforate the free margin of the reflected flap and the outer part of the elevated flap, the knots being tied on the under surface of the latter, whence they can be removed with facility when the opposing surfaces have united firmly, which they do in about ten days. Then the free margin of the raised



A. B.

Fig. 229. A, A cleft of a breadth sufficient to require the employment of a flap from the entire alveolus. The dotted lines indicate the incisions, that to the left of the cleft being on the nasal surface of the palate, while that on the right is on the buccal aspect. (Lane.) B, The flaps sutured in position. The shaded area represents the surface laid bare by the removal of the flap. (Lane.)

flap is attached by separate sutures to the raw surface of the reflected flap. Finally, the opposing edges of the free margin of the soft palate are united in a similar manner.

"In Fig. 230 I have attempted to indicate diagrammatically the details of the method I have described. It is intended to represent the mouth of an infant, showing a broad cleft involving almost the entire palate. The position of the alveolus is indicated by the three crosses, xxx. 1 represents the incision which extends forwards and outwards through the mucc-periosteum from the anterior limit of the cleft, and which passes over and beyond the alveolus to its outer surface, while 2 commences at its outer limit and runs back along the outer surface of the gums about the junction of the cheeks and alveolus. An incision, 3, is then made from its posterior extremity along the free margin of the palate to the uvula. The flap included between these incisions is raised from the subjacent structures, a specially designed small knife or a carefully constructed pair of sharp-pointed scissors being used for the purpose. As the posterior palatine foramen is approached, an elevator pressed in between the flap and the bony palate causes the posterior palatine vessels and nerves to protrude for a considerable length in a tube of periosteum. This is readily grasped by a pair of efficient compression forceps and divided beyond.

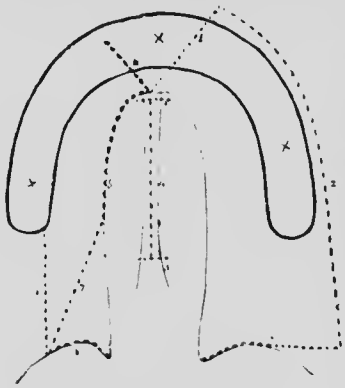


Fig. 230.

"It happens not uncommonly in the type of cleft palate illustrated by Fig. 230 that the septum presents a free margin which extends almost, if

not quite, to the level of the cleft. In these cases I make an incision, 4, through the mucous membrane and periosteum or perichondrium along the middle line of the septum with two small traverse incisions, 5, at either end, and turn down laterally the narrow flaps so formed, leaving the cartilage or bone bared or exposed. By placing the flap which has been raised, in position, the line along which it will rest on the septal margin can be readily defined. With a sharp knife the surface of the reflected flap is denuded of its covering mucous membrane along the area of impact. By a series of sutures perforating the superjacently imposed flap and the margin of the septum if it be not too hard, or the flaps of muco-periosteum if the edge be bony, the reflected flap is pinned to the septum; 6 in Fig. 230 shows the incision along the free margin of the cleft continued as 7, obliquely outwards and backwards along the upper surface of the soft palate. The incision 8 extends from the posterior limit of 7 along the lower free margin of the soft palate to the tip of the uvula, and the incision 10 forwards and outwards from the anterior limit of 6 on to the

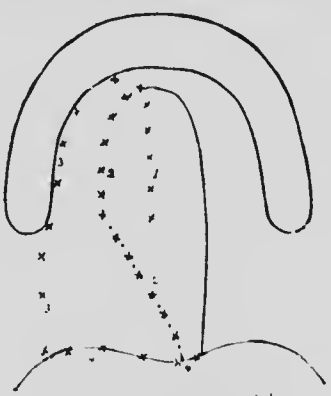


Fig. 231. Flaps in position. (Lane.)

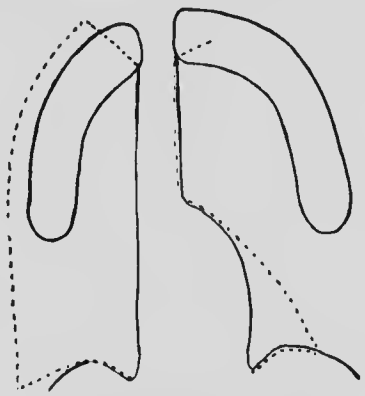


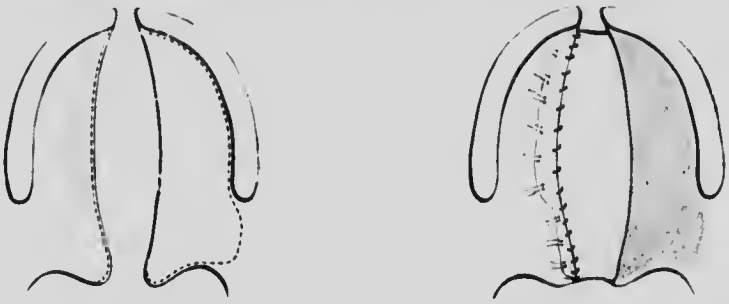
Fig. 232. Flaps for a common type of cleft palate. (Lane.)

alveolus. This last incision facilitates the raising of the flap on this side, and of the introduction beneath it of the reflected flap from the opposite side. After the muco-periosteum external to the incision 6 has been raised from the bone, the soft palate is freed from the posterior margin of the hard palate, and the mucous membrane on its upper surface turned outwards to the position of 9.

"In Fig. 231 the flaps are shown in position. The sutures along the line 1 represent those attaching the septum to the reflected flap. Those along 2 show the sutures which unite the free edge of the raised flap to the under surface of the reflected flap; those along the line 3 anchor the edge of the reflected flap, and those along the line 4 connect the flaps where they form the free margin of the new soft palate.

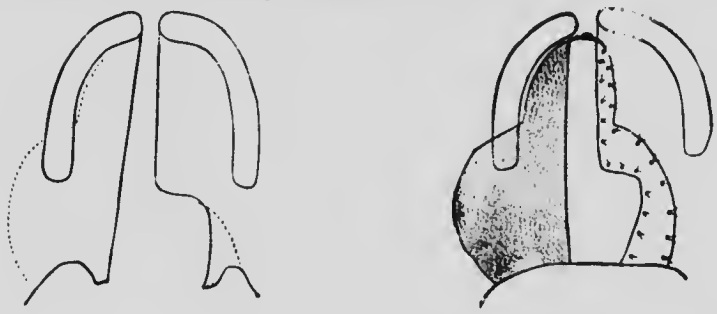
"Another common type of cleft palate is that illustrated in Fig. 232, the cleft in front being to one side of the middle line extending from between the septum and a portion of the roof of the mouth, while posteriorly the cleft in the soft palate is fairly symmetrical. As the mucous membrane is always very thin where it covers the septum and the adjacent portion of the roof, the flap must be reflected inwards from the narrow or less developed side and raised outwards from the septum, the narrower

flap being fixed beneath the muco-periosteum covering the broader side of the roof of the mouth.



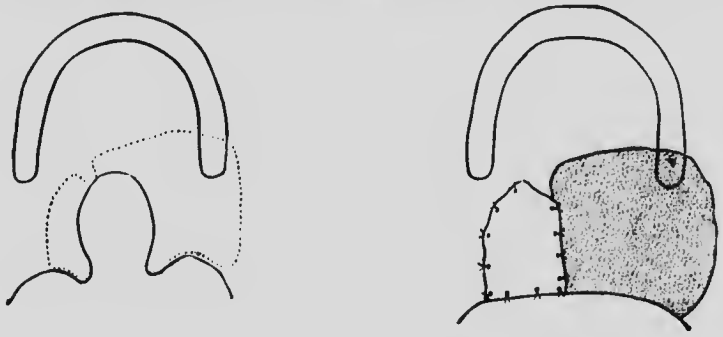
A. B.

FIG. 233. A. A complete cleft of the palate. The dotted lines indicate the incisions, and the shaded area the portion of muco-periosteum elevated from the subjacent bone. (Lane.) B. The flap fixed in position by a double row of sutures. The shaded part shows the surface of hard palate stripped of muco-periosteum. (Lane.)



A. B.

FIG. 234. A. A common form of cleft. The dotted lines on the nasal aspect to the right of the cleft and on the buccal aspect to the left of the cleft indicate useful incisions. (Lane.) B. The flaps in position and sutured. (Lane.)

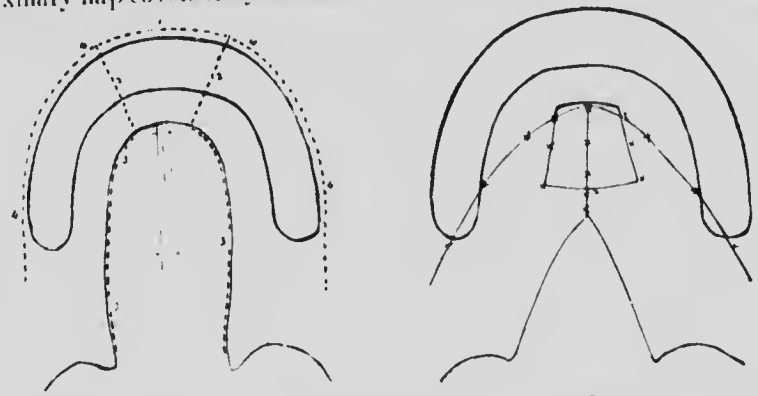


A. B.

FIG. 235. A. The dotted line to the right of the cleft represents the incision along the buccal aspect of the palate, and that to the left the incision along the pharyngeal aspect. (Lane.) B. The flap sutured in position.

"Figs. 233, 234 show the forms of flap when the teeth have come through the gum, or when a sufficient flap can be obtained without encroaching on the gum, and Fig. 235, the manner in which the cleft

in the soft palate is closed. Associated with a complete cleft of the palate there is often a displacement forwards of the pre-maxilla, which is attached to the under surface of the septum beneath the tip of the nose. I have found it best to divide the mucous membrane along the limits of the pre-maxilla, laterally and posteriorly avoiding any interference with the soft parts in front. The muco-periosteum is separated from the subjacent pre-maxilla and is reflected forwards. The pre-maxilla is cut away from the septum by means of biting forceps, the edge of the septum being nicely trimmed and rounded. This flap, which consists of a mesial relic of lip and muco-periosteum, is opened out when it covers a considerable area. Its margin is attached by sutures to the raw under surface of the reflected flap and to the raised flap, which is rendered raw where the pre-maxillary flap covers it by the removal of its epithelial covering by means



A. B.

FIG. 236. A, Flaps for a very wide cleft. (Lane.) B, Flaps in position. (Lane.)

of a sharp knife. In this way the gap between the alveolar segments is filled up very advantageously, and later, when the cleft in the lip is closed, the mesial relic of the lip serves to complete the septum and to afford attachment to the lateral margins of the cleft.

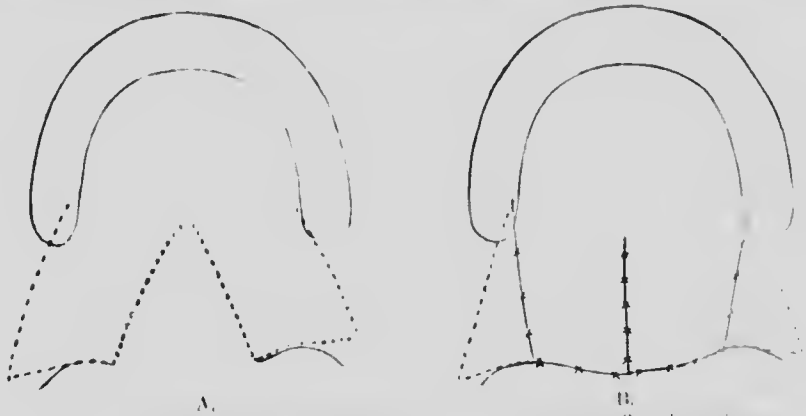
"It happens not infrequently that it is impossible to close the whole length of the cleft by one single operation.

"Fig. 236 illustrates such a condition. The cleft is a very wide one, and it is impossible to close it by the reflection of the flaps in the manner described. An incision is made along the entire aspect of the gum along the line indicated by 1. Two are made along the direction of 2, and two others along the free inner margins of the cleft. The flap included between 1 and 2 on either side is turned back, great care being taken of its attachment, which is usually very thin. The flaps comprised between 1, 2 and 3 are raised from before backward, care being taken to avoid any damage to the descending palatine vessels. These flaps are then displaced inwards, as in Fig. 236B, their opposing margins being sutured together and to the subjacent flap, and if possible to the septum also.

"At a later period the posterior portion of the cleft may be closed in one of two ways, the method varying with the breadth of the cleft and the extent of material at disposal. The first and more generally applicable method is by reflecting a flap inwards on one side, leaving it attached by its inner margin, the other flap being rendered raw on its posterior surface

and its area extended as in Fig. 235. The second method is to reflect a flap inwards as before, while the flap from the opposite side is raised from the subjacent parts by an incision extending along its inner, posterior, and outer margins, so that it pivots anteriorly as in Fig. 237 and can be made to cover the flap reflected from the opposite side. Or, both flaps may be made to pivot upon their anterior attachments, their internal edges are sutured carefully together, the outer free margins being anchored wherever a suitable attachment can be found. The free inner margins of the cleft are also pinned down to the subjacent flaps by sutures.

"In Fig. 237 I have indicated the mode of closure of the back of the cleft by raised flaps, the outlines of which are represented as dotted lines, and in Fig. 237B the suturing of the raised flaps on both sides in



A. B.

FIG. 237. A, Flaps for closure of back of cleft. (Lane.) B, Flaps in position. (Lane.)

position. In order to avoid confusion, the knots of the sutures which attach the inner margins of the cleft to the superjacent flaps are not indicated in this diagram.

"In this diagram the outlines of the flaps are represented as firm lines, the dotted lines representing the position of the incisions, and the raw portions of the area deprived of mucous membrane, and more over the flaps, which have been brought inwards so as to oppose their margins.

"As regards the treatment of the infant after the operation, no change whatever in diet is adopted, and no attempt made to wash or spray the interior of the mouth. Measures are taken to ensure that the hands cannot be introduced into the mouth. At the end of about nine or ten days the stitches are removed. Should a cleft of the soft palate, that of the palate, the former is closed as soon as the latter has been dealt with, never before. In most cases I perform both operations under a single anæsthesia."

The Flap Operation and Langenbeck's Operation compared.[1] The chief advantages claimed for the flap operation are: (1) It can be used for closing very wide clefts in infancy. (2) No tissue has to be pared away. (3) A much larger extent of raw surface is brought into close

[1] *See also* the remarks on p. 505.

contact than by Langenbeck's operation. (4) The tension, at any rate in the lower bridge cutting the vessels of the hard palate, is much less. (5) Whereas, in Langenbeck operation the pressure of the tongue tends to tear apart the slender line of raw surface which has to unite, in the flap operation the pressure is beneficial, as it keeps the raw surface of the two bridges in close contact. (6) The early flap operation is necessary for the proper development of the nasal passages and the naso-pharynx.

The following are the chief disadvantages of the early flap operation:—

(1) The mortality is not what might be expected from the greater severity of the operation and the age of the patient, is greater. In Sir W. Arbuthnot Lane's series of cases it was 5 per cent. The question of the early operation being a life-saving one and of the late mortality, have already been touched upon.

(2) The resulting palate is thinner, less symmetrical, and more narrow; hence the soft palate is less mobile than after Lane's or Langenbeck's

A B

Illustrations of A. Lane's methods for closing a cleft in the soft palate.

operation. As the result of this the defective speech is less likely to be improved.

(3) Mr. James Berry[1] has pointed out another disadvantage, viz. that the flaps may undergo atrophy, even to the reappearance of a perforation, sometimes after the operation.

(4) The flaps taken from the gums may [illegible] the tooth follicles.

Brophy's Operation (Figs. 239, 240). Brophy, surgeon-dentist, of Chicago, operates on the palate first, and deals with the cleft by thrusting the maxillary and palate bones together. As it has not been received with favour in this country it will only be briefly described here. It is a much more serious operation than those already described, one of which will be suitable for cleft palate of any degree or extent. There is a very heavy mortality, and, in addition, there is a considerable possibility of necrosis of the jaws—a very grave complication in young infants. It was first introduced into this country by Mr. Owen. The following description of the operation is taken from "Cleft Palate and Hare-lip," p. 47. The child operated on by Mr. Owen by this method was three months old, the cleft a broad one communicating into the right nostril. The vomer was adherent to the palatal process of the left maxilla.

"The operation was begun by paring the edges of the cleft, and after this I tried, but ineffectually, to thrust the maxillæ towards each other by firm pressure with the fingers and thumb. Next I raised the cheek, and, with a knife, towards the

[1] *Loc. supra cit.*

posterior extremity of the hard palate, just behind the malar process, and above the level of the horizontal process of the palate bone, drove the end of a strong needle on a handle through the substance of the maxilla. This needle carried a

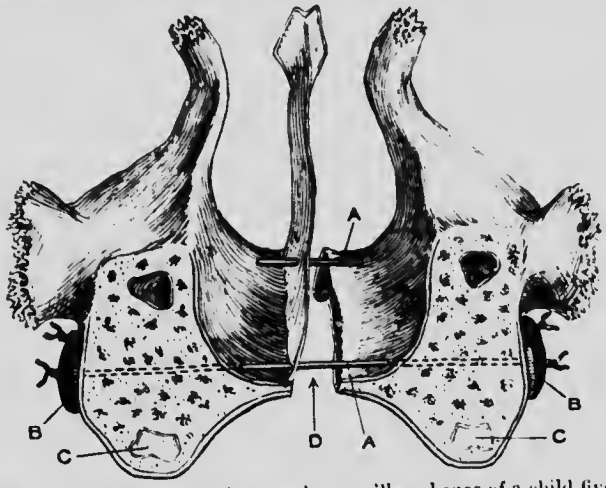


Fig. 239. Vertical section of the superior maxillary bones of a child five weeks of age, showing congenital cleft palate. A A, Silver wire tension-sutures. B B, Lead plates. C C, Germs of the first temporary molar teeth. D, Cleft palate. (Brophy.)

thick silk pilot-suture through to the cleft, where its loop was pulled down towards the mouth. Then the needle was similarly passed through the opposite maxilla, the loop being brought down as before. The second loop was passed through the

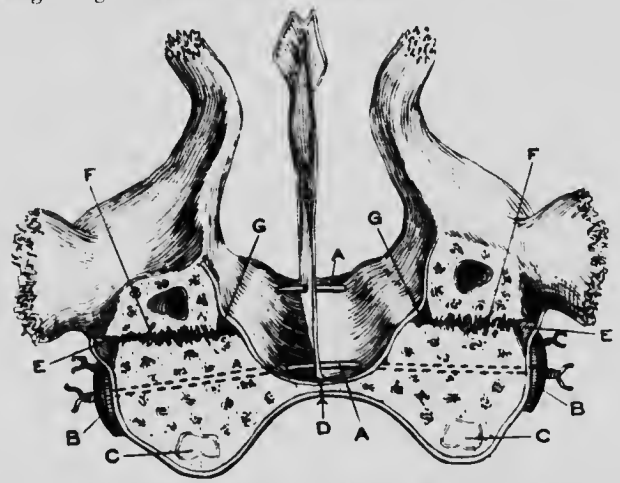


Fig. 240. Vertical section similar to that in Fig. 239, showing method of closing cleft of hard palate. A A, Silver wire tension-sutures. B B, Lead plates. C C, Germs of first temporary molar teeth. D, Cleft closed. E E, Muco-periosteum, forming external wall of the triangular space made by forcing the lower fragments of the bone inward. F F, Lines of fracture made by approximation of the palatal processes. G G, Triangular space on nasal surface of bone made by approximation of the palatal processes. (Brophy.)

first, which, being drawn upon, was made to bring the second loop through both of the maxillæ and across the nasal fossa, above the level of the hinder part of the alveolar processes. The sharply-bent end of a silver wire was then hooked on to

this loop, and by pulling back the latter, the wire was made to take its place. The wire suture thus lay above the horizontal processes of the palate-bones, where it could be seen through the cleft. Similarly, a wire suture was taken through the maxillæ above the front part of the cleft. Two small, oblong, leaden plates, with a hole drilled near each end, had already been prepared, and one of them was then laid along the outside of the right maxilla, under the cheek, the end of the hinder wire being passed through the posterior and the end of the front wire through the anterior hole. The right ends of the wire were then twisted together from left to right, the plate being closely applied against the maxillæ, after which the ends of the wire were pressed down flat. The ends of the wire under the left cheek were then similarly treated, and, as they were being twisted up, the maxillæ were squeezed together, or, rather, another vigorous attempt was made to squeeze them together. But I could not move them. So, in accordance with Dr. Brophy's method,[1] I then incised the mucous membrane over each malar process, and, introducing a scalpel, divided the ma . lae sufficiently to enable me to thrust their palatine processes into the middle line. After this it was at once seen that the width of the gap in the lip had been greatly reduced, and that the lateral halves of the palate were brought closer together. Fine wire sutures were then passed through the freshened borders of the entire cleft.

"When the maxillæ have been thus thrust together, the wires extending between the leaden plates have to be tightened up and again twisted. These wires and plates are not disturbed for three or four weeks. Some superficial ulceration sometimes takes place beneath the borders of the plates, but it is of no importance. The wires and plates may be removed after about the third week. The infant was very ill for two or three days, and the union of the sutured borders was only partial, but the front of the cleft was solidly closed, and a useful bridge held securely at the junction of the hard and soft palate. Ultimately the cleft was completely closed by four supplementary operations. The lip was dealt with about two months later. The whole result was admirable."

After-Treatment. When the child is put back to bed, warmth should be applied by hot bottles. The side position is best at first, that blood may trickle out of the mouth. When the risk of vomiting has passed a little ice may be given. The hands should be secured for the first few days. For the first forty-eight hours milk with ice or barley-water only should be allowed. After this, yolks of eggs, arrowroot, broths, soups, and (in about ten days) light puddings, jellies, may be allowed. If the patient's temper and intelligence allow of it, the mouth may be regularly syringed or washed with Condy's fluid or boracic-acid lotion. In other cases it is best to leave the wound quite alone. The nurse should devote herself to preventing the child from crying, and to keeping the patient amused. Whenever it is possible the child should be taken into the fresh air after the first two or three days (Owen). There should be no hurry to remove the sutures, which, if not of silk may remain for seven or ten days in the soft and an almost indefinite time in the hard palate. No one should be allowed to look at them either early or often. To prevent the child getting the fingers into the mouth it is well to mould felt splints in front of the elbow-joints. These will allow of movements of the hands and use of toys.

To make this subject of after-treatment at all complete a few words must be said about the improvement of speech after the cleft has been surgically cured, and the occasional need of an obturator. Even after a complete closure of the cleft much awkwardness of speech is liable to remain, this being, of course, the more marked the older the patient is.

[1] Dr. Brophy's words on the point are: "If we are unable to close the fissure with these wires, if from lack of tissue or from firm resistance of the parts it cannot be done, there is a further method to be employed which will obviate these difficulties. With your knife, after the cheek is well raised, divide the mucous membrane just over the malar process. Here insert a knife in the horizontal direction dividing the bone freely, but damaging the mucous membrane as little as possible."

Parents are often to blame for the little trouble they will take to further the success of the surgeon's efforts, and this refers in many cases to those who have not the excuse of the ignorance and toilsome life of the poorer classes. They too often act as if, because the cleft is closed, no further responsibility rests with them. Again, the patients, being usually children, without a thought as to the future, and satisfied with the improvement in their deglutition, present many difficulties. Not only has the child to be taught the right way of using its organs of speech, but wrong habits, especially nasal and guttural tones, have to be unlearnt. This is only to be brought about by means of systematic lessons and practice gone through regularly day by day for months and even years. No plan will be found better than that recommended by Mr. W. Haward, Clin. Lect., "On Some Forms of Defective Speech":[1] "The instructor should sit directly facing the pupil; the pupil is made to fix his attention thoroughly upon the face of the teacher, and to copy slowly his method of articulation. This should be displayed by the teacher in an exaggerated degree, every movement of the lips and tongue being made as obvious as possible to the pupil, and the more difficult sounds or movements prolonged for the purpose. Thus, for instance, suppose the word 'sister' were to be practised, the teacher, having filled his chest with a long inspiration, would open his lips and draw back the angles of his mouth, so that the pupil could see well the position of the tongue against the teeth; he could then prolong the hissing sound of the 's,' and, finally, separating the teeth as the sound of the 't' in the second syllable issues, allow the pupil again to see the position of the tongue as the word is ended. Or, for another example, take the word 'lily.' Here the teacher would separate the lips and teeth, so that the tongue would be seen curved upwards, with the tip touching the hard palate; the word would then be pronounced with a prolongation of each syllable, the teeth and lips being kept open, so that the uncurling of the tongue and its downward movement are clearly seen. So, again, in teaching the proper method of sounding such words as 'wing' or 'youth,' much aid is given by keeping the lips somewhat separated, so that the relation of the tongue and palate can be made manifest. The pupil must be made to fill his chest,[2] and then to imitate as closely as possible every movement and sound of the teacher; and this may sometimes be assisted by making the pupil feel with the finger as well as observe with the eye the relative movement and position of the teacher's tongue and palate. There should be no other person in the room to distract the pupil's attention. It is best to continue the exercise for a short time only, and to repeat it frequently, rather than fatigue the child by a long lesson; and it is a good plan to take an ordinary elementary spelling-book and to mark the words which the pupil finds most difficult to pronounce,[3] so that these may be especially practised."

With regard to the question of obturators and vela;[4] in cases where it has been found impossible to close a very wide cleft, or where it is evident that even after a successful operation the palate will be so tense and short as to be quite unable to touch the pharynx, and so shut off the

[1] *Lancet*, 1883, vol. i, p. 111.

[2] Opening the mouth widely and learning to keep the tongue down on the floor of the mouth are two points to be early and strenuously insisted upon. The patient should practise them before a looking-glass.

[3] Especially those containing the letters t, b, d, k, g, s, z, and i (Rose).

[4] Acquired clefts, due to syphilitic disease, or necrosis, in adult patients, are usually best treated by obturators.

nose from the mouth, an obturator may be required. A very useful form, that of Dr. Suersen, of Berlin,[1] and several others, are described by Mr. Newland Pedley.[2] The whole question is very fairly dealt with, and many useful hints are here given as to the improvement of speech in these cases. The chief disadvantages of instrumental aids are that if fitted early they will require frequent alteration; on the other hand, unless worn early they will be of little service. Moreover, the expenses of the necessary repairs and renewals can rarely be met by hospital patients. Just the same care in overcoming faulty habits of speaking and in teaching correct ones is required now as after a successful operation.

Causes of Failure. (1) *Vomiting.* (2) *Premature cutting of sutures from tension.* (3) *Hæmorrhage.* Serious hæmorrhage in children, either at the time or later, is very rarely met with. In cases of severe hæmorrhage during the operation Mr. Berry's advice is worth remembering. "If a smart hæmorrhage occurs, the knife should not be at once withdrawn, but made to cut a little further, so as to ensure that the vessel, whether artery or vein, is completely divided."

Mr. H. Marsh,[3] in the case of a patient aged 21, was compelled to plug the posterior palatine canal owing to severe hæmorrhage on the sixth day.

The hæmorrhage recurred twice, the last time being as late as the fourteenth day, and was arrested on each occasion by the following means: "Searching with a sharp-pointed probe, passed through the lateral cut, about one-third of an inch in front of the hamular process, which can be easily felt through the soft palate, and about the same distance directly inwards from the wisdom tooth, I felt, after two or three attempts, that I had fixed the probe in the orifice of the canal, and at the same time the patient screamed with pain when the large posterior palatine was touched. A wooden plug, made by sharpening a piece of firewood, was then pressed firmly into the canal, by holding it in a pair of strong forceps with its point looking upwards, and a little backwards in relation to the roof of the mouth. Directly the plug was introduced the bleeding ceased." The recurrence was due to the plug slipping out.

(4) *Whooping Cough.* (5) *Exanthemata.* (6) *The child putting a finger into the wound.* (7) *Swallowing of solid food.* (8) *Feeble condition of the child*, with congenital syphilis, &c. Children of defective mind always cause additional anxiety in the after-treatment. (9) *Acute infantile Diarrhœa.* Though mentioned last, this baffling pest of surgery is too well known to those who have to operate, in the summer on little children in hospitals.

With reference to the above causes of failure, while, very occasionally, hæmorrhage at the time of the operation in a weakly child, prolonged vomiting or want of supervision after the operation, may be the cause, in the very great majority of cases the failure is due to some neglect of the precautions which are recognised as essential. They are, (*a*) insufficient relief of tension on the sutures by inadequate use of the raspatories in freeing the muco-periosteum flaps when the lateral incisions are made, or in separating the soft parts at the junction of the hard and soft palates; (*b*) unskilful paring of the edges, by which either not enough is done, the cleft not being completely pared, or too much is removed and the tension thereby increased; (*c*) bruising of the edges from unskilful manipulation with instruments or sponges, difficulty in passing the sutures, &c. In some cases where, in spite of free separation of the parts, the operation

[1] *Brit. Med. Journ.*, 1882, vol. ii, p. 875.
[2] *Guy's Hospital Reports*, 1894.
[3] *Clin. Soc. Trans.*, vol. xi, p. 71.

occasionally fails, perhaps from the presence of much scar tissue, union may still be secured, much as in the case of a hare-lip (p. 488), if about the tenth day the edges are carefully pared, and drawn together with sutures of silkworm-gut or silver wire, sufficiently stout not to cut through readily, and not drawn too tight. The explanation of this happy result is probably found in the abundance of vascular loops now present on either side of the cleft. In the case of a partial union, where one or more holes persist, there should be no hurry to interfere, and the child should be got into the best possible condition beforehand, by a stay at the seaside, if possible. Where a gap remains in the soft palate, the course to be taken will be, according to its width, either a fresh operation on the former lines, or one in which a flap is employed by Lane's method (Fig. 235).

REMOVAL OF GROWTHS OF THE PALATE

Growths here, though rare, have a special interest, from their position, and may thus be briefly noticed. For a good account of them reference should be made to a paper by Mr. Stephen Paget,[1] in which the following points are brought out: (1) The chief groups are the polypoid and warty, the adenomatous, the sarcomatous, and the carcinomatous; this last including the encephaloid, which are very rare, and the epitheliomatous, commencing in irritation here as elsewhere. (2) That it is hardly possible to tell beforehand to which group the growth belongs. (3) Most of them, especially the adenomata, can be shelled out with surprising ease. (4) That the growth itself should not be cut into.

The commonest growths which the surgeon has to deal with here are sarcomata and epitheliomata. In either case, where the growth is large and vascular, we would strongly urge the advisability of making use of such aids as intratracheal anæsthesia or a preliminary laryngotomy and plugging the fauces, slitting the cheek and ligaturing the external carotid on the side in which the growth extends farthest back. Tying the above vessel not only renders the operation much more bloodless, and so enables it to be more thoroughly done, but diminishes also the risk of secondary hæmorrhage, a risk that in a part like this, which cannot be kept aseptic, is always present. Mr. Jacobson followed the above course in two cases, in each of which the disease implicated the pterygoid region on one side. One was an epithelioma of the hard and soft palate involving the alveolar process and the pterygoid region on the left side. In the other case, one of sarcoma of the right pterygoid region and the soft palate, an operation had already been attempted by a surgeon at Johannesburg. Ligature of the right external carotid allowed of the removal of some enlarged glands at the angle of the jaw, and prevented any severe hæmorrhage when the growth was shelled out of the palate and right pterygoid region. In 1905, five years after the operation, this patient was married and fruit-farming in California. The parts were perfectly sound.

In the case of a growth of the hard palate, peeling it off with a blunt dissector and scraping the bone will be quite insufficient. The bone around should be freely removed with a chisel or gouge and mallet, or a partial removal of the upper jaw (*e.g.* its palate and one alveolar process) performed, if needful.

[1] *St. Bartholomew's Hospital Reports*, vol. xxii.

CHAPTER XXV

REMOVAL OF THE TONGUE—OPERATIONS FOR EPITHELIOMA OF THE TONGUE

REMOVAL OF THE TONGUE

(Figs. 241–245)

THE day when the belief is accepted, and acted upon, that cancer of the tongue, like other epitheliomata,[1] has a pre-cancerous stage, and that this is the stage in which we ought to operate, will be a happy one for hundreds of patients and for the results of surgery. Of all the painful deaths by which men leave this world there are few more miserable and distressing than that which closes life by cancer of the mouth. And yet, though in the case of the tongue this most important stage is, from the position of the organ which it attacks, peculiarly under our eyes and lies open to our examination and detection, how frequently it is overlooked![2]

Before describing the different operations it will be well to say something with reference to two or three very practical points which arise with every case of tongue cancer, a form of cancer which, it must be remembered, is very frequent and increasing in frequency;[3] which attacks all ranks of life; which, after its early stage, is especially malignant,[4] and, finally, for the relief of which an operation is as much dreaded and deferred by men as that for carcinoma mammæ is by women.

A Pre-Cancerous Stage. However tongue cancer begins, it usually passes through the above stages, *i.e.* a stage (the duration of which is unknown, and varies extremely) in which inflammatory changes only are present, viz. ulceration and other changes in the epithelium, not amounting, as yet, to epithelioma, but on which epithelioma inevitably supervenes. The boundary line between this pre-cancerous stage and cancer is extremely narrow; the duration of this stage may be, and often is, extremely brief.[5]

The common pre-cancerous lesions are dental or traumatic ulcers and chronic superficial glossitis—usually of syphilitic origin.

Aids in recognising this stage are: (1) The duration of the ulcer,

[1] The rare sarcoma of the tongue is alluded to at p. 548.

[2] *See* Papers by Mr. Jacobson, *Guy's Hospital Reports*, 1889, p. 245; *Practitioner*, May 1903.

[3] Amongst common cancers, *e.g.* of breast, rectum, uterus, &c., cancer of the tongue stands about third, although so rare in women. Mr. Barker, in his carefully worked-out article on "Diseases of the Tongue" (*Syst. of Surg.*, vol. ii. p. 578), gives a series of tables showing that in the previous thirty years there had been a steady increase from 2·6 to 11·5 per cent.

[4] This is shown in the following facts: (*a*) The rapidity here is quite different from that in other epitheliomata. Epithelioma, usually thought a slow cancer, here, in a moist warm cavity, much irritated, and never dry and warty, is terribly rapid. (*b*) Gland invasion is here not only certain, but inevitably early as well.

[5] *See* a paper by Sir H. T. Butlin on "The Early Diagnosis of Cancer of the Tongue and the Results of Operation in such Cases." (*Proc. Roy. Soc. Med.*, Clin. Sec., March 1912, p. 99.)

(2) Its obstinacy to treatment. (3) The age of the patient. (4) Absence of any induration or fixity.

Questions arising before operation. The operating surgeon will often be called upon to give an answer to the two following questions: Will the disease be permanently cured? If a permanent cure is impossible, will life be bettered and prolonged?

A. **Will the disease be permanently cured?** Really permanent cures, *i.e.* cases in which no reappearance of the disease has shown itself five years after the operation on the tongue, are as a matter of common knowledge, still very rare. From Mr. Jacobson's experience—and it has been a large one, chiefly of advanced cases—the proportion of permanent recoveries carefully watched would not be above 12 per cent.[1] Reappearance in the tongue after a well-performed operation is rare, but as the glands are invaded in the great majority of patients by the time they come to us, a permanent recovery is in these cases exceptional, however thoroughly repeated operations are performed.[2]

Sir J. Hutchinson [3] drew attention to the following facts which cannot be emphasised too strongly. Gland infection here begins almost from the very day that the sore assumes suspicious features. Again, lymphatic glands may become involved through ulcers of the most insignificant size and of the briefest duration. Lastly, the same authority points out that cancer germs may remain latent in the lymphatic glands for several years and then show signs of disease. Before leaving this subject it may be pointed out that invasion of the glands is here not only certain, usually early, but also peculiarly baneful, owing to (1) the way in which epithelioma infects the glands—inflammatory cells, as well as those of cancer, passing from the primary growth, if ulcerated, as it usually is, into the glands; and (2) the great importance of the structures amongst which the cervical lymphatic glands lie. When epitheliomatous glands are operated upon, the following conditions interfere with a thorough extirpation of the disease: (*a*) The number of the glands and the abundant communication between the different groups, the importance of the structures closely adjacent to the deeper ones, and the fact that the glands may be affected and yet so minute as to escape the most careful operator. (*b*) The presence only too often of septic cells (the original trouble being, usually, an ulcer) as well as of malignant deposit in the glands so mats them to adjacent parts as to make extirpation quite impossible. In-

[1] Kocher (*Op. Surg., Eng. Trans.*, p. 415) gives the following statistics: "Between 1890 and 1903 our operations numbered sixty-two. In only ten could the operation be performed from the mouth without a preliminary operation, while in thirteen the cheek had to be split; in twenty-three the jaw was divided in the mid-line, in four laterally, while in three cases it was partially resected. In seven cases complete excision of the tongue from its root was undertaken." The total operation mortality was only 6·6 per cent. in uncomplicated cases and 14·51 per cent. in those in which the jaw was divided. "We were able to obtain the subsequent history in fifty-seven of the sixty-two patients. Only five may be regarded as radical cures, a sufficiently long interval having elapsed. In one case a recurrence took place after three years, in another after ten years. Six patients who have been under observation for less than three years are in perfect health up to the present time, so that if we regard all these six cases as cured, our statistics as regards radical cure would be 22·8 per cent., but in absolutely certain cases, *i.e.* up to seven years, 16·2 per cent. have remained free from recurrence." The results of 197 cases operated upon by the late Sir H. T. Butlin will be found recorded in the *Brit. Med. Journ.*, Jan. 2, 1909, p. 1.

[2] If a sore has been persistent for more than three months, permanent recovery is very doubtful. If it has persisted for over six months, if more than one-third of the tongue is invaded, if the floor of the mouth is involved, permanent recovery is well-nigh certainly hopeless.

[3] *Brit. Med. Journ.*, 1891, vol. ii, p. 1190.

flammatory softening having set in leads to their breaking down during attempts at their removal, with the result that shells, still the seat of cancerous foci, are left behind. These relics, owing to the vascularity of the surrounding parts, do not die, but preserve sufficient vitality to act, a little later, as centres of recurrent disease.

The explanation of the small number of permanent recoveries after removal of cancer of the tongue is not altogether to the credit of our profession. Patients and we, alike, are too often both to blame. The gravity of the disease is overlooked, the time of the "pre-cancerous stage" is lost. Because cancer of the tongue is so often preceded by syphilis, or local irritation, the practitioner diagnoses the above, and suggests them as the essential part of the mischief: "gives drugs another chance," *e.g.* potassium iodide, mercury, caustics.[1] To these there are, in nearly every case, the strongest objections in the pre-cancerous stage. Time is lost, strength is lost, and the patient is lulled and befooled, while all the time the vascularity and irritation around the ulcer are increased. Furthermore, the patient is in part responsible for the delay, as he very naturally dreads the operation, exaggerating its danger, painfulness, and the supposed inevitable loss of speech. We shall never be able successfully to combat the above till (1) the importance and value of the pre-cancerous stage are recognised and thus limited operations are justified; (2) when medical men will assure their patients that even after more extensive operations, sufficient power of speech will remain.

B. **If a permanent cure is impossible, will life be bettered and prolonged?** Cases which are not operated on die within eighteen months, many in twelve months. An operation wisely planned and well carried out often gives a gain of six or eight months. This is a gain not only of time, but also of comfort. Death by glandular recurrence in the neck is less painful and noisome than death by mouth cancer. No one who has seen much of tongue cancer will have any difficulty in answering the question which of the two is the more painful to the patient and distressing to those around him—tongue cancer with its terrible fœtor, profuse and foul salivation, its pitiless, incessant, weary, racking aching of tongue, ear, face, and teeth; or recurrence in the cervical glands, an alternative in which the patient is often able to work up till near the last, and, till towards the close, is free from the agonising tenderness, the stinking fœtor, the dribbling of foul saliva (not only half poisoning the patient, but rendering him noisome to others), and the slow starvation day by day of tongue cancer. Where an operation is certainly attended with risk, the patient in facing it may be relieved by the assurance that a life prolonged in hideous misery and constant agony is worse than death following close on an operation. "When a man has only, suppose, two or three years to live, it is no small advantage if at least half the time can be spent in comfort rather than in misery, and in profitable work rather than in painful idleness" (Paget).

If a patient cannot make up his mind to an operation and is losing precious time, he should be warned, without being unduly frightened, of the state of things, alluded to in the few lines above, which will inevitably follow. Usually, as soon as this sets in, *i.e.* when the condition of the tongue renders him a nuisance to himself and others, the patient becomes

[1] A word of warning may be given here with regard to the use of X-rays or radium in the early stages of this disease. An epithelioma of the tongue will not be cured by these means and much precious time may easily be wasted.

willing to run any risk. But, too often, by this time, the glands have for some time been enlarged, and the mischief has reached the floor of the mouth or the alveolar mucous membrane by extension, though not yet perhaps with ulceration.

Operations. The following four will be described, viz.:

(1) **Whitehead's.**

(2) **Kocher's modification of Syme's operation.**

(3) **Kocher's former operation.**

(4) **Trans-hyoid pharyngotomy.**

Preliminary Treatment. Whichever method is chosen the following details are to be attended to carefully. For as many days as possible before the operation every effort should be made to get the mouth clean. All loose teeth or stumps and all tartar should be removed. The patient should brush his teeth two or three times in the day thoroughly, and make himself handy in washing out his mouth, and in the use of a feeder and tube. Much too often these most important steps are left till after the operation, and to a nurse. If practised beforehand they occupy the patient's thoughts, and after the operation they are not a new thing to him, and no one, however much in earnest, can carry it out as well and as painlessly as the patient himself. As to the mouth-wash, from its unirritating nature, Condy's fluid is excellent. Solutions of chinosol or of carbolic acid are also admirable. Before the operation the surgeon should take note of the teeth, as to their cleanness, and whether sufficient molars are present to take the leverage of the ordinary gag. If this is not the case, Hewitt's wheel-gag may be used. Some surgeons recommend that, when the patient is anæsthetised, the surface of the ulcer should be treated with pure carbolic acid, strong formalin, or even the actual cautery, with the view of rendering the surface as aseptic as possible. The surgeon should also ascertain beforehand the exact situation and extent of the growth. The transverse incision behind the growth should always lie a [illegible] inch posterior to the cancer. Only in some cases involving the posterior third is this occasionally impracticable. Even in doubtful cases it will be wiser to make a rule to adopt the above margin. If he leaves any examination to be made at the time of the operation, his finger may not only become infected if he be dealing with an ulcer, as is usually the case, but he will very likely start bleeding, which is needless, and may be embarrassing if the anæsthetic at that moment be causing difficulties.

(1) **Whitehead's Operation** (Fig. 211). By this method the tongue is removed through the mouth by scissors, the glands being also removed either at the same or another operation. The advantages of this method are very great. They are: (*a*) The transverse section of the body of the tongue can be placed, deliberately, well behind the growth. (*b*) The resulting wound is very clean, there being very little laceration. The infection which would take place from an extensive operation, even with scissors, is readily checked by the use of the lotions mentioned above. The advantage of those in saving a patient whose vitality is very often lowered, from the depressing effects of being liable for days to breathe and swallow with a fœtid sore in his mouth, in securing rapid granulation and healing, and thus enabling the patient to be early propped up, and soon to leave his bed, must be obvious to every surgeon who knows how great the risk is of fatal broncho-pneumonia. For the same reason secondary hæmorrhage, where ordinary care is taken, is unknown. (*c*) The instruments required are extremely simple and few, as will be seen from the

accounts of the operation.[1] The chief disadvantage of Whitehead's method is that it does not permit of the surgeon cutting deeply in cases where the growth has extended along the muscles towards the hyoid bone. To such cases it is unsuited and Kocher's modification of Syme's method is always then to be preferred.

Before describing the operation certain preliminary points of it must be discussed.

A. **The Anæsthetic.** It is most essential that the anæsthetic should be in the hands of a man who can be thoroughly trusted. It is often taken badly in these cases, with much dyspnœa and restlessness at first;

Fig. 211.

and, during the operation, owing to the open mouth admitting much air, and the fear of interfering with the operator, the patients often "come to" prematurely. The only thing is to get them well under at first; later on it will be best not to keep them too much under the influence of the anæsthetic, in order that the sensibility of the larynx not being lost, the blood may not enter the air passages. The administrator must watch the tint of the lips, the veins in the cheeks, and know when a little blood is only safely, though noisily, bubbling at the back of the fauces, and when it is getting into the trachea. If the tint of the parts mentioned above is sufficiently red or pink all is well; they quickly show a tendency to lividity on the one hand, and pallor on the other.

[1] On the value of Mr. Whitehead's method Sir B. Butlin writes (*Oper. Surg. of Malig. Dis.*, p. 154): "Whitehead's operation for removal of one part or the whole of the tongue has been my stock operation for the past ten years or more."

The question of the advisability of a preliminary laryngotomy now arises. It forms no part of a Whitehead's operation proper. The operator who introduced the scissors method, and whose success with it is so well known, never at any rate, at first, made use of a preliminary laryngotomy. After the laryngotomy has been performed the pharynx is plugged with sterilised gauze and the anæsthetic is administered through the laryngotomy tube.

The anæsthetist and his apparatus are thus much more out of the way of the surgeon, there is no chance of blood being drawn down into the larynx or trachea, and, on this account, there is a diminished likelihood of septic pneumonia. With the fauces plugged, and the patient breathing through a laryngotomy tube, the surgeon can neglect the hæmorrhage more, can so operate with greater deliberation, and consequently is enabled throughout to keep more surely wide of the disease. For these reasons a preliminary laryngotomy, with plugging of the fauces, may be recommended in these cases: (1) When the growth extends beyond the middle of the tongue into the posterior third. (2) When the floor of the mouth is at all involved. (3) When the tongue is so fixed that the diseased portion cannot be drawn out of the mouth. In growths limited to the anterior half of the tongue, unless there is much fixity, laryngotomy is not needed, for, as will be seen below, sufficient of the tongue in such cases, after very little use of the scissors, comes right out of the mouth.

If it be decided to perform laryngotomy, this operation is done as described on p. 562, and sterilised gauze, secured by a loop of silk, is packed into the pharynx behind the fauces. The gauze must be pressed well back, and care taken that it does not force backwards the base of the tongue, or it may cause some difficulty in securing the lingual artery when the transverse section of the tongue is made far back. In a prolonged operation, where the sponge becomes soaked with blood, it must be removed and renewed. So little sloughing and swelling follows Whitehead's operation that, as a rule, the laryngotomy tube may be removed before the patient has left the operating table or as soon as he is back in bed.

The anæsthetic may also be administered by Crile's method, in which tubes are passed along the floor of the nasal fossæ to the superior aperture of the larynx, the pharynx being plugged with sterilised gauze when these are in place. The intratracheal method of anæsthesia (*q.v.*, p. 781) is admirable for the removal of the enlarged glands, and also for the operation on the tongue: the tube in the mouth does not get in the way of the operator. The sole disadvantage is that the somewhat complicated apparatus may not be at hand, or the services of an anæsthetist sufficiently skilled in its use available.

B. **Should the tongue and the enlarged glands be both dealt with at one operation?** There is much to be said in favour of both sides of this question. Removal of the tongue itself is a serious operation, and removal of the enlarged glands requires always a long and careful dissection calling for much care and deliberation on the part of the operator. For thorough extirpation of malignant glands the operator should not be hurried. On the other hand, many patients, after undergoing one operation of such severity as removal of the tongue, are unwilling to consent to any further operation. The surgeon should therefore be guided by the extent of the disease and the number and fixity of the enlarged glands, and also the temperament and condition of the patient.

In an elderly patient of impaired vitality with extensive disease and many enlarged glands, operation in two stages will certainly be desirable. In a younger and more healthy patient with less extensive disease the whole may be safely completed under one anæsthesia. When the operation is done in two stages some surgeons remove the tongue first and the glands about ten days later; other remove the glands first, leaving the tongue to be dealt with later. One disadvantage of the first of the plans is that owing to septic absorption the diseased glands may enlarge, break down and suppurate, thus increasing the difficulty of their removal. Against the second plan it is argued that the primary growth is still left and may continue in the interval to disseminate epitheliomatous cells. An advantage of first operating upon the glands is that the lingual artery may be tied during the operation.

C. **Splitting the Cheek** (Fig. 242). This step is an excellent one. It may be made use of, in men especially, in cases where the disease is situated very far back, extending close to, or on to, the anterior pillar of the fauces, where the hæmorrhage is expected to be especially free, where the light is unavoidably very bad, or where there is unusual difficulty in getting the jaws well apart. The improved view is a very great aid in these cases. The cheek is divided as far back as the anterior border of the masseter, below Stenson's duct and parallel to the branches of the facial nerve which thus are not injured: the facial artery is divided and the ends of this and several small branches are secured at once. The parts require most careful adjusting afterwards, especially at the corner of the mouth, where, from the dribbling of saliva, primary and exact union is not always secured. As the branches of the facial nerve are not divided, there is no resulting muscular atrophy.

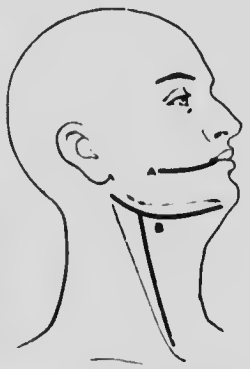


Fig. 242. A, Incision for splitting the cheek. B, Incision for removing the enlarged glands.

D. **Preliminary Ligature of the Linguals.** When the tongue and the enlarged glands are removed at the same operation the removal of the glands should be first effected and the lingual artery ligatured in the course of this part of the operation. Otherwise this precaution is not recommended for the following reasons: (1) The hæmorrhage may be as free as in the usual operation with scissors, performed without any such preliminary.[1] (2) If the operation with scissors be performed with attention to the details given below, the hæmorrhage is not so difficult to deal with as to require this precaution. (3) The operation of ligature of one, or possibly both, linguals is by no means an operation that can always be done quickly, and may be a matter of considerable difficulty.

The Operation. A good light is absolutely essential. Daylight close to a window is far the best. If it is needful to operate when the above cannot be obtained, as on a foggy November afternoon, a good head-lamp will be useful. But no tongue should, if it can be avoided, be removed on a foggy day, not so much on account of the light, but because of subsequent respiratory trouble.

[1] When this happens the vessel has been probably secured in front of a large dorsalis linguæ, subsequently divided.

In making arrangements for a good light, the surgeon will remember that, while the removal itself takes but a short time, getting the patient under the anæsthetic, and keeping him under its influence, often prolong the operation. It may not be superfluous to add here that this is an operation which calls for coolness and decision on the part of the operator, and for promptness with their help on the part of all those who assist. The surgeon must be cool and deliberate at three periods especially: (1) In taking up all bleeding-points which are not checked by pressure and by pulling on the tongue; there must be no hurried and often

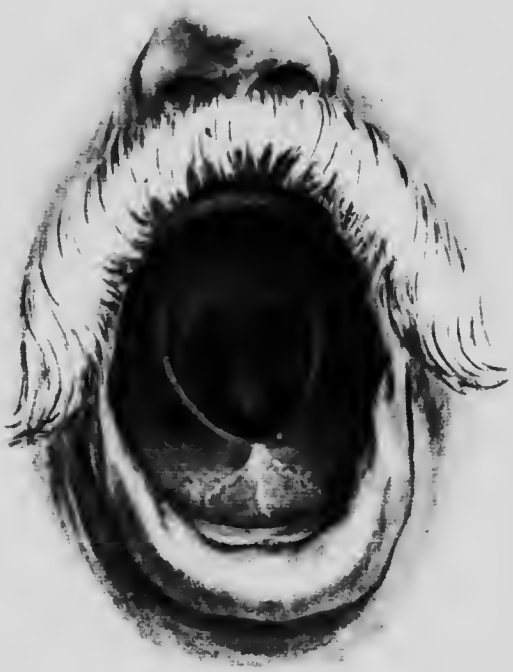


FIG. 243. Condition of mouth a year after complete removal of the tongue in a patient aged 67. The absolutely edentulous jaws are to be noted.

futile snapping at such spirting vessels. (2) In making the transverse incision, the operator's mind must be absolutely decided where he is going to cut, and he must not forget the fact that it is no good cutting well behind the growth if the section below is made dangerously near it. (3) When the tongue is removed there must be no hurry in taking the patient back to bed before all bleeding is thoroughly arrested. As long as any blood tends to trickle out of one corner of the mouth some vessel, probably one of the linguals or a dorsalis linguæ, requires tying. Yet another condition calling for patience and coolness on the part of the surgeon is where the patient, because he was not sufficiently anæsthetised at first, or from some delay in the operation, requires additional

anæsthesia. No crowding on the operator, no obstruction to the light by bystanders, should be permitted for a moment.

The anæsthetic having been administered, preferably by Crile's or by the intratracheal method, the patient is brought quite to that side of the table at which the surgeon stands. A gag[1] is placed on the side of the mouth opposite to the growth, and the mouth widely opened. The tongue is then transfixed on the diseased side, well back in its anterior third, with a needle loaded with stout silk or catgut; this is looped and knotted, and the tongue thus well drawn out of the mouth. The surgeon then, where one half only is involved, with a sharp knife splits the tongue longitudinally along the median raphe, to a point well behind the growth. Where the whole anterior portion of the tongue is diseased this step, which would mean cutting through the growth, is to be omitted.

The diseased half or the whole tongue being drawn well out of the mouth by means of the [illegible] or by reliable forceps, the surgeon next divides with scissors t[illegible] mucous membrane between the tongue and the alveolar process, keeping [illegible] bone so as to be wide of the disease. The anterior pillar of the [illegible] first divided. While the above steps are taken, an assistant [illegible] any blood into the hollow of the cheek and out of the m[illegible] and sponging, and sponge-pressure on bleeding-points, are most essential if the surgeon is to see his way and cut wide of the disease.

If the disease has implicated the frænum and its vicinity, two or three of the lower incisors should have been previously extracted so that the scissors may be introduced below the level of the disease. If this be not done the scissors have to be dipped in over the teeth in an awkward way, and one which, as soon as bleeding occurs, makes it impossible to be certain of getting below the disease. The scissors can be introduced with much greater facility, and used to much better purpose, if a gap be made by extraction of these teeth.

When half of the tongue has been freed all round the muscles between it and the floor of the mouth are cut through with a series of short snips until the diseased portion is separated on the level of the lower part of the jaw, and well beneath the growth, as far back as is needful. Where the surgeon feels that he is cutting dangerously near the base of the growth, the tongue should be raised by a vulsellum-forceps grasping it laterally. During this stage oozing will take place, and one or two small arteries bleed with varying freedom in different cases, but these will yield to pulling steadily on the tongue, and to firmly applied sponge-pressure.

The tongue having been freed horizontally up to a point well behind the growth, the transverse section is now made, and here arises the question as to the best way of securing the lingual artery. The most accurate method is that of Mr. Catheart. Many surgeons are in the habit of finding the lingual artery by cutting down on it gradually as the deeper parts of the tongue are divided: Mr. Catheart has put this most important step on a definite anatomical basis.[2]

His method is founded on the fact that the hyoglossus under which the lingual artery runs, though attached to the posterior third of the tongue, can be reached from the mouth when the tongue is drawn far out, and the mucous membrane has been divided between it and the jaw. The

[1] Sir F. W. Hewitt's modification of Mason's gag is the readiest and most efficient in cases where sufficient teeth are present.

[2] *Ann. of Surg.*, July 1902, p. 15.

mouth being opened widely, and the tongue drawn forwards with a stout ligature in each half, the mucous membrane is divided along the middle line of the dorsum, behind the growth and between the tongue and the jaw; the tongue is split and the fibres of the genio-hypoglossus divided close to the symphysis with scissors. The diseased half of the tongue can now be drawn well out of the mouth, especially if the anterior pillars of the fauces have been snipped through as well. With a few vertical strokes of a director the anterior edge of the hyoglossus is next defined. The director is then insinuated beneath the muscle, the tissues being separated with the point before the instrument is pushed on. The muscle is next carefully cut through on the director for about two-thirds of its extent, and the fibres retracting leave the artery at the bottom of the wound covered only by a little connective tissue. With the point of a director the vessel can then be easily defined as a bluish cord, and traced downwards and backwards. An aneurysm-needle should then be passed under it, and the vessel tied before it is cut. Some may prefer to seize it with forceps and cut before tying it, but the previous ligature is easier. After the artery has been ligatured and divided, a few snips should be made with the scissors radiating out from the ligatured artery into the substance of the tongue; this lessens the chance of cutting the artery again in the later stages of the operation. All that now remains to be done is to complete the operation, cutting wide of the disease. The advantages claimed by Mr. Cathcart for his method—and anyone making use of it will confirm every word that he says—are ease and certainty in securing the lingual: diminished bleeding from small vessels; greater certainty in cutting wide of the disease. Mr. Cathcart finds that, by his method the same part of the artery is reached as is tied in the usual operation for a preliminary ligature in the submaxillary triangle.

Another method which will occasionally be found most serviceable for the temporary control of bleeding is that of the late Mr. Heath. If any difficulty occur in dealing with a divided lingual (Mr. Cathcart's methodical plan should prevent this), especially when the tongue has been severed far back, or a ligature has slipped, Mr. Heath advised that one or two fingers should be slipped into the pharynx over the stump of the tongue, so as to draw this forwards. This step immediately arrests the haemorrhage by pressure, and usually brings into view the bleeding-point, which is at once secured.

If it be needful, the surgeon then proceeds to deal with the other half of the tongue, a step which is much facilitated by the room given for manipulation by the removal of the first half.

In this and other operations for removal of the tongue, when sufficient absolutely healthy mucous membrane can be safely left, it may be drawn together and sutured over the cut surface with sterilised catgut. This step undoubtedly saves pain and promotes rapid healing, and should, wherever feasible, be carried out.

Removal of Half the Tongue. Removal of half the tongue should be reserved for early cases, where the growth is situated on the free border and has not deeply extended into the muscular substance. (1) The removal of half the tongue is suitable and strongly called for in certain cases. (2) That such an operation, performed in fitting cases, leaves the patient with an organ which is (*a*) safe from recurrence, (*b*) a most helpful one in speaking, swallowing, &c. (3) That it is only by operating early in these cases, and by thus being in a position to promise the patient that the

less severe operation will be sufficient, and will give him immunity from disease and leave him with a most useful organ, that we shall ever attain to better success in our operations for cancer of the tongue, removal of the tongue being a mutilation especially dreaded and deferred by the patient.[1]

When half the tongue is removed the tip is likely to be drawn over and bound down to the floor of the mouth on the opposite side, partly by cicatrisation and partly by muscular action. A more mobile and useful though shorter stump may be obtained by removing the anterior end of the sound half. (Fig. 241.)

Removal of the Lymphatic Glands. This should be carried out in every case as a routine measure, whether enlarged glands can be felt or not, for the following reasons. (*a*) Infection of the glands begins here almost from the day that the ulcer assumes suspicious features. (*b*) That this infection may be started by ulcers of the smallest size and of but brief duration. (*c*) That deposits of epithelioma may here remain latent in the lymphatic glands for two years certainly, and then commence to grow. (*d*) That gland infection here is not only certain but peculiarly baneful (p. 530).

For the above reasons exploration of the anterior triangle and removal of glands should always be urged as a matter of routine on patients with cancer of the tongue. By adopting this routine practice, no doubt, a few needlessly extensive operations will be performed, but with cancer of the tongue as with cancer of the breast, we do not know, and have no means of diagnosing, the few cases in which the glands are not involved. If not done, reappearance of the disease in glands, which could not be felt to be enlarged on ordinary palpation at the time of the operation on the tongue, is certain. The question of removing the glands at the same time as the tongue, or at a second operation, is discussed on p. 534. Even greater thoroughness is required here than in the case of removal of tuberculous glands; the full details given at p. 641 for the removal of these should be referred to. The chief guiding principles alone will be given here. Each subdivision of the anterior triangle, and all the groups of glands mentioned below, must be exposed in the fullest way. For this purpose a curved incision is made, commencing just behind and above the angle, extending forwards, below the body of the jaw, nearly to the symphysis. A second incision commences in the posterior third of the first, and is carried downwards along the anterior border of the sterno-mastoid (Fig. 242). Flaps composed of skin, fasciæ, and platysma, are raised, thus allowing of a free exposure of the infected structures. The mylo-hyoid is divided to allow of the removal of those glands between it and the hyoglossus and genio-hyoglossus muscles: the sterno-mastoid is also divided, if necessary. Not only is every one of the groups of glands mentioned below to be investigated, and every gland that can be seen, whether enlarged or no, to be removed, but, in order to extirpate possibly infected lymphatics, the subjacent muscles are to be dissected clean, and all cellular tissue and fat cleared away. The internal jugular is here also the chief landmark, but in this case there may be less hesitation in removing it between two ligatures. The chief groups of glands are to be taken away as far as possible in one piece. The greatest care must be taken not to rupture infected glands or to cut into them when the overlying soft tissues are very thin. The chief groups affected are the lingual, the submaxillary,

[1] *See Guy's Hospital Reports*, 1889, p. 252.

the submental, and the deep cervical.[1] The submental is often overlooked. In addition to the lymphatic glands, the submaxillary salivary gland should also be excised, for infected lymphatics soon become adherent to and grow into it. Wharton's duct should be ligatured. The condition of the deep cervical group should be explored by following downwards the whole length of the carotid sheath as far as it is accessible. Attention must be directed to avoid injury to the descendens hypoglossi. Should enlarged glands be present on both sides of the neck a similar operation must be carried out on the opposite side also. Infection of the glands on the opposite side to that of the growth of the tongue may be present though unfelt. It may take place by means of lymphatics meeting in the tongue, or by the free communication which exists between the deep lymphatics of the two sides of the neck. When all bleeding vessels have been secured and ligatured, and all oozing stopped, the wound is sutured, a drainage-tube being inserted at its lower angle.

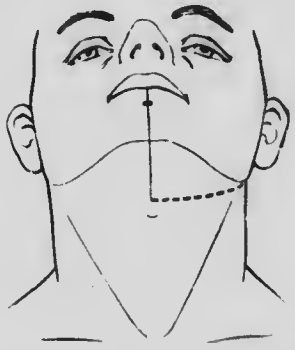


Fig. 214. Incision for Syme's operation for removal of the tongue. The dotted line shows how the incision may be extended for the removal of glands.

Advisability of operating on enlarged glands at a later date, *i.e.* some time after the operation on the tongue. While this step can be sometimes successfully undertaken, it is done under much less favourable conditions. There are few more difficult questions to decide than those which arise in these cases. The patient, maybe in the prime of life, with a soundly healed scar in his mouth, comes again to the surgeon, perhaps after a long disappearance, with infected cervical glands and urges further operation.

Each case must be decided upon its own merits. It is not the least use operating when the uppermost deep cervical glands are involved, *i.e.* those under the upper third of the sterno-mastoid, where the muscle is firmly tied down by processes of deep cervical fascia, and where the glands extend to the mastoid process behind, and the angle of the jaw in front, and into the pterygoid region. Operation will also probably be futile (*a*) when any of the glands are soft and breaking down; (*b*) where both anterior triangles contain enlarged glands.

(2) **Kocher's Modification of Syme's Operation.** (Figs. 211, 215.)[2] This consists in dividing the symphysis menti and then removing the whole tongue and floor of the mouth with knife or scissors. This is especially indicated when the growth has extended deeply into the tongue and has involved the floor of the mouth. It is a severer operation than the one already given, and may involve prolonged after-treatment, owing to the tardy union of the jaw. Where this operation is contemplated in an aged or broken down patient every attempt should be made to improve the general health previously. Prof. Kocher[3] has given up the operation through the sub-maxillary region, and adopted what is known

[1] Sir H. Butlin (*Brit. Med. Journ.*, February 11, 1905) adds that search should be made between the genio-hyoids in case a gland lies here.

[2] *Lancet*, 1858, vol. i. p. 16, and vol. ii. p. 168.

[3] *Text Book of Oper. Surg.*, 4th ed., Stiles and Paul, 1911.

with us as Syme's operation. In his words (p. 118): "Our 'normal procedure' now consists in dividing the jaw in the middle line in all cases where the cancer extends as far back as the isthmus of the fauces and where it has involved the arch of the palate." Again he writes: "It is only when there is a small new growth at the tip or the side of the tongue that we do not split the jaw." His modifications of Syme's operation are given below. The following are the advantages claimed. "It gives the best access and causes the minimum of injury. The hæmorrhage is very

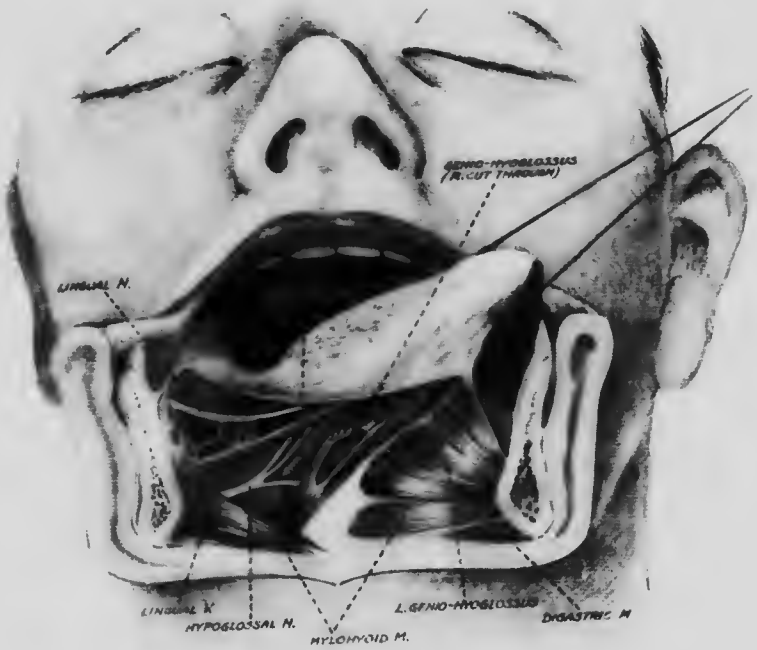


FIG. 245.—Kocher's modification of Syme's operation.

slight, as it is more effectively controlled; the secretions of the wound drain away more satisfactorily; and, what is most important to our mind, by preserving the muscles of deglutition along with their nerves a better functional result is obtained than by any other method. This non-interference with deglutition is of the greatest importance in preventing secondary aspiration-pneumonia, the greatest danger which threatens the patient. It is astonishing to see how patients can swallow on the same day, the following, or at most the third day after this operation, and hence they are able to get rid of the wound secretions and prevent their getting into the larynx." The severity of the operation in patients usually of poor vitality must be weighed. How in the advanced cases, for which

this method is recommended, the muscles of deglutition and their nerves can be safely spared and the result claimed attained, it is difficult to understand. An anæsthetic having been given [1] the patient's head and shoulders are raised, and the surgeon divides the soft parts of the chin, as far down as the hyoid bone, if the soft parts of the floor of the mouth are much implicated. The vessels being secured, the jaw is drilled, without any previous separation of the periosteum, below the teeth a quarter of an inch on either side of the middle line, and then sawn through.[2] The mouth must be kept carefully sponged out, the halves of the jaw being forcibly retracted. The tongue is well drawn out by a loop of stout silk, the mucous membrane snipped through between the tongue and the alveolar process and the anterior pillars next divided. The mylo-hyoids and the anterior bellies of the digastrics are now separated in the mid-line.

The genio-hypoglossi [3] and genio-hyoids thus exposed are cut through, and the tissues in the floor of the mouth separated as deeply as necessary with the scissors or blunt dissector, aided by the finger, partly by cutting and partly by tearing, any vessels that require it being tied. The lingual artery comes into view at the anterior border of the hyoglossus and is easily secured and ligatured. The tongue being thus freed laterally and below as far back as is useful, the transverse section is made, one half at a time, with the precautions recommended at p. 537.

The floor of the mouth is now carefully inspected, and any suspicious patches or enlarged glands most carefully removed. In raising the former, before using the scissors, a sharp hook is often very useful. The two halves of the jaw can then be wired, but to promote speedy union a cap of vulcanite or silver should, later, be fitted on to prevent displacement of the fragments. A drainage-tube should be brought through from the mouth to a point just above the hyoid bone, before the soft parts are united with sutures.

The chief modifications used by Prof. Kocher in his recent adoption of this method are as follows: He operates with the patient in the Trendelenberg position. After section of the jaw and the preliminary division of the mucous membrane he severs the muscles, the mucous membrane far back, the soft palate and pharynx, if invaded, with the thermo-cautery. The final division of the tongue itself, after previous ligature of the vessels, is made in the same way, the use of this instrument being considered to aid in the complete removal of the disease. Xeroform is rubbed into the cut surfaces, but only in a thin layer, so as not to produce toxic symptoms if swallowed. Bismuth paste is smeared over the line of suture.

(3) **Kocher's Former Method by Lateral Inframaxillary Incision.** As stated above, Prof. Kocher has now replaced this method by his modification of Syme's operation. This operation may, however, be selected for cases where there is coexisting disease of the mandible. As it is still employed by many surgeons, it will be briefly described.

[1] Intratracheal anæsthesia is strongly recommended for this and similar operations.

[2] By some it is advised to saw this somewhat angularly instead of vertically, to promote interlocking and union of the fragments. As however, necrosis may follow this as well as the other form of bone section, the longer time that it entails is scarcely worth giving.

[3] If only half of the tongue needs removal—a rare contingency in the cases which call for this operation—the complete separation of these muscles and the consequent danger of the falling back of the tongue will alike be avoided.

The following are the advantages: (1) It gives very good access. By slitting the cheek, when needful, the access given by the intrabuccal method is quite as good. (2) It permits of the simultaneous removal of the glands as well as of all the tissues which intervene between them and the primary seat of the disease. As far as the submaxillary glands are concerned this is true, and at first sight it is a distinct advantage over the intrabuccal method, this advantage is not so real as to give a great advantage over Whitehead's method. When the submaxillary glands are involved by cancer, the deep carotid group are also usually infected, though, to the unaided eye, they may appear healthy. The complete removal of all glands that may be affected involves a long and most careful dissection. Mr. Jacobson is of opinion that the close of such a severe operation as removal of the tongue is not the time for such a dissection. The majority of patients are not fit to bear further operative steps, necessarily prolonged. Few surgeons undertaking it will do justice to themselves. With regard to the second claim, that this method removes all the tissues which intervene between the glands and the primary seat of the disease, it is impossible that any operation, whether by the submaxillary or the intrabuccal route, can make certain of removing the lymphatic tract which runs under the jaw between the cancer and the glands. Even removing a portion of the jaw as a regular step would not make certain of this tract; and being not only uncertain, but also adding enormously to the patient's discomfort immediately after the operation and for the rest of his life, should not be attempted. (3) It admits of preliminary ligature of the lingual or external carotid artery. This claim is a just one, but any surgeon familiar with the intrabuccal method and the precautions given above will know that no such preliminary ligature is really needed.

The disadvantages are: This operation is a severe one; it also opens up freely the connective tissue of the neck. The statement that the operation can be performed aseptically must be received with much caution. It is impossible to cleanse thoroughly the naso-pharynx and other regions which lie near.

The Operation. The mouth having been prepared as directed at p. 532 and the anæsthetic having been administered by one of the methods recommended on p. 534, where the disease extends far back, an incision is made from just below the symphysis down to the hyoid bone, and following the digastric muscle back to the anterior edge of the sterno-mastoid, then up to near the lobule of the ear. The flap thus marked out of platysma and fascia is turned up, and the facial artery tied. The submaxillary region is then thoroughly cleaned out and the lingual artery secured beneath the hyoglossus. By cutting through the mylo-hyoid muscle and dividing the mucous membrane, the cavity of the mouth is now freely opened, and the tongue brought out through the wound and divided as far back as needful, one half being removed after splitting the organ, or the whole tongue removed, the opposite lingual being tied if needed.

The large wound is then carefully packed with strips of sterile gauze, a drainage-tube being first inserted, and xeroform or Whitehead's varnish (p. 547) applied. The patient continues to breathe through the laryngotomy-tube until the wound and mouth are quite sweet, and thus there is less danger of infective broncho-pneumonia.

(4) **Trans-hyoid Pharyngotomy.** Mr. Carless advises[1] this method in certain cases of growth involving the posterior third of the tongue. The cases he refers to are those of disease far back on the dorsum of the tongue, spreading towards the epiglottis but not involving the root of the tongue. He hopes that by this operation it may be possible to save the anterior portion of the organ. Such cases are rare, the tongue being usually fixed and the disease generally infiltrating forwards as well as backwards. Where the severe operation of Syme or that of Langenbeck (p. 515) has been thought unsuitable on local or general grounds, such cases are usually best left alone. It will be seen that there was no local recurrence after *Mr* Carless's operation.

His patient, aged 67, was admitted September 1900. A "lump" had been noticed on the back of the dorsum of the tongue in January 1900. The organ could be protruded fully, and there was but little discomfort in swallowing. Nothing

[1] *Practitioner*, May 1903, p. 661

was to be seen of the growth from the front. With a laryngoscope a large indurated ulcer invading the epiglottis, reaching forward from it about an inch and a half, and more marked upon the left side than the right, could be seen. There was an enlarged gland beneath the angle of the mandible.

September 4, the patient was operated upon by trans-hyoid pharyngotomy. A preliminary high tracheotomy was performed, a Hahn's tube inserted, and chloroform administered by this, a sponge being kept over the entrance of the larynx. The operation was performed on the lines given at p. 538. After separation of the genio-hyoids and exposure of the hyoid bone this was divided in the middle line with bone-pliers. "The two segments were drawn apart by the retractors, and with a little undercutting a considerable interval was obtained, in which was exposed the middle thyro-hyoid ligament, and beneath it a pad of fat. Through these structures an opening was made with the knife just above the thyroid cartilage, and the base of the epiglottis was cut through a little above the false vocal cords. This opening was enlarged by scissors on either side by dividing the ligament and portions of the thyro-hyoid muscles, so as to enable the finger to be inserted, and thus the exact size and situation of the growth on the back of the tongue were readily defined. It was then merely a question of snipping with the scissors to take away the growth. Incisions were made in either side of the epiglottis, well away from the lateral margins, and thereby the segments of the hyoid bone were more easily separated, giving additional space to work in; next I removed a V-shaped segment from the back of the tongue, including the whole of the diseased tissues, and this without encroaching on the main vessels and nerves, although the left hypoglossal was seen. The bleeding was very slight and easily controlled by ligatures. I drew the edges of the V-wound together at the anterior extremity, but behind it was too extensive for this to be undertaken. Three catgut sutures were employed in this way. The two halves of the hyoid bone were stitched together by a catgut suture passed through the periosteum. The central part of the wound was left open and a gauze plug introduced, the rest being closed with sutures." Finally a smaller Hahn's cannula was introduced. This was replaced by a tracheotomy-tube after forty-eight hours, the latter being removed on the tenth day. Five weeks after the first operation the glands on the left side were removed. Eighteen months after the first operation the patient appeared free from recurrence, but a few months later the glands on the right side of the neck became enlarged.

(5) **The Ecraseur.** This method, which has many disadvantages, and no advantages over those described above, is now practically obsolete. It will not be described and is only mentioned here to warn against its employment.

EPITHELIOMA OF THE TONGUE AND OTHER PARTS AS WELL

Question of Operation. These cases, in which it is most difficult to decide aright, fall mainly into two groups.

A. Where the epithelioma is situated far back, affecting the tongue, tonsil, palate, and perhaps the posterior part of the body of the jaw.

Here the cancer affects a region very rich in lymphatics, and invasion of the glands will probably take place early. For this reason permanent successes are practically unknown here, though operations are, from time to time, published as successes, often within a few weeks or months of their performance.

In deciding upon operation the surgeon will be guided first by the age of the patient, the natural expectation of life, the vitality and power of recovery, and the state of the viscera, especially the lungs.

Then he will investigate very carefully the following points: How far any fixity of the growth here points to involvement of the muscles at the root of the tongue, if the mandible is involved near its angle; how far the epiglottis or the upper aperture of the larynx is involved; whether the secondary growth of the tonsil and its pillars is hard and

fixed, or movable on the parts beneath; whether the pharynx itself is involved. Next, if there is enlargement of the lymphatic glands, their extent, fixity, and how far any softening or breaking down is already present.

Any of the above should usually decide against operation in these cases; and as to the glands here and in all kindred cases, epitheliomatous enlargement in the posterior triangle, and especially those under the upper third of the sterno-mastoid, renders operative interference hopeless as to permanent success.

In deciding upon an operation, the points fully dealt with on p. 539 will be found helpful.

Operation. In these cases where the growth involves the tongue far back, and other parts such as the jaw, tonsil, palate, &c., the only steps that can be possibly adequate will be those taken on the lines of Langenbeck's operation or one of the methods of pharyngotomy given in the next chapter, according to the site and direction of extent of the epithelioma. The chief steps in Langenbeck's operation are the slitting of the cheek and the division of the jaw, steps which, while they provide good access to a growth situated far back, also emphasise the severity of the operation in the case of the lowered vitality often presented by these patients.

The patient is first brought fully under the anæsthetic, which is afterwards continued by a nasal or intratracheal tube.

The cheek is slit, the facial artery secured, and the incision then carried across the mandible just in front of the masseter into the submaxillary region, over which it is continued to meet the anterior border of the sterno-mastoid about the level of the hyoid bone. From this point flaps are raised sufficiently for thorough exposure of the submaxillary region. This is cleared out, the facial artery tied again low down, together with the lingual. The jaw is now sawn with a Gigli's saw obliquely downwards and forwards. As the section passes through the basilar border the saw should be turned still more forwards. The object of this oblique section is to lock the fragments together, there being a marked tendency for the anterior one to drop and the posterior one to be raised. Before the saw is applied holes are drilled without disturbing the periosteum. This is next carefully divided. The section through the mandible should pass behind the last molar tooth. If the posterior belly of the digastric and the stylo-hyoid are now divided, the two halves of the jaw can be very widely separated, and the diseased area rendered accessible. The diseased parts are then removed by the knife or the cautery. The choice between them is referred to at p. 552. As the lingual artery will have been tied on one side the haemorrhage will not be troublesome, or more than a watchful assistant can sponge away through the divided cheek. In this operation, as in lateral pharyngotomy, if the surgeon is in doubt as to the lower limits of the disease, by carefully fixing a hook in the epiglottis and lifting up the larynx he will be able to clear up this point. The jaw is wired and the wound closed in the usual way. If the patient's condition admits of it, the condition of the deep cervical glands must be investigated, otherwise this step is deferred for a fortnight. Adequate drainage must be provided. This and the treatment of the wound are referred to at p. 556. Where the mandible or the muco-periosteum over it is infiltrated, part of the bone must be removed. If it be possible a strip of the basilar border must be retained, otherwise the sufferings of the patient and the difficulties of the after-treatment are much increased. On this point, where the

vitality of the patient is unusually good, the case next related is encouraging.

B. In this group the epithelioma has attacked the chin and fore part of the tongue and the floor of the mouth. Here the outlook is better as to a permanent cure, owing to this part being farther from the larynx and less richly supplied with lymphatics. All the affected parts must be removed unsparingly, and the resulting deformity may be very great.

Fig. 246 shows this well, and is also a good instance of the fact that occasionally, when occurring on a superficial surface, and one which dries quickly, epithelioma ulcerates slowly for a time.

Fig. 246.

The patient, a man aged 33, had been originally operated on for epithelioma of the lip at a hospital in the south of England. The disease recurred, and gradually invaded the chin and symphysis menti, the front of the tongue, and the floor of the mouth. The case was a distressing one, on account of the large foul sore prominently in view, the filthy smell of the discharge, and the neuralgic pain constantly present due to the disease having involved both inferior dental nerves. The man had been seen by two other London surgeons, and operation had been advised against owing to the very small chance of a permanent cure, and the deformity which was certain to follow on the operative interference necessary. As no enlarged glands could be felt, and as the patient, young himself and healthy otherwise, had a young wife and child, the decision was left to him, after the two sides of the question had been put clearly before him, he decided to run the risks.

At the operation, performed by curved incisions carried out from the angles of the mouth on to the cheeks, then across the submaxillary regions to the anterior border of the sterno-mastoid, and thence running inwards to meet at the hyoid bone, healthy tissues were cut through, but it was quite impossible to provide adequate flaps. It was necessary next to saw the jaw through just in front of the masseter on each side, as section in front of this point showed that the inferior

dental glands were invaded by the growth. While a finger in the mouth carefully defined the extent to which the floor and soft parts were invaded, as shown by the induration—no ulceration, happily, having taken place here—the diseased structures, including the anterior half of the tongue, were cut away with a wide margin of healthy tissue. All haemorrhage having been arrested and drainage provided, the skin on either side was brought together as far as possible. No epithelomatous glands were found. The patient made a good recovery, his chief trouble at first being inability to take any food at all, which necessitated feeding him with a tube, and the pain caused by the sawn fragments moving in inflamed soft parts with any spasmodic action of the muscles. Now, June 1906, eight years after the operation, he is free from recurrence. The chief drawbacks to his lot, in addition to the necessary deformity, are that he needs a tube for liquid food, that his power of speech is limited owing to the loss of his lower lip and the way in which the stump of the tongue is tied down in the scar, and the constant dryness of his mouth. He is able to work at home, making hen-coops and the like. His wife has borne him a second child. If he continues to have no recurrence of the growth, it might be possible to close in the gap by means of a flap taken from the arm.

After-treatment of operations on the tongue. The chief objects here are: (1) to keep the wound as sterile as possible: (2) to give sufficient food.

The importance of previous cleansing of the mouth, teaching the patient to do this, and to feed himself has already been spoken of at p. 532.

After the operation the cut surface may be brushed over with "Whitehead's varnish." This is a modified "Friar's Balsam," a saturated solution of iodoform in ether being substituted for the spirit, and one volume in ten of turpentine being added. Ice is given to suck, and milk and brandy and beef-tea are administered either by a soft œsophageal tube or by enemata, or both. But it is generally found that, after the first six hours, a patient previously practised in the matter will give himself sufficient food, with a feeder and tube attached.[1] After the patient has had his first sleep the surface is brushed over, every two or three hours at first, with some dilute antiseptic lotion and he is soon encouraged to sit up and wash out his mouth constantly with carbolic acid (1 in 60 or 80), a wash of a tablespoonful of spirit of wine in a tumbler of water (Hutchinson), or Condy's fluid or chinosol 1 in 2000. It is not the kind of wash used that is of so much importance as the frequency and painstaking with which it is used. From time to time the stump may be painted over with Whitehead's solution. The patient should be kept warm and free from draughts, and propped up or turned on to either side alternately. It is well to try to induce patients to sit up a little on the second day, if possible, and get them, when this is feasible, into an armchair a day or two later. Yolks of eggs, arrowroot, soups, pulped vegetables in broth, and such like are, as soon as possible, taken in addition to the milk and brandy and beef-tea.

Causes of Failure. In considering the deaths which follow soon after the operation, the effects of pre-existing bronchitis and emphysema, interstitial nephritis, aortic disease, and, sometimes, previous haemorrhage from the growth may have to be remembered.

(1) *Broncho-pneumonia, Abscess and Gangrene of the Lungs, Empyema.* As these are infective in their nature, and due to the patient breathing foul gases and drawing down putrid fluids into his lungs, the treatment must be preventive, every endeavour being made to keep the mouth sweet

[1] If this is not the case, a soft tube must be passed. Nutrient enemata are not sufficient.

and to relieve the patient's breathing by attention to the details already given.

(2) *Hæmorrhage.* This is rarely met with at the time of the operation or soon after, if every spirting artery has been properly secured.

Haemorrhage also will be rarely met with as a secondary complication if the wound has been kept sweet. In cases of bleeding, if the application of a ligature to the bleeding-point taken up by a Spencer-Wells forceps or a tenaculum is impossible, firm pressure with a sponge and adrenalin chloride should be made use of after all clots have been removed. If the wound has been allowed to become foul, it must be cleansed by brushing it over with formalin (1 in 250), Whitehead's varnish, or, in the absence of these, with turpentine—a most powerful cleansing styptic.[1] If all the above fail, either applying and leaving in situ a pair of Spencer-Wells forceps, packed around with soft gauze, or ligature of the lingual, must be resorted to (*q.v.*).

(3) *Cellulitis. Erysipelas.* (4) *Pyæmia.* (5) *Exhaustion*—more rarely, *shock.* (6) *Œdema of the glottis.* (7) *Suffocation* from falling back of the tongue. (8) *Reappearance.* The gravity of this has been already mentioned at pp. 530 and 540. For the first year after the operation every patient should come under skilful supervision at intervals of a month and no longer.

The steps already detailed of the different operations on the tongue will suffice for the rare cases of **sarcoma.** For fuller information reference may be made to an article by Sir A. D. Fripp and Mr. Swan.[2] The following are the directions for treatment: "One point which appears to be very emphatically demonstrated by the cases which we have collected is that these tumours should be widely removed by an incision into the healthy lingual tissue well clear of the growth; for although the ease with which the obvious new growth can sometimes be enucleated is very tempting, yet such a method of separation from the surrounding compressed tissues is extremely liable to be ineffectual in removing all traces of the growth, the pseudo-capsule remaining will contain the nucleus for a recurrence at a later date. The question which method of operation is most applicable depends on the nature of each individual case, and among other things on the situation and volume of the tumour. Small tumours of the anterior part can be attacked from the mouth; those placed in the middle third of the tongue can be more easily reached by dividing the cheek; but those cases in which the growth has extended downwards in the muscular attachment of the tongue, whether projecting in front of or behind the circumvallate papillæ, demand a supra-hyoid incision, opening up the floor of the mouth or the pharynx as the case demands. If recurrence should ensue the secondary tumour must again be removed and widely."

Ranula. Dermoid Cyst. Mention may be made here of these cysts, the former of which project into the floor of the mouth, while the latter are surrounded by the muscle of the base of the tongue and can be felt more or less distinctly on palpation between the chin and the hyoid bone.

A ranula is a term somewhat vaguely used for cysts in the floor of the mouth.

[1] See the remarks on a case of ligature of the occipital artery. If the bleeding is of the nature of oozing, solution of adrenalin and one or two injections of ergotin should certainly be tried.

[2] *Practitioner*, May 1903, p. 673. Endothelioma is another rare form of tumour occasionally met with here. Sir F. Eve has recorded two such cases (*Proc. Roy. Soc. Med.*, Clin. Sec., May 1910, p. 173).

These cysts, which have a thin wall and a bluish colour, are generally derived from the mucous glands in the floor of the mouth or from the incisive glands: rarely they are derived from Wharton's duct or from one of the ducts of Rivini. An attempt should be made to dissect the cyst out after incising the mucous membrane of the floor of the mouth. They can only rarely be removed entire, though the attempt should be made. When the cyst is opened or torn a thick glairy fluid escapes; the wall of the cyst should then be cut away as far as possible, any portion which cannot be got away being treated with a strong solution of silver nitrate. In cases where the cyst does not come away entire no sutures should be employed.

Dermoid cysts in this region are not uncommon. They are generally derived from the upper portion of the thyro-glossal duct. They are best removed by making an incision in the middle line extending from the chin to the hyoid bone. The mylo-hyoid muscles are then separated and the deeper muscles divided in the line of the original incision until the capsule of the cyst is reached. It is then enucleated with the help of a blunt dissector. The wound is then closed, drainage not being as a rule required.

CHAPTER XXVI

OPERATIONS FOR GROWTHS OF THE TONSIL, FAUCES, BASE OF THE TONGUE AND PHARYNX

The new growths here are most commonly round-celled sarcomata and epitheliomata.

In sarcoma of the tonsil, in adults, there is a steady enlargement of one tonsil, without, at first, pain or inflammation; a globular swelling, the size of a walnut, appearing firmly elastic, tending to infiltrate adjacent structures, and fungate as a sloughing mass into the mouth.

In the epitheliomata the patients are older; the mischief often begins as "a sore throat." The mass occupying the site of the tonsil is now much harder, and soon ulcerates, forming an excavated ulcer with the characters of epithelioma, and soon implicating adjacent parts. The base of the tongue may be involved secondarily. Dysphagia, emaciation, &c., are more rapid here.

Before describing any operations for removal of tonsillar growths it is right to allude to their great malignancy, owing to the rapidity with which the glands are affected both in epithelioma and most of the sarcomata. In this, rather than in the importance of its relations, lies the failure of operations on the tonsil, and no one who has watched the rapidity with which (owing to the intimate connection between the tonsil and the lymphatic glands) enlargement of the glands at the angle of the jaw takes place in subacute tonsillitis will wonder at this. Diagnosis at the earliest possible moment is of greatest importance here.

Sir H. Butlin[1] writes on this malignancy: Sarcoma of the tonsil "proves fatal, in very many instances, within a year or even six months of its first appearance; indeed, few persons survive for more than three quarters of a year."

Dr. Newman,[2] writing of sarcomata of the tonsil, draws a distinction here which may have some practical importance. While admitting that round-celled sarcomata, by far the most common variety, quickly invade the glands, he points out that the spindle-celled sarcomata may remain limited within a capsule, and so be capable of complete removal. Thus in one case of Dr. Newman's the patient lived five years after removal of a spindle-celled sarcoma through the mouth, and then died rapidly owing to disease appearing in the opposite tonsil.

OPERATIONS

A. **Through the Mouth.**

B. **By Incision in the Neck. Lateral Pharyngotomy.**

C. **Combined Operations. Through the Mouth by slitting the Cheek and Lateral Pharyngotomy.**

[1] *Oper. Surg. of Malig. Dis.*, p. 176.
[2] *Malig. Dis. of Throat and Nose*, p. 176.

D. Median, or Trans-Hyoid Pharyngotomy.

Whichever method is chosen, the selection of cases here for operation must be a very careful one, owing to the great malignancy of these growths, and the advanced stage which the disease has often reached; even in these regions, we often hear the statement that the patient suffered very little inconvenience in the earlier stages.

Cases Favourable for Operation. Where the growth is still small, localised to the touch well defined, still movable, free from ulceration, and where no enlarged glands can be made out. On the other hand, where the swelling in the mouth is continuous with one in the neck, each diffuse and ill-localised, and the primary growth showing a friable, ulcerated surface, operation will be contra-indicated. Gastrostomy may even be called for as a palliative operation. In intermediate and doubtful cases, as where one or more enlarged glands exist, but still separate and mobile, the surgeon will be justified in giving his patient a chance, knowing the distressing future if the growth be left—the agonising earache, the dribbling of fœtid saliva, the dysphagia, &c. The following points require particular attention. Here, especially, is it true of malignant disease, that the mischief is liable to be found more extensive than was thought to be the case before the operation. Owing to the danger of infective pneumonia the presence of any bronchitis is against operation. And the same may be said of cases where there is any fixity of the jaw, as this suggests extension along the connective tissue between the pterygoid muscles. Owing to the difficulty in feeding the patient—and rectal feeding alone will be quite insufficient—the vitality of the patient, and his amenability to directions, must be estimated beforehand. The more the growth encroaches on the orifice of the larynx the greater the risk of broncho-pneumonia and œdema glottidis. The frequency with which the glands are early implicated has already been referred to.

A. **Through the Mouth alone.** This method can only rarely be made use of, *e.g.* in a very early stage of tonsillar new growths, when the disease is limited to the tonsil itself, not implicating the adjacent pillars, and when there is not the least evidence of glandular enlargement.

If the following operation seems somewhat severe, the infiltrating tendency of growths here must be remembered.

With regard to the anæsthetic and other general considerations reference may be made to the remarks on p. 533.

The patient's head is suitably raised and supported, in a good light, and the cheek on the affected side divided from the angle of the mouth to the masseter, the two ends of the facial artery being secured. The mouth is now kept widely open by a gag inserted on the opposite side, the tongue drawn out of the mouth, and the masseter pulled backwards by a retractor. As much room and light as possible being thus obtained the surgeon divides the soft palate first in the middle line, and then from within outwards with scissors; he next, either with the same instrument or with a blunt dissector, dissects around and carefully extirpates the tonsil with the pillars of the fauces. The whole operation should be slowly and deliberately carried out, the surgeon cutting wide of the growth and encroaching on the tongue, &c., if needful. He thus removes the growth together with a margin of healthy tissue, and gives his patient the best chance. Though some sarcomata here are encapsuled, and can be shelled out, recurrence is, unfortunately, probable after this step.[1] The

[1] Butlin, *loc. supra. cit.* p. 175.

method of removing widely is far preferable. Bleeding will be best arrested by temporary forci-pressure and firm sponge-pressure.

Some surgeons do the whole operation with the cautery instead of the scissors.[1] The objections to the cautery are: (1) that it requires a special instrument, which may not be at hand; (2) if it destroys an infected surface, it also introduces infection and risk of secondary haemorrhage; (3) with it, it is very difficult to judge aright of the nature of the surfaces divided, whether sound or infiltrated; (4) it necessitates the use of chloroform, which may be inconvenient. For these reasons the use of the cautery, if it be employed at all, should be limited to searing thoroughly the surface of the wound.

The case of small growths of the tonsil accessible from the mouth having been considered, that of malignant disease situated or extending lower down will be next referred to. We will suppose that the glands require investigation, but that there is no softening or adhesion of these to the soft parts overlying them or to the pharynx.

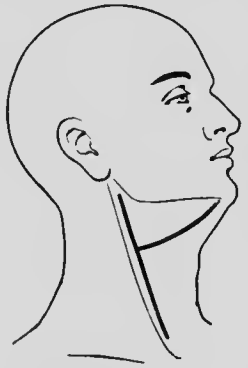


Fig. 247. Incision for lateral pharyngotomy.

The following courses are open to the surgeon:

B. **Lateral Pharyngotomy.** C. **Lateral Pharyngotomy combined with division or partial resection of the mandible, with one through the mouth, by slitting the cheek, or with Langenbeck's operation** (p. 545). D. **Median, Sub- or Trans-hyoid Pharyngotomy.**

B. **Lateral Pharyngotomy**[2] (Fig. 247). The glands having to be dealt with an incision is made along the upper half of the anterior border of the sterno-mastoid—it may have to be extended to the sternum—and a second carried forwards from this at the level of the hyoid bone curving upwards to the mandible to one side of the chin. The submental group of glands is rarely involved in these cases. The skin, platysma and fascia having been divided and the external jugular, occasionally, secured, the flaps are dissected up and down and wrapped in sterile gauze. The facial vessels are next divided between ligatures and the submaxillary salivary and lymphatic glands cleared out. If the glands are extensively involved the incision along the sterno-mastoid must be extended to the sternum and the deep cervical group extirpated with the precautions given at p. 539.

The operator now decides according to the vascularity and extent of the primary growth whether he will deal with the external carotid by ligature and extirpation of its branches (*see* ligature of external carotid), or whether he will be satisfied by tying, close to their origin, such branches as the lingual, the ascending palatine (if not already secured by the ligature of the facial) and the ascending pharyngeal. This question is considered a little later (p. 554). The further steps in the exposure of the pharynx are division of the muscles which overlie it, the digastric and

[1] Treatment of the raw surface, or of any doubtful area where it has been impossible to cut sufficiently widely of the growth by dia-thermy (*see* p. 396), may also be tried.

[2] Mr. F. J. Steward has recorded a case in which he removed a growth from the anterior and left lateral aspects of the pharynx by this method. The pharynx was exposed by division of the depressor muscles, thyrohyoid membrane, superior cornu of thyroid cartilage, and left lateral wall of the pharynx (*Proc. Roy. Soc. Med.*, Clin. Sec., March 1912, p. 137).

stylo-hyoid first, then the stylo-glossus and stylo-pharyngeus, and the stylo-hyoid and the hyoglossus as far as may be necessary. The hypoglossal, gustatory and glossopharyngeal will be in the upper part of the wound and the superior laryngeal nerve in the lower. All, especially the last, are to be spared when possible. The pharyngeal wall is now exposed. With the aid of a finger in the mouth, or slitting the cheek, the growth is now removed with as free a margin as possible with scissors. If the vascularity of the growth or other conditions seem to require the use of the cautery, the surgeon must remember the difficulty which this method entails in estimating the condition of the tissues left after its use.

Question of Closure of the Pharynx. This very important matter must now be referred to. Immediate closure with sterilised catgut in one or two layers, care being taken not to allow any inversion of the mucous membrane, has the advantage, if the sutures are sufficiently close and if they hold, of diminishing very largely the escape of infected discharges from the pharynx, and of facilitating the swallowing and feeding of the patient. On the other hand, owing to the stitches very rarely holding here as in the case of the œsophagus (*q.v.*), escape of the above discharges into the deepest part of the wound and a most dangerous cellulitis has not infrequently followed suture of the pharynx, especially when this has been followed by suture of the superficial incisions. For this reason the upper part only of the opening in the pharynx should be sutured, a drainage-tube inserted here, the wound lightly plugged with a strip of sterile gauze, and a few sutures of stout salmon-gut inserted in the flaps so that these can be partly drawn together when the deeper part of the wound is safely closed. As feeding of these patients by the mouth is imperatively needful, an additional precaution taken by some is to pass a soft tube by the nose below the wound in the pharynx. To prevent this being vomited when the patient is recovering from the anæsthesia, or when he is restless and unmanenable, the tube may be sutured to the mucous membrane of the pharynx with catgut.[1] Where the opening in the pharynx is too large for suturing, or where the cautery has been employed, plugging with gauze both of the deep and superficial wounds must be resorted to.

C. We will now consider cases where the growth is situated higher up and farther back, and an ordinary lateral pharyngotomy is not sufficient for its exposure. This is afforded by division or resection of part of the mandible. The preliminary steps are the same as those already given, the upper end of the first incision (p. 552) being carried farther back, and the upper flap dissected higher up. When the mandible is exposed and the submaxillary region cleared out the bone is divided in front of the masseter with a Gigli's saw, the section being made obliquely so that its line encroaches more upon the outer and lower aspect of the bone than upon its inner and upper, because the sawn extremity of the posterior fragment has a tendency to pass inwards and upward (Kocher). Before the saw is used, holes should be drilled for the passage of the uniting wire. The two halves of the mandible are now drawn forcibly apart, the displacement of the anterior fragment being aided by free division of the posterior belly of the digastric and the stylo-hyoid. Where, owing to the extent of the growth, mere division of the bone and separation of the fragments will not give sufficient room, the mandible should be divided obliquely just behind the angle and the ascending ramus removed by disarticulating the condyle. The muscles must be detached, including the posterior part of the masseter, and the inferior dental artery ligatured.

[1] The passage of a soft nasal tube at intervals for the purpose of feeding is preferable.

If the angle is left, a precaution always to be taken, the above resection, while giving good access to the disease, will be found to give satisfactory results as to subsequent mobility of the jaw and disfigurement.

The above methods apply chiefly to growths involving the parts about the fauces; where it is chiefly the region of the orifice of the larynx that is encroached upon, viz. base of tongue and epiglottis, these parts can be exposed by a lateral pharyngotomy which opens the pharynx farther forwards, and by removing the great cornu of the hyoid bone. As this course runs additional risk of causing injury to the superior laryngeal nerve, and thus an insensitive condition of the larynx, and as cases involving the epiglottis are the most unfavourable of all owing to the especial risk of aspiration-pneumonia, if any operation is performed, it should be a median or trans-hyoid pharyngotomy (p. 557).

The after-treatment will be the same as that given at pp. 547 and 556.

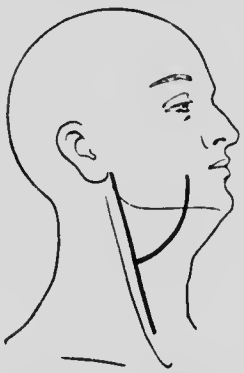


FIG. 248. Incision for lateral pharyngotomy with division of the lower jaw.

Choice of Operation. Where the growth is no longer quite small, where it is not limited to the tonsil itself, where there is any enlargement of glands, or where the existence of this, though not certain, is, from the duration of the case or the presence of ulceration, very probable, lateral pharyngotomy, with or without incision of the cheek, should be performed. It gives free access to the tonsil and adjacent parts, it enables the surgeon to have the important vessels of the neck retracted, it admits of a simultaneous removal of enlarged glands, and putting a temporary loop upon the common carotid (*q.v.*), or ligature of the external carotid, or trusting to securing the facial and lingual close to their origin, whichever course be preferred. On the other hand, this operation is a severe one. The jaw, if divided, must be wired, and necrosis of the bone or non-union may follow. For it must be remembered that this wound cannot be an aseptic one, and the opening in the pharynx, especially if this has been made by the cautery, may set up septic infection in spite of drainage. The following words of Prof. Kocher on the extent of operation probably required are weighty ones: "We would warn our readers especially against attempting to operate from the mouth in those common cases of carcinoma situated at and behind the isthmus of the fauces, and spreading on to the epiglottis, and involving the soft palate and lateral wall of the pharynx, because, in cutting wide of the diseased tissues, one cannot avoid doing a serious injury to adjacent parts and dividing large arteries. If the carotid is wounded in adherent indurated tissues, there is a great risk of not being able to arrest the hæmorrhage quickly enough, whereas from outside one can control the large vessels with much greater certainty. If the new growth involving the tongue and pharynx has extended to the fold between the jaws and the bone itself, it is best, after dividing the lower jaw as above described, and separating the capsule of the joint and the external pterygoid, to disarticulate and remove the ascending ramus, after detaching the healthy muscles, including the masseter. In this way, subsequent closure of the jaw is most certainly avoided." Cases involving the epiglottidean folds or their neighbourhood are the most unfavourable of all owing to especial risk of aspiration-pneumonia.

Possible Aids in the above Operations. (1) *Ligature of External Carotid.* At first sight this step, which ensures very little bleeding, a clear field of operation, and absence of anxiety as to blood entering the larynx, seems one of universal application. But again, the fact that the wound may become infected renders mere ligature one of risk. With the pharynx opened in the neck, or a laryngotomy or tracheotomy performed, and the tube, if necessary, retained, infective softening and ulceration about the ligature may occur with fatal secondary hæmorrhage. Thus Sir Watson Cheyne lost a patient twenty-five days after an extensive operation for epithelioma of one tonsil.[1] He states that Polaillon, who has tied the external carotid in most of his cases, has lost several from this cause. Sir Watson Cheyne is inclined, therefore, only to make use of ligature of the external carotid when the operation is performed in two stages,[2] viz. removal of the enlarged glands and ligature of the external carotid first, and, about a week later, the removal of the growth in the throat.

Primary and secondary hæmorrhage alike will best be met by adopting Dawbarn's method of excising the external carotid and its branches (*see* ligature of this vessel).

(2) *Question of a Preliminary Laryngotomy or Tracheotomy* The question of a preliminary laryngotomy for the administration of the anæsthetic in these cases has already been considered. In these cases it may also be called for on the following grounds: (*a*) the growth is likely to extend to the base of the tongue, the epiglottis, or the upper opening of the larynx; (*b*) there will be increased difficulty in swallowing and increased difficulty in keeping the wound clean.

The objections to this step are obvious. It introduces another and necessarily infected wound; it is the means of colder air being introduced; it interferes with coughing and emptying the upper air-passages, an interference already brought about by the wound in the pharynx. The nearer to the larynx that the growth extends, the more emphatically is a laryngotomy or a tracheotomy with its additional risks required. And more than this, the longer will the tube need to be retained, owing to the risk of œdema of the glottis. This risk is present during the first fortnight, and if the tube has been removed early, it must always be kept at hand.

(3) *The Trendelenberg position.* Where a preliminary laryngotomy or tracheotomy has not been performed, this may be tried after the first part of the operation when the glands have been removed. It has been strongly advocated by Prof. Keen, of Philadelphia, in all severe operations affecting the larynx. At the time of the operation its liability to cause venous congestion must be remembered, and its maintenance afterwards, on which Prof. Keen lays stress, is difficult owing to the tendency of the patient to slip down against the head of the bed. This may be obviated, in part, by flexing the knees over an inclined plane. Like a laryngotomy or tracheotomy, it, of course, cannot be relied upon entirely to prevent the occurrence of aspiration-pneumonia.

[1] *Objects and Limits of Operations for Cancer*, p. 59.

[2] In a case in which Sir W. Cheyne adopted this plan, a week intervening between the two operations, "there was no more bleeding from the deeper parts than if the external carotid had just been tied" (*ibid.*, p. 67). Sir W. Cheyne only advises that the operation be performed in two stages in cases where the patients are weakly, and the primary and glandular disease both extensive, and perhaps, also, where ligature of the external carotid appears to be desirable. He points out a serious objection to this method of operating, viz. that after removing the glands, open lymphatic vessels are left which may contain or convoy cancerous material to the newly made wound, and thus infect it before the second operation.

(4) *The use of Eucaine.* This is worth remembering in the deeper stages of these operations, especially those carried on near the orifice of the larynx. By the smaller quantity of general anæsthetic thus required the amount of bleeding at a trying time may be lessened.

After-treatment. The same precautions as after removal of the tongue must be taken for keeping clean the wound in the mouth and neck. At the close of the operation Whitehead's varnish may be applied. The treatment of the wound in the pharynx has been referred to above, the patient very frequently washing it out by one of the fluids given at p. 547. The patient should have practised gargling out his mouth and fauces beforehand (p. 532). In order to prevent the frequent soaking and changing of the dressings as much as possible, he should use small quantities, and hold his head to the opposite side. It will probably be well to retain one drainage-tube in situ for a week or ten days. This has been objected to on account of the danger of erosion of the external carotid. This may be prevented by dealing with the vessel as advised at p. 555. In any case the risk of insufficient drainage is far greater. It should be taken out and boiled before re-insertion daily. Feeding by aid of a soft tube passed along the sound side will be needful for some time, perhaps as long as two or three weeks, where removal of parts around the tonsil, the wall of the pharynx, or the base of the tongue has been extensive. The patient's feeding himself should be forbidden as long as any attempt at this causes choking or coughing, owing to the danger of fluids entering the air-passages. During feeding a pad of gauze should be placed over any opening in the neck. Sir Watson Cheyne has found it useful to keep the patient's head hanging over the side of the bed and turned towards the sound side, the liquid being taken in small amounts and very slowly. As after removal of the tongue, the patient should sit up and be got out of bed as soon as possible.

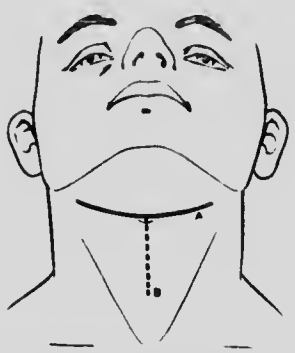


Fig. 249. A, Incision for sub-hyoid pharyngotomy. B, Vertical incision in addition to the above recommended by Kocher for tumours of the sinus pyriformis and the region of the arytæno-epiglottidean folds.

Median Pharyngotomy. As this form of pharyngotomy has been but little performed in England, and as it is highly spoken of by Prof. Kocher, the different methods which he recommends, viz. sub-hyoid pharyngotomy by a free transverse incision, and median pharyngotomy by a T-shaped incision, by which not only is a growth of the pharynx but part of the larynx as well removed, are described fully below.[1] Mention may also be made of the French method of trans-hyoid pharyngotomy, in which a vertical incision is made and the hyoid bone divided.

In Mr. Jacobson's experience, the last, aided, if needful, by division of the thyroid cartilage, gives sufficient room for dealing with growths of any extent which it is advisable to attack. The first two will enable the surgeon to deal with growths of more limited size.

"Sub-hyoid pharyngotomy, introduced by Malgaigne and Langenbeck, deserves special attention. By utilising all the advantages of this procedure, the operation becomes much more frequently indicated than former authors supposed. It has

[1] *Third Eng. Ed. Trans.*, Stiles and Paul, p. 434.

the advantage of giving excellent access with little injury to the surrounding structures. Not only is the operation indicated for the removal of all growths situated at the entrance of the larynx, *e.g.* growths involving the epiglottis, arytenoepiglottidean folds, arytenoid cartilage, mucous membrane at the level of the hyoid bone, and of the sinus pyriformis, but equally for growths situated at the root of the tongue, and on the lateral and posterior walls of the pharynx as far down as the œsophagus.

"We have found preliminary tracheotomy and packing unnecessary; blood can be prevented entering the larynx by having the patient in the correct oblique position. A general anæsthetic can be dispensed with, and instead, a 1 per cent. solution of cocaine can be injected for the skin incision, and 5 to 10 per cent. solution can be repeatedly painted on the mucous membrane.

"The incision, four inches long, is made along the hyoid bone from the greater horn on one side to that on the other, dividing the skin and muscular fibres of the platysma. The hyoid bone is then exposed and the anastomosis of veins crossing it are ligatured. The hyoid artery and vein lie on the bone, and are retracted to the upper side of the wound. The muscles inserted into the lower border of the hyoid bone are divided at their insertions.

"The thyro-hyoid membrane is now exposed. The central part appears as a broad tense ligament, but the lateral parts are thinner. The central portion, which encloses fat and often a bursa, is transversely divided along the bone. The mucous membrane is [illegible] divided, giving rise to some spirting from small vessels. We do not consider it possible to divide it at a distance from the hyoid, on account of the superior laryngeal nerve, which enters the larynx by piercing the lateral part of the thyro-hyoid membrane. If the twigs of the nerve are cut, the larynx becomes insensitive, and the entrance of food, mucus, and wound secretions into the larynx. As the foreign bodies cannot be reflexly coughed up aspiration-pneumonia is developed.

"The epiglottis can now be seized with a hook at its upper border and drawn forwards. This gives an excellent view of the entrance of the larynx, especially the neighbourhood of the arytenoid cartilages, which is so often the seat of disease (tuberculosis and cancer), and also of the lowest part of the pharynx and the root of the tongue. If the epiglottis must be removed, it is seized with a hook at its lowest point (which can be easily felt above the dip in the thyroid cartilage) and dragged outwards. After the mucous membrane has been divided it can be easily pulled out and cut away. As in laryngotomy, the reflex irritation of the mucous membrane must be quieted by frequent applications of a 5 per cent. cocaine solution, so as to enable the operation to be continued in comfort.

"The new growth should be thoroughly removed with the thermo-cautery, the parts being clearly exposed to view. The cautery arrests all oozing, and gives a better chance of a radical cure. As regards after-treatment, it is well under certain circumstances to perform tracheotomy to avoid the danger from œdema glottidis, which often develops in an extremely insidious way, and may cause danger from asphyxia. The main wound is dressed with iodoform gauze and collodion. We used formerly to stuff the wound, but we have now abandoned the practice. As we always cut round new growths with the fine blade of a thermo-cautery and carefully stop all bleeding, we have found it sufficient to insist that the patient must lie with the head low whenever he is recumbent; but he should be allowed to sit up very early, to allow of easy expectoration of the secretions of the wound.

"We avoid, wherever it is possible, performing secondary tracheotomy. It is only when the sensitiveness of the larynx has been destroyed by injury to the superior laryngeal nerve that one cannot trust to the cough-reflex to prevent secretions from flowing down.

"*Median Pharyngotomy.* Owing to the extreme frequency of tumours, especially carcinoma, in the region of the entrance of the larynx, *i.e.* affecting one of the arytenoid cartilages and the arytenoepiglottidean folds, and infiltrating the wall of the pharynx and the sinus pyriformis, it is advisable to give a definite description of the method of exposing the lower part of the pharynx with the least destruction of the parts.

"Just as we have lately, on principle, employed a median incision for the tongue and upper part of the larynx, we have similarly restricted the use of lateral pharyngotomy in favour of median pharyngotomy, for cases of carcinoma such as those for which we have frequently been called upon to operate, and the results have been thoroughly gratifying as regards its precision and the minimum damage done to the surrounding structures.

"The incision is made, as in sub-hyoid pharyngotomy, along the lower border of the hyoid, but extending farther outwards on the diseased side, and only about an inch and a half across the middle line on the healthy side. From this another incision is carried down to the thyroid and cricoid cartilages in the middle line as far as the isthmus of the thyroid, care being taken to avoid the vertical veins; the transverse veins are ligatured as in median laryngotomy.

"On the diseased side the sterno-hyoid, thyro-hyoid, and omo-hyoid are divided parallel to the hyoid, and the subjacent thyro-hyoid membrane is cut across as described in sub-hyoid pharyngotomy; the tip of the epiglottis is then seized with a small sharp hook and dragged forwards and towards the healthy side.

"The extent of the new growth anteriorly is now defined, and the epiglottis is divided ¼ cm. in front of the disease along its lateral border down to its base. By this means a better view is obtained, and one is able to decide how much of the cartilaginous plate of the thyroid will have to be excised. The thyroid cartilage is then split in the middle line, and the muscles attached to the wing of the thyroid cartilage are separated, along with the perichondrium, from the diseased side. With a sharp hook the wing of the thyroid on the diseased side can be sufficiently drawn outwards and downwards to enable the tumour to be detached from below and then from behind, and the mucous membrane to be divided in healthy tissue in the region of the arytenoid cartilage (it is often necessary to divide it between the arytenoids). The new growth is now grasped by the fingers, and the limits of the hardness examined with sufficient exactness to decide where the soft parts (the muscular attachments of the pharynx) are to be divided from the outside. The limits of the mucous membrane towards the pharynx along with part of the pharynx can be carried out, the bleeding being easily controlled and the diseased tissues completely removed.

"As will be gathered from the description, we get at the lateral and posterior walls of the pharynx by adding to the incision parallel to the hyoid the median incision with splitting of the thyroid cartilage. This allows one half of the larynx to be powerfully pulled downwards and forwards."

Trans-hyoid Pharyngotomy by a Vertical Incision. This method has considerable advantages for the removal of growths at the base of the tongue, the epiglottis and the opening of the larynx. A case in which it enabled the operator, Mr. Carless, to deal with a growth situated far back in the tongue, has been referred to at p. 543 where details of the operation will also be found.

Operation. An incision is made through the skin and subcutaneous tissue, in the middle line from the symphysis to the top of the thyroid cartilage. The raphé of the mylo-hyoid is divided, the hyoid bone exposed exactly in the mid line, and divided with bone-forceps. The two halves of the bone, together with those of the mylo-hyoid and the genio-hyoids are well retracted. This affords a space of about one and a half inches in width. According to the site and size of the growth further access must be obtained by dividing the mucous membrane above and the thyro-hyoid ligament below. The operator now inserts a finger to ascertain the position and size of the growth; another introduced through the mouth will aid this. The epiglottis is now drawn forwards as advised (p. 557) and excised with the growth by a V-shaped incision if possible, as this can be partly sutured with catgut at the upper part. If the epiglottis is clearly not involved, it may be dissected free and left. The wound is packed with gauze, which is brought out at the lower angle, sutures being only employed above.

Numerous details, already given, have been omitted here. A preliminary tracheotomy will be required owing to the manipulations about the upper aperture of the larynx. The risk of subsequent œdema glottidis (p. 555) must not be forgotten. It would probably add to the after safety of the patient, if before the pharynx is opened, the Trendelenberg position were adopted. The patient must be fed at first with a soft tube.

Lateral pharyngotomy has an apparent advantage over the median method in that the incision for the former operation, if added to, admits of removal of infiltrated glands at the same time. Mr. Jacobson says, "For my own part, I am strongly of opinion, with all deference to that of Sir W. Cheyne (p. 555), that it will be much wiser to remove the glands by a second operation, as has been advised in the case of epithelioma of the tongue (*q.v.*). An operation with the object of extirpating all the glands which may be affected (not only the group which can be felt), is sufficiently trying both to patient and surgeon to require a time for itself."

CHAPTER XXVII

OPERATIONS ON THE AIR-PASSAGES IN THE NECK. TRACHEOTOMY. INTUBATION. LARYNGOTOMY. THYROTOMY. EXCISION OF THE LARYNX

THYROTOMY

Indications. Owing to the improvement of the endo-laryngeal methods of operating thyrotomy is now less frequently called for. It may, however, be required under the following circumstances.

(1) Growths which cannot be removed through the mouth, but which do not require severer operations on the larynx itself. The following are the chief conditions which must decide the removal of laryngeal growths by an operation from the mouth or by thyrotomy:

(*a*) The amount of special laryngeal skill possessed by the operator.

(*b*) The nature of the growth, whether multiple or no, if pedunculated, if recurrent after attempts at removal from the mouth.

(*c*) The extent of the growth.

(*d*) The irritability of the larynx. The amount of self-control of the patient. Any tendency to asphyxia. While the much rarer fibromata are to be remembered, it is to papillomata in children that the following remarks apply.

It will be assumed that endo-laryngeal interference is not available, or that it is not to be entertained from the age of the patient, the history of dyspnœa, or the marked degree of aphonia which points to the growths having reached an extent which may at any time bring on sudden and rapidly fatal dyspnœa. The question now lies between thyrotomy and tracheotomy, both of which operations have serious disadvantages.

The disadvantages of thyrotomy are undoubted. It is frequently insufficient, the growths quickly reappearing. It is liable, when repeated, to be followed by stenosis, this, perhaps, occurring in proportion to the vigour of the treatment. It is obvious that in little children—and these growths may occur in the first years of life—owing to the anæsthetic and the nature of the part which is operated on, there must be some risks at the time, and a little later. The possibility of aphonia is another serious disadvantage. This will, however, probably be already present, and, in many cases, after the operation the voice steadily improves with the growth of the child.

The full description given at p. 588 of the technique of thyrotomy for malignant disease will suffice for those cases of papillomata or fibromata which occasionally occur in adults.

(2) Large rough foreign bodies,[1] *e.g.* bits of bone, &c.

[1] At the present day, such foreign bodies would almost always be extracted by Brüning's direct-vision tubes. As this accident might occur when these very special instruments were not available, this indication is still included.

In a case brought before the Clinical Society [1] by Dr. Taylor and Mr. Golding Bird a bit of mutton bone was impacted between the vocal cords, where it could be seen with the laryngoscope. It was removed by Mr. Golding Bird by a vertical incision with its centre over the cricoid cartilage, the cricothyroid membrane being incised horizontally. A tracheal dilator being introduced, the bone was seen at once, and extracted with Toynbee's ear-forceps. The large size of the fragment, its apparently firm position, the fact that the broad surface, and not the edge, presented, together with its position just at the cricothyroid membrane, led to the external operation being made use of.

Mr. M. Shield [2] related a similar case successfully dealt with by thyrotomy. The bone had been impacted four days. Pus escaped when the preliminary tracheotomy was performed. The bone could not be seen when the thyroid cartilage was divided, but was detected, very firmly impacted below the cords, with the finger. The tracheotomy-tube was removed in twelve hours, and the wound then drawn together by sutures previously passed. The voice was, ultimately, completely recovered.

(3) Much rarer indications for thyrotomy are: Cases of stenosis of the larynx as a result of injury or syphilis. The late Mr. M. Shield has described two such cases. In that due to fracture of the larynx, thyrotomy a few months later with removal of the cicatricial tissue and dilatation of the larynx with the finger enabled the patient to dispense with her tracheotomy-tube, and to speak with a good voice at the time when she was last seen, two months after the thyrotomy. The syphilitic case admitted of less benefit, and retention of the tracheotomy-tube was needful.

Operation. As a high tracheotomy will usually be required, it will facilitate matters, especially in little children, where the field is small, if the first incision is made from the top of the thyroid cartilage to a point about an inch and a half below the cricoid. An ordinary tracheotomy-tube will suffice here if a small tampon of gauze secured with silk is placed above it. It affords an additional element of safety to open the trachea as a preliminary step, owing to causes of interference with respiration even in the case of a foreign body, as this may prove to be fixed; as the upper part of the wound may usually be closed in these cases there is less need to make two distinct incisions, a step which may cramp the operator considerably.

After the performance of the tracheotomy the next steps vary somewhat according to the condition which calls for the operation. If it be a foreign body, the upper part of the incision should be deepened over the cricothyroid space, the membrane opened, and a tracheal dilator inserted. If the body be not seen, a probe will probably find it and suitable forceps extract it. This will prevent any of the interference with the vocal cords inflicted by thyrotomy. If the latter step be required, as in the case of papillomata, after all hæmorrhage is arrested, the thyroid cartilage is divided along its centre with scrupulous exactness. This is easily affected in children with scissors introduced through an opening in the cricothyroid membrane. In adults a fine pair of bone-shears or a very fine saw will be needed. The two halves, treated with the utmost delicacy, are now opened out with sharp hooks. A solution of eucaine and adrenalin is next applied; and at this stage a trial of the Trendelenberg position may be made.

The removal of papillomata is often attended with much difficulty owing to their friability. They are best snipped away with small scissors curved on the flat; the application of fused chromic acid, silver nitrate,

[1] *Trans.*, vol. xvii, p. 214.

[2] *Brit. Med. Journ.* 1902, vol. ii, p. 941.

sulphuric acid, or the cautery may be tried, though often without success, to prevent the inveterate tendency to reappearance.

The object of the operation being accomplished and all haemorrhage arrested, the alae of the thyroid are united by one or two points of silver suture not passed through the entire thickness of the cartilage. A sterilised dressing is then applied.

The tracheotomy-tube must not be removed till all risk of intra-laryngeal oedema, &c., has passed by, though it may be early replaced by one of india-rubber. The after-treatment and complications are much as after tracheotomy (pp. 570, 572).

Coughing will be especially harmful now.

Impairment of the voice occurring after thyrotomy has been alluded to above. It may arise quite apart from any injury inflicted on the cords during the operation, owing to the cicatrix subsequently involving the anterior commissure of the cords. Where the masses of papillomata are large, though the removal has been complete, the patient has in a few cases never been able to dispense with the tube. In this event, the presence of papillomata above the opening in the trachea must be thought of. In order to deal with them, the trachea must be opened again a little lower down.

The treatment of laryngeal papillomata by the endo-laryngeal method (by Killian's or Brüning's direct-vision tubes) described on p. 508 is probably the most satisfactory method of treatment.

Treatment of Laryngeal Papillomata by Tracheotomy alone. The results of thyrotomy for papillomata are so unfavourable both as regards reappearance,[1] much impairment of voice, and stenosis that it has been proposed to resort to tracheotomy alone with the object of giving entire rest to the parts: further, there is some reason to believe that, if unirritated, these growths have a tendency in early life to disappear. The disadvantages of this method are obvious, viz. the length of time the tube will have to be worn and the difficulties which will arise when the tube is ultimately dispensed with (p. 572). Dr. G. Hunter Mackenzie was the first to bring this step forward,[2] showing that the papillomata tended slowly to atrophy when the larynx was put at rest and freed from the irritation incidental to coughing, &c.

The length of time during which the cannula[3] requires to be worn varies much. In Dr. G. H. Mackenzie's three cases it remained in the trachea twelve, six and seven months respectively. Numerous confirmatory cases are given by this authority.[4] He agrees with the statement already made that the trachea should be opened as soon as the aphonia is complete and permanent, without any waiting for the onset of dyspnoea. To this Dr. Mackenzie adds the warning "that infraglottic papillomata may be present without much vocal alteration, but with considerable respiratory disturbance."

Dr. Railton, of Manchester, published[5] two cases illustrating the value of this treatment. In one child the cannula was worn for three years and

[1] In addition to this very marked tendency to reappearance, there is the risk that the trachea may have to be opened to prevent suffocation after the child has appeared to be convalescent.

[2] *Edin. Med. Journ.*, November 1881; *Lancet*, April 6, 1889; and *Brit. Med. Journ.*, September 12, 1896, p. 609.

[3] An india-rubber tube is to be used whenever possible, and granulations springing up at the wound are to be destroyed at regular intervals.

[4] *Brit. Med. Journ.*, 1901, vol. ii. p. 881.

[5] *Ibid.*, February 19, 1898, p. 489.

nine months, and in the other for twenty-five months before it was finally removed.[1]

In these cases the condition of the voice and the breathing is examined from time to time by taking out the cannula and closing the opening, but the instrument is not finally withdrawn until every trace of stridor and hoarseness has disappeared.

George A. Wright, of Manchester, whose experience at the Pendlebury Children's Hospital has been very large, gives[2] an interesting case in proof of this warning.

In a child of five, tracheotomy had been performed for laryngeal papillomata. The tube had been removed, at first for short intervals, and later altogether. The child died suddenly in an urgent attack of dyspnœa. The fact that, in addition to a mass of papillomata on the vocal cords and at the site of the tracheotomy wound, there was an early stage of tuberculosis of the bronchial glands and lungs, suggests, as is pointed out, the possibility of a hospital infection with tuberculosis through the tube.

LARYNGOTOMY OR INTER-CRICO-THYROTOMY

In this operation the tube is inserted through an opening in the cricothyroid membrane. It is called for, in preference to tracheotomy, on account of the greater facility with which it is performed, in cases of emergency, and in those where a tube can quickly be dispensed with.[3] Finally, it is inapplicable before adolescence.

Indications. (1) Sudden impact of large foreign bodies threatening suffocation, as when a bolus of food carelessly swallowed lodges in the upper aperture of the larynx.[4]

(2) Before operations likely to be attended with much bleeding, *e.g.* those on the tongue, jaw, tonsils, &c., in order that the fauces may be plugged with a sponge. Wherever the tube can be soon dispensed with, this operation is very superior to a high tracheotomy, often recommended.

(3) When spasm of the larynx is threatening very suddenly, as in tetanus or aortic aneurysm. As a rule, tracheotomy, when there is time to perform it, is preferred in these spasmodic affections, and it will be considered later (p. 563 *et seq.*).

Operation. An anæsthetic will be given in those cases in which laryngotomy precedes another operation: in other cases the patient's head must be kept steady. In either instance the head will be thrown back as far as possible, while the neck rests on a firm support. The precise position of the thyroid and cricoid cartilages is then distinctly made out, the notch in the upper part of the former and the ring of the latter being almost always recognisable. The larynx being then steadied (not squeezed) with the left fingers and thumb, and the skin at the same time drawn moderately tense, an incision about an inch and a half long is made, exactly in the middle line, over the lower part of the thyroid, the cricothyroid interval, and the cricoid.

[1] Possibly a cure may be secured in a shorter time by a combination of the methods: removing the papillomata carefully at once by a thyrotomy, and at the same time giving rest to the larynx by keeping a tube in the trachea. As these papillomata are sometimes associated with congenital syphilis, it is always worth while to make a judicious trial of hyd. c. cret.

[2] Ashby and Wright's *Diseases of Children*, 4th ed., p. 350.

[3] Owing to the proximity of the tube to the cords, this operation is not suited to cases in which an instrument has to be worn for any time.

[4] In these very urgent cases the operation may be performed with, *faute de mieux*, a sharp penknife and toothpick quill, or the opening may be kept patent for a time by retractors improvised out of bottle wire.

If relief be urgently called for, the knife should pass down to the cricothyroid membrane at once, and the left index having identified this, the membrane is opened by cutting horizontally just above the cricoid cartilage. The object of this is to keep away from the neighbourhood of the cords and to avoid the little cricothyroid vessels.

If the surgeon have more leisure, he may reach the cricothyroid membrane more gradually, feeling his way, using retractors, and perhaps identifying the interval between the sterno-hyoids. The only advantage of this is that all haemorrhage can be arrested before opening the air-tube. This is sometimes severe, and has led to fatal dyspnœa.

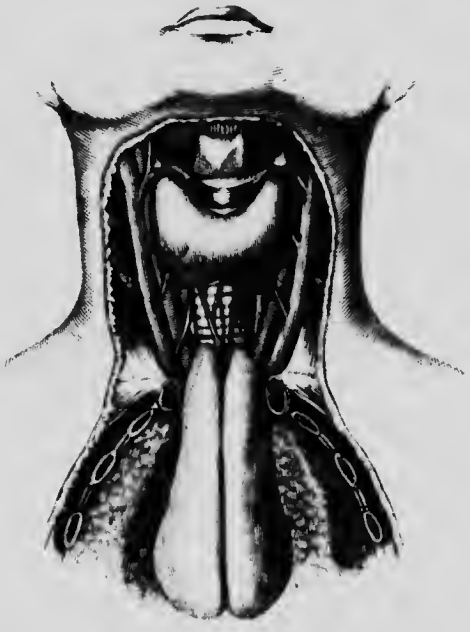


FIG. 250. Anatomy of the neck in early childhood, to show the relations of the thyroid [1] and thymus. (Heath.)

In inserting the tube, care must be taken that both the cricothyroid membrane and the subjacent mucous membrane are incised, and that the tube is really within the cavity of the larynx, not pushed down into the cellular tissue outside it. The space is always small, and, after middle life, increasingly rigid. The cannula, which should be shorter than those used for tracheotomy, of uniform bore throughout, and oval in section, is then secured with tapes.

TRACHEOTOMY

This operation will be carefully considered under the first of the following indications, and more briefly in its relation to the other ones.

Indications. (1) Diphtheria.

(2) Syphilitic and tuberculous ulceration, in order to give rest to the crippled part (p. 589).

[1] The isthmus of the thyroid gland is too large.

(3) Malignant disease of the larynx (p. 600).

(4) Papillomata of the larynx. By itself (p. 564) or as a part of the operation of thyrotomy (p. 560).

(5) In some cases of acute laryngitis (p. 580).

(6) Certain spasmodic affections, *e.g.* tetanus, or aneurysm of the thoracic aorta (p. 581).

(7) Foreign bodies in the air-passages: the removal of those which may lodge in the bronchi are treated separately (p. 608).

TRACHEOTOMY, WITH SPECIAL REFERENCE TO CASES OF MEMBRANOUS LARYNGITIS

General points all bearing upon a successful result: A. The age of the patient. B. Right time of operating, and wise selection of cases. C. Skilful operation. D. Painstaking and appropriate after-treatment.

A. **Average of Recoveries after Tracheotomy for Membranous Laryngitis.** Cases of laryngeal diphtheria requiring tracheotomy are the most severe and fatal of all cases of diphtheria. In pre-antitoxin days one recovery in three or four cases was a very good average. The percentage of recoveries has improved in the most striking manner since the introduction of treatment by antitoxin. Thus the statistics of the fever hospitals of the Metropolitan Asylums Board show the following striking figures.[1] In 1894 there were 261 cases, of which 184 died, or 70·4 per cent. In the nine succeeding years there were 2632 such cases, the numbers lying between 180 in 1903 and 390 in 1900.

The fatality has been as follows:

In 1895 it was 19·4	In 1898 it was 38·0	In 1901 it was 30·9
In 1896 it was 41·0	In 1899 it was 39·1	In 1902 it was 32·5
In 1897 it was 10·0	In 1900 it was 31·3	In 1903 it was 32·22

B. **Right Time for Operation.**[2] **and Wise Selection of Cases.** The nature of the dyspnœa is very various, and on this account the above two points are most important.

The four following conditions of dyspnœa are met with:

(i) Dyspnœa rapid, urgent, and localised to the larynx: much anxiety and restlessness: orthopnœa: stridor, the loudness of which is probably proportionate to the degree of obstruction in the larynx and the patency of the small tubes. In Prof. Buchanan's words, it points to a cavity ready to receive air if it could but get it, and to a passage narrowed

[1] These statistics are quoted from Sir W. P. Heeringham's article in *Clifford Allbutt's System of Medicine*, vol. i. p. 1031.

[2] Those surgeons who recommend an early operation rely especially on the existence of much sucking in, and of undoubted dyspnœa. With regard to the first, Dr. Passavant (*Ann. Surg.*, vol. i. p. 153) holds that tracheotomy, if deferred, allows prolonged dyspnœa to bring about simultaneously with retraction of the epigastrium, &c., an action on the lung surfaces analogous to that of a cupping glass upon the skin, viz. hyperæmia, stasis, hypersecretion of mucus, splenisation, and atelectasis. With regard to dyspnœa, Dr. Ranke, of Munich, lays great stress upon an early operation: "If a child with pharyngeal diphtheria has become hoarse, and shows laryngeal stridor and difficulty in breathing, which has already led to ever so short an attack of real dyspnœa, that child ought to be operated upon at once." Another practical point bearing upon the right time for operation is the fact that at night time children often get worse. If, then, a case is advancing, and parents cannot towards the day's close make up their minds to sanction an operation, they should be warned that the patient's condition may call for an operation which will be of necessity hurried, and be performed under much less favourable circumstances as to light, &c.

either by false membrane or spasm or both. On inspection of the chest, the extraordinary muscles of respiration are seen to be in action, there is much sucking-in of the infracostal and epigastric, and, later on, of the suprasternal and supraclavicular regions. While this sucking-in is vigorous and well marked, the lungs are probably free.

Auscultation and percussion are difficult. If the bases are resonant, and show vesicular murmur, it is of good omen. So, too, if the eyes, though starting, are bright, the face suffused, not livid, the lips of fairly natural colour, the cervical veins not much distended, the extremities not cold and the seat of stasis: in such cases the membrane, if present, is limited to the larynx, and the tendency to death is by laryngeal apnœa.

Tracheotomy here is not only justifiable, but imperatively called for, if previous treatment has failed: the prognosis is favourable if the operation is not too long deferred. Hopeful conditions: sudden onset, previous good health, absence of albuminuria, evidence of toxæmia little marked or absent.

(ii) When the dyspnœa increases more slowly though continuously. The restlessness is less violent, and the respiratory effects are less exaggerated. The sucking-in is much less marked, especially above. The chest seems to be impeded in its movements, puffing or heaving out *en masse*, and with difficulty; on auscultation and percussion, instead of vesicular murmur, or conducted hoarse laryngeal rhonchus, and normal bases, there will be found sibilant râles, small crepitation, and deficient resonance. These point to the exudation being no longer localised to the larynx, but more probably invading the finer bronchial tubes and air-vesicles, the former being swollen and infiltrated with membrane, the latter clogged with viscid mucus. The tint of the face is now pale or leaden. The operation is here much less likely to be successful, from the extension of the membrane, and the condition of the lung and of the right heart. Other unfavourable conditions: onset with much asthenia, albuminuria, evidence of toxæmia well marked.

(iii and iv) Dyspnœa, intermittent or paroxysmal. In the former case it is due probably to collections of viscid mucus or membrane in the larynx and trachea. Good power of expectoration is here very important. Paroxysmal dyspnœa means spasm. This, very common in all laryngeal dyspnœa, is especially so in children. The danger of this is obvious, and the question of tracheotomy will have to be decided according to whether the spasms are increasing, and by the distance of the medical man from his patient.

Dr. A. K. Gordon[1] puts the indications for operation excellently. "They are in order of appearance: a croupy cough, laryngeal stridor, retraction of the epigastrium and intercostal spaces, restlessness, cyanosis: then cessation of restlessness, cessation of retraction, followed by the apparent comfort which precedes death. It is important, however, not to take any one of them by itself, except apparent cessation of respiration, as an indication for operation: in the stage of active discomfort, where there is restlessness and dyspnœa, so long as there is no cyanosis, one should nowadays give a sufficient dose of antitoxin and wait, unless, of course, the patient cannot be watched, in which case it may be best not to attempt a cure without operation. It is when the stage of active discomfort is beginning to pass into that of diminishing distress and this is invariably heralded by blueness of the lips that the operation

[1] *Med. Chron.*, 1902, p. 96.

should be done. The sign of restlessness, however, deserves some mention, since its absence is occasionally taken as a sign that the operation is not required when the associated cyanosis should really demonstrate that the quietness is that of impending death; sometimes, too, its presence in a marked degree is the cause of an operation which is really premature, or unnecessary. It is well, too, to remember that retraction of the epigastrium during inspiration varies with the age of the patient. In a baby it is present in health when there is crying or struggling, and in small children a slight broncho-pneumonia will give rise to retraction when the larynx is healthy. In adults, and occasionally in big children, there is often no inspiratory retraction at all, though there be much laryngeal obstruction. The chief occasion in which tracheotomy is required in the absence of cyanosis is when repeated attacks of dyspnœa (especially after the first forty-eight hours of the disease) point to the presence of loose membrane in the trachea or larynx, in which case tracheotomy should be done in a quiet interval."

Three Chief Dangers of Deferring the Operation too long. (1) Œdema of the lungs.[1] Owing to the deficient entrance of air, reflex contraction of the pulmonary arterioles takes place, leading to distension of the main trunk, the right heart, and systemic veins. The bronchial veins being also engorged, serous exudation takes place into the finer tubes and vesicles at the bases, and respiration is thus further impeded.

(2) Exhaustion of the heart. Children if they repair quickly are exhausted quickly also.

(3) Thrombosis of the pulmonary artery. Owing to the stagnation in front, the blood current moves more and more slowly, and this obstruction by thrombi is not remediable by operation. The signs of this condition are increasing dyspnœa, a very feeble pulse, and combined pallor and lividity.

Recommendation of the operation to the friends. (*a*) In reply to questions as to the chance of cure, the surgeon will answer, with caution, that the operation conduces to cure by removing the most urgent danger by giving relief to the lungs, and thus also improving the strength by sleep and quiet. (*b*) He will be able to say that if death occur after tracheotomy it will be by exhaustion or by cardiac failure, not by apnœa, most distressing to witness, as well as to the patient.

C. **Points to be noted as to the operation.** *Question of anæsthetic.* In an infant, or when there is any indication of cardiac failure, or any marked cyanosis, or unconsciousness, an anæsthetic is best avoided. These children are so ill that they often scarcely notice the incision and are less adversely affected by it than by the administration of an anæsthetic. If these more serious symptoms are not present, or in older children, especially when there is a tendency to struggle, a little chloroform—*i.e.* just enough to prevent struggling during the operation—is as a rule safe and advantageous. It allays spasm and thus improves the breathing. It prevents struggling and promotes sleep after the operation. The greater the experience of the operator, the better his surroundings as to assistance, the greater the indication to dispense with chloroform. When an anæsthetic is given, the operator should be close at hand, with everything ready, in case the dyspnœa increases suddenly. The question of the use of eucaine, with or without chloroform, is referred to at p. 582: it is obviously more adapted to adults.

[1] *See also note*, p. 564.

Site of Operation. High or low, *i.e.* above or below the isthmus of the thyroid. It will be worth while just to consider here the parts met with in the middle line, (*a*) above and (*b*) below the thyroid isthmus. (*a*) Skin, superficial fascia, branches of the transverse cervical and infra-mandibular (seventh) nerves, lymphatics, cutaneous arteries, anterior jugular veins which with their transverse branches are smaller here deep fascia, cellular tissue, superior thyroid vessels, the isthmus, usually over the second and third rings, and pre-tracheal layer of deep cervical fascia. The importance of this last is twofold: if the trachea be insufficiently opened the tube may be passed between the trachea and the fascia overlying it, embarrassing the patient's breathing and the operator alike. If the wound become septic this layer, continuous below with the pericardium, may conduct pus into the mediastinum. (*b*) The surface structures are much the same but the anterior jugular vein and its transverse branches are much larger. The sterno-thyroids are here quite close together.[1] The inferior thyroid veins are larger. A thyroidea ima artery may be present, and the innominate artery cross as high as the seventh ring. The trachea is also deeper, smaller and more mobile, having no steadying muscles here as higher up. The thymus, too, in young children may present a difficulty. In addition to the above anatomical objections to the low operation, there are three surgical ones, viz. (1) pus is now more easily conducted into the mediastinum. (2) In the same way, broncho-pneumonia is more probable from a wound in the trachea low down. (3) From the proximity of the chest, and its suction action, the tube is much more pulled into the wound, and hence may more easily become displaced.

Operation. The instruments required are a small scalpel, the handle of which can be used as a blunt dissector, two or three pairs of Spencer-Wells forceps, two or three Lane's tissue forceps, dissecting forceps, scissors, director, sutures and ligatures of catgut and silkworm gut, and suitable tubes[2] and pilots. They should be spread out ready to hand on a sterilised towel, as in an instant, moving the child or beginning the anæsthetic may cause the most urgent dyspnœa. The question of an anæsthetic has already been discussed. The child's neck and head, at first raised and relaxed,[3] are stretched over a sandbag or a large bottle wrapped up in a towel, while the hands are secured in the jack towel which firmly encircles the body. Three assistants at least are desirable one to

[1] Above, the sterno-hyoids are almost in contact in the middle line, with only an interval of about an eighth of an inch—a strong argument in favour of keeping in the middle line exactly (Parker).

[2] The best tracheotomy-tubes are Parker's and Durham's. If the latter are chosen they must be of reliable manufacture. Whatever tube is chosen, it should have a movable shield to prevent irritation of the trachea, and it should just fit snugly in the trachea, being lightly held by this. Mr. Parker (*loc. supra. cit.*, p. 84) argues strongly in favour of angular tubes. He shows that the usual quarter-inch tubes impinge with their lower extremity on the anterior wall of the trachea, thus tending to produce ulceration and grave risks (p. 575). Whatever tube is chosen, it should be as large and as short as possible: it should be of the same size throughout, without tapering: the inner tube should project a little beyond the outer one, while the whole tube should fit snugly, standing out as little as possible in the neck. As to the size of the tubes needful, Mr. Parker recommends a series running from Nos. 18, 20, 22, 24, 26, and 28 for the outer tube. Of these sizes the following are the most useful: No. 24 in children from one to three, and No. 26 in those from three to seven.

[3] Whenever an anæsthetic is being given in cases of dyspnœa, the patients, whatever the age, should be allowed to choose their own position at first, and any movements or alterations in the position of the head and neck, preparatory to the commencement of the operation, should be carefully made.

support the head and give the anæsthetic, another to sponge, and the third to prevent any struggling and to hold a light if needed. It is almost superfluous to add that the light should be the best possible. The surgeon [1] with his left thumb [2] and forefinger steadies the trachea and makes it a little prominent as well, without any compression; he then incises the soft parts in the middle line from about the centre of the cricoid [3] downwards for about two inches, cutting well through the fat, often abundant here, and exposing the interval between the sterno-hyoids; he incises this interval and, if he has reason to fear hæmorrhage, with the point of a steel director placed in the upper part of the wound, he slits down the remaining soft parts in the middle line till he can distinctly feel or, with the aid of retractors, see the tracheal rings. The point of the knife is often required here to incise surely the pre-tracheal fascia.

Until the trachea is distinctly exposed the left forefinger and thumb must not be removed from their steadying position on either side. With the blade of the knife held upwards, the middle line of the front of the trachea is then punctured, stabwise, and two or three rings divided. The sufficiency of the opening is known by a free and noisy rush of air, accompanied often by the expulsion of membrane, which should be sponged away at once. On the other hand, an inadequate opening will be indicated by the hissing only of air through the slit-like opening, without any free rush and with no escape of membrane or relief of the dyspnœa. In this latter case the first opening must be found by the finger-nail and carefully enlarged.[4] The cannula is then inserted on a pilot, and secured with tapes in situ. Some prefer to use a hook to steady the trachea, and a pair of dressing-forceps or dilators to separate the edges of the incision; these are more likely to be helpful in a "low" operation, or where a pilot is not used to insert the cannula. If it be desired to try and remove any membrane,[5] the cannula should not be inserted at once, but the opening dilated with dressing-forceps, or with Golding-Bird's or Parker's dilator. When inserted, the cannula must be in the middle line, otherwise there will be troublesome irritation of the trachea and plugging of the cannula. Several sizes of tube should always be ready and sterilised. The larger the tube that can be inserted, the more snugly it rides in the trachea, the less the irritation and consequent formation of granulations, the less risk of membrane being drawn down past it from above, and lastly, the less frequently will it need changing. The wound should be sutured, around the tube closely, with silkworm gut.

Chief Difficulties. (1) Insufficient skin-incision, giving no room for

[1] He first, as soon as the head and neck are in position, marks the chief spots in the middle line, viz. centre of the chin and manubrium, and (when they can be felt) the hyoid bone and the thyroid and cricoid cartilages, especially the last.

[2] Dr. Buchanan considers the following a good rule: "Never plunge the knife into the trachea till the white rings are clearly seen at the bottom of the wound." In cases of real urgency the surgeon must be satisfied with touch and not with sight.

[3] This cartilage is often accidentally divided.

[4] If the opening be to one side, as well as too small, a fresh and adequate one should be made in the middle line.

[5] Mr. Parker, one of the chief authorities on this subject, strongly advises that all membrane as well as mucus be got rid of, on account of its impediment to respiration, its infectiousness, and the patient's inability to get rid of it himself by coughing after tracheotomy. On this account Mr. Parker recommends gently twirling about a feather (the shorter and finer pheasant-tail feathers are the best) soaked in a solution of sodium carbonate, and passed several times, not only down into the trachea, but up into the glottis. Mr. Parker condemns attempts to suck out membrane, by putting the lips directly to the wound, as of no service to the patient, and as possibly very disastrous to the operator.

the deeper work.[1] (2) Not keeping to the middle line, the abundant fat, and the indistinctness of landmarks, *e.g.* a flat thyroid in a little child, aiding this mistake. (3) Not steadying the trachea. This omission leads to missing the air-passage altogether. Cutting to one side of it, or cutting into it laterally, instead of centrally, and insufficiently. (4) Haemorrhage, the chief bugbear of the operation, varies extremely. Generally it is not great. The greater the experience of the operator, the more strictly he

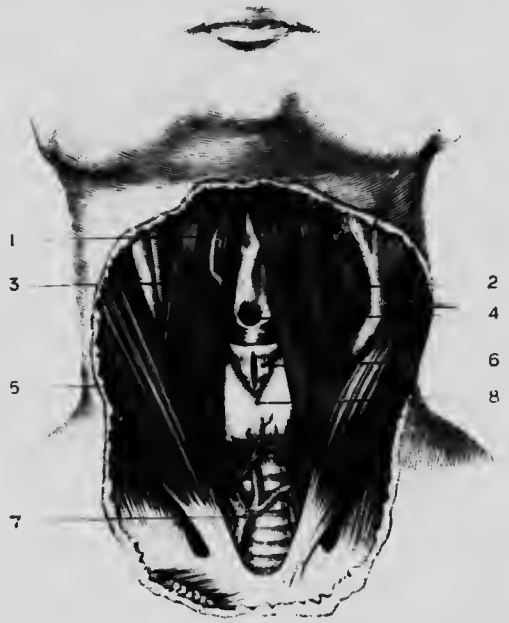


FIG. 251. Anatomy of the neck of an adult. 1. Sternohyoid. 2. Foreign body in the oesophagus. 3. Omo-hyoid. 4. Crico-thyroid membrane. 5. Sterno-mastoid. 6. Tracheotomy opening in the trachea. 7. Inferior thyroid veins. 8. Isthmus of the thyroid gland. (Heath.)

keeps in the middle line, the more rapidly he is able to operate safely, the more may the bleeding be disregarded. Any artery which spurts should, of course, be tied at once or caught in Spencer-Wells forceps, and a vein of any size which lies in the way should be caught between two of these forceps before it is divided. Venous haemorrhage, as a rule, stops as soon as the trachea is opened and respiration established. A sufficient median skin-incision aids the meeting of haemorrhage. With regard to the isthmus of the thyroid, this may usually be neglected by the surgeon; if felt by the finger to be large, it may be depressed.[2] If encountered in older subjects, or if large in children, it may be compressed by two pairs of Spencer-Wells forceps before division, or ligatured on either side by passing an aneurysm-needle beneath it. If, as rarely happens, the venous bleeding is very free, and the patient's condition from dyspnoea critical,

[1] As in a colotomy, or other deep incision, the wound should not not be funnel-shaped.

[2] In children this may certainly be ignored. If the knife is used to open cleanly and sufficiently the deep fascia, and then a round pointed steel director to clear the way down to the trachea, the operation will be almost bloodless.

the trachea must be felt for and opened before the hæmorrhage is arrested. The urgency of the case must here come before the amount of the bleeding. In these cases the moment the trachea is opened the patient must be turned well over on to his side. Entrance of blood, to any amount, into the lungs must be avoided; it will add to the dyspnœa now, and, later on, may set up broncho-pneumonia. (5) Insertion of cannula. If the trachea has not been steadied, and the rings not clearly made out by sight or touch, the opening will very likely be made inadequate or to one side. Another difficulty may arise here from the tracheal fascia not having been sufficiently cut, or from the tube being pushed down between the fascia and the trachea, this, of course, only further embarrassing the breathing. Lastly, though the tracheal rings are cut, the swollen and inflamed mucus membrane may not have been sufficiently divided, or a false membrane may have, in the same way, been carried before the knife. (6) Little or no relief after insertion of the cannula. Though this may have been well and truly done, it is not followed by the relief which has been expected. This may be due (*a*) to the tube being passed between the trachea and some membrane which plugs it; (*b*) to the trachea and bronchi being blocked with membrane, &c., (*c*) to the child, owing to the operation being performed late, being practically asphyxiated before the completion of the operation. The indications now are to pass a long narrow feather down the tube, to remove the tube, and to clear out the trachea, while artificial respiration is vigorously performed and kept up, the opening into the trachea being kept patent by dressing-forceps or by one of the dilators above mentioned (p. 568). If feathers or brushes fail to reach and remove the membrane, trial may be made of aspiration. The best means of effecting this is by Mr. Parker's tracheal aspirator, which consists of a small glass cylinder, three or four inches long, to one extremity of which the end of a silk catheter is attached, and to the other an india-rubber tube ending in a mouthpiece.[1] It can be taken to pieces to facilitate cleaning. Before use a little cotton-wool is packed into the cylinder to prevent any dangerous membrane reaching the operator's mouth. Direct suction should never be performed in membranous laryngitis; in other cases where blood alone is the cause of the dyspnœa, it may of course be thus removed.

D. **After-treatment.** This subject, neglected in most books, is often too little looked to in practice. The question of the most suitable atmosphere for the patient will first arise. By many a tent (readily improvised by converting a cot into a four-poster, by fastening on four vertical pieces of wood at the corners, joining these by four horizontal pieces, and throwing a sheet over all) is recommended, and, one side of the cot being left uncovered, steam is conducted thither by one of the different forms of croup-kettles. While fully aware of the need of moisture when the atmosphere is dry, when the membrane tends to crust and become fixed, Mr. Jacobson is of the opinion that the above unvarying rule of cot-tenting and use of steam is disadvantageous. The weakly condition of children with membraneous laryngitis, and all that they have gone through, must be remembered. Believing that such seclusion and so little admission of air tend to increase the asthenia, and any tendency to infection it is much better to keep off draughts by a screen, which allows of the escape of vitiated air above, using steam only if needful, according to the size of the room, fireplace, &c., and according to the kind of ex-

[1] *Loc. supra. cit.*, Fig. 12, p. 98.

pectoration,[1] whether easily brought up by cough or feathers, or viscid, quickly drying, and causing whistling breathing. The inner tube must be frequently removed and cleansed, every hour or two at first. If the secretions dry on and cling to it, they are best removed by the soda solution mentioned below. At varying intervals between the removals of the tube, any membrane, &c., which is blocking it, appearing for a moment at its mouth and then sucked back, must be got rid of by inserting narrow pheasant feathers, and twisting them round before removing them. If the exudation is slight, moist, and easily brought up by a cough or feather, sponging and brushing out the trachea are not called for, but they should be made use of when there is much flapping, clicking or whistling breathing; and if this is harsh, dry or noisy, instead of moist and noiseless, two of the best solutions are sodæ bicarb. gr. v-xx to aq. ℥j, or a saturated one of borax with soda. These may be applied by a hand or steam-spray over the cannula for five or ten minutes at a time, at intervals varying according to the relief which is given, or applied with a laryngeal brush, feather or a bit of sponge twisted securely into a loop of wire. When any of these are used, the risk of excoriation and bleeding, and the fact that only the trachea and large bronchi can be cleansed, must be borne in mind; and with regard to manipulations for cleansing the trachea, and removing the inner tube, it is most important to remember that these may be overdone, and a weakly child still further exhausted by meddlesome interference. This point requires special attention from the surgeon in the case of some nurses who should be given very definite instructions as to this most important point. There is often much difficulty in getting sufficient food taken. This and the amount of sleep are two most important points.

For the first twenty-four hours the child should be disturbed as little as possible. The pain in swallowing, the impairment of the act owing to the presence of the tube, &c., and thus the facility with which liquids may reach the lungs, are facts to be duly remembered. It will usually be better to pass a Jacques catheter (No. 4 or 6) by the nose, and then to feed the patient, at regular intervals, with definite amounts. Care must be taken to see, by the absence of irritation, that the tube is not in the larynx, and, if the above soft tubes are used, that they do not coil up at the back of the tongue.

The Removal of the Tube next requires consideration. It should be dispensed with at the earliest opportunity, either altogether, or replaced by an india-rubber tube between the fourth and ninth days. Quite apart from the danger, which is inseparable from a metallic tube,[2] of irritation and ulceration of the trachea, there is this object in getting rid of the tube as soon as possible, that the longer the child is allowed to breathe through the tube the more is the act of breathing through the natural

[1] G. A. Wright (*Diseases of Children*, p. 164) quotes from Cock's (*Arch. Pædiat.*, January 1884) that sudden obstruction of the tube is most often due to inspissated mucus, not membrane; this thick mucus is secreted usually about twenty-four hours after the operation and after three or four days the discharge becomes thinner and more puriform. But blocking of the tube with membrane does certainly occur; it is known by the sudden cyanosis and struggles of the child, while no air enters the tube. The whole tube must be removed; if this and the consequent coughing does not expel the membrane, the wound must be dilated, and the membrane extracted.

[2] Mr. Parker points out (*loc. supra. cit.*) that black patches seen on the outer tube when removed may indicate ulceration of the trachea, and show the need of changing the tube. Such discoloration may point, here and in intubation, to an inferior quality of the metal of the tube.

passages allowed to be, as it were, forgotten, with the result that, on the tube being removed, asphyxia is threatened. The chief points to go by in deciding as to whether the tube can be safely dispensed with or replaced by one of india-rubber is the freedom of entry of air through the larynx, and absence of any sucking-in below, and whether some skilled observer can remain present and decide whether sufficient air is reaching the lungs through the larynx and through the wound without being in a nervous hurry to replace the tube.

Conditions which Impede the Removal of the Tube. (1) Prolonged formation of membrane. The longest possible period for this is probably about ten days. Patience and support are the main indications here. (2) The larynx is crippled like any other inflamed part. (3) The air passage is closed by granulation, usually above the cannula. More common than these is obstinate swelling of the mucous membrane. Here some advise that the tube be removed, and astringents and caustics carefully applied from below, with the aid of an anæsthetic if necessary. It has often been found more satisfactory to reinsert a tube of large size, with a hole on its convexity, and to leave it in for a week or two, thus giving further rest to the parts. Needless resort to caustics will certainly risk the occurrence of stenosis later on. (4) Closure of larynx by deep ulceration cicatrising after detachment of membrane. In such a case, with the aid of anæsthetics, the larynx must be opened up by probes of increasing size and laminaria tents introduced from below, and later on by the use of Macewen's tubes (p. 573). (5) Paralysis of the dilating crico-arytenoidei postici, from fear, excitement, or during effort.[1] (6) The commonest cause of inability to dispense with the tube is probably due to the rapidity with which the larynx falls into abeyance when a child is allowed to breathe through a tracheal cannula, the patient at this age not being intelligent enough to understand the importance of dispensing with the tube, and perhaps too young to care to talk, or, if older, not realising the need of again using its voice while all its wants are supplied. With the above condition are coupled a nervous dread of having the tube removed, and paroxysms of temper and struggling which rapidly produce embarrassed breathing. Any organic mischief, such as adhesions in the larynx, is extremely rare, and granulations above or below the tube are more often talked of and given as a reason for inability to dispense with the tube than really seen.

But while real organic mischief is rare and the usual cause is due to conditions which would seem to be only temporary, it is well known that, in some cases, getting a little child to dispense with the tube is a most baffling and prolonged affair. The following points are worthy of attention: Early attempts to remove the cannula, whether metal or india-rubber. A reliable nurse. Ability on the part of the surgeon so to arrange his time as to be himself frequently present at first, and, in the intervals, to be represented by an assistant who will not replace the tube before it is absolutely necessary to do so, and who can dilate the opening with a pair of dressing-forceps and perform artificial respiration if these steps are required. Shortening the india-rubber tube, till eventually little

[1] In a case in which tracheotomy had been performed by Mr. Jacobson, and while the child was being watched for the first few hours after the tube had been dispensed with, most urgent symptoms came on during the slight straining which accompanied an action of the bowels, the patient falling off the bed-pan on to the floor apparently lifeless. Artificial respiration restored the child, and the case did well.

more than the shield is worn, the child being comforted by the apparent presence of the tube. Encouraging the child to make use of his larynx by breathing through the tube and expiring through the larynx while the tube is closed. Patiently persevering efforts to get a child to talk, or, in the case of a younger one, to use his larynx by blowing out a spirit-lamp or using a penny trumpet. All this time every attempt should be made to improve the general health: wise feeding (too frequent or too large meals provoke dyspnœa), attention to the bowels, tonics such as Easton's syrup, proper clothing, cold or tepid sponging followed by friction, change of scene and air in every possible way, especially at the seaside.

In a large majority of cases the above treatment, aided by patience, tact, and time, which allows of development of the air passages, will suffice. In a few the attempts at removing the tube will still fail. Where this is so, and, in fact, in any case where the use of the tube seems likely to be protracted, the larynx should be dilated—a step which is brought about by simple means, as the larynx is usually merely functionless from disuse, not blocked up, or the glottis closed—by a tube through which the child is made to breathe.

In a recent case the simplest way of effecting this is, after chloroform has been given, to remove the tracheotomy-tube, dilate the wound if needful, and pass upwards from it a drainage-tube or catheter with a double silk web; the upper end of this is drawn out of the mouth (with the aid of a gag if needful), and tied to the lower end which projects through the wound.

The tracheotomy-tube is then replaced for a day or two, and on the withdrawal of the tube from the larynx it can usually be dispensed with altogether. Another very simple and efficient means is thus given by G. A. Wright[1]: "A flexible probe should be passed up through the glottis from below, and a piece of silk carrying a small sponge be attached to it: the probe should then be drawn out through the mouth, and the sponge, carried through the larynx, sweeps it out, breaks down any adhesions, and clears away mucus or any granulations."

Occasionally, in cases of longer standing, the above simple treatment may not be sufficient, and here intubation with vulcanite tubes (pp. 576 *et seq.*), or the use of Macewen's tubes passed through the larynx[2] and into the trachea below the wound, should be made use of. If intubation tubes are not available, chloroform having been given, one of Macewen's tubes—they resemble stout gum-elastic catheters with terminal fully bevelled openings—is passed from the tracheal opening downwards through the larynx into the mouth.[3] Having hooked this end out of the mouth,[4] the surgeon now passes the other end down the trachea beyond the wound, a step sometimes accompanied with difficulty. The object of the surgeon should be to place this lower end of the tube only just below the tracheal opening, so that air is drawn in from the end projecting through the mouth into the trachea, without leaving any needless length of the tube here or in one bronchus for fear of setting up irritation or secretion. To prevent the child pulling out the tube, the hands should be secured for the

[1] *Loc. supra. cit.*, p. 165.

[2] See paper by Mr. Bilton Pollard (*Lancet*, 1887) on this subject.

[3] It is more easy to pass the tube this way owing to the facility with which, when passed from above, it finds its way into the œsophagus.

[4] The tube will be found to pass readily behind the soft palate.

first few hours, and to prevent the tube being bitten it is well to pass a piece of drainage-tube[1] over the first few inches. This end is then secured with tapes around the head. The tube may be left in from twelve to eighteen hours, according to the amount of secretion and the facility with which the tube is blocked.

While this treatment is being carried out it is well to isolate the child in a separate room, as the breathing through the tube is very noisy, being often accompanied by very loud bubbling sounds, and the aspect of the child while this necessary dilating of the larynx is going on is one of apparently great distress.

When it is evident that the tube is clogged it must be withdrawn and cleansed, and, a little anæsthetic having been given, again inserted. At any time, if needed, the cannula must be re-inserted and artificial respiration performed. It will be readily understood that during this time the presence of the surgeon, and reliable assistants who will not lose their heads, and nurses with much tact and temper, are pre-eminently required. Even when laryngeal breathing has been restored and the tube has been dispensed with, the child must be carefully watched, especially at night. If natural breathing fails, it is better, whenever there is time, to replace the Macewen's tube in the trachea rather than re-insert the tracheotomy-tube into the old wound, a mode of relief which is too likely to be resorted to on account of its facility, but one which tends to keep up the sinus-like nature of the wound in the trachea, and brings back that most pernicious tendency of the child to prefer and confide in this mode of breathing.

Complications during the After-treatment. (*a*) *Hæmorrhage.* This is not uncommon; if immediate, it is due to some vessel having been left unsecured. Later on, it may be brought about by ulceration of the trachea set up by the pressure of the cannula[2]; through separation of false membrane by sloughing; a velvety and swollen condition of the mucous membrane: or by prominent granulations. The treatment is clearly preventive—to dispense with a tube, especially a metal one, as soon as possible, and from the first to use one of appropriate length and curve (footnote, p. 567).

(*b*) *A Sloughing Condition of the Wound.* If this is threatening, attention must be paid to the tightness of the tapes, so that the cannula be not needlessly buried in the wound, and to the wearing of a collar of boric lint under the shield. The tube must be removed at intervals, or replaced by an india-rubber one, air tending to enter without a tube as soon as the edges of the wound are healing. If the wound be not only sloughy but gangrenous and diphtheritic, in addition to frequent cleansing with a camel's-hair brush, the use of hot boracic or zinc chloride lotions, stronger measures, such as the application of silver nitrate or pure carbolic acid, will be called for. The general treatment will not, of course, be neglected in these cases.

(*c*) *Emphysema.*[3] This is usually the result of a faulty operation. The

[1] This simple means is much better borne by the child than the gag. Its suggestion was made, some years ago, by Dr. Arthur E. Poolman.

[2] Some undoubted cases of ulceration into the innominate after low tracheotomies in children are on record, *e.g. Path. Soc. Trans.*, vol. xi. p. 20.

[3] On this subject the reader should consult the full and detailed papers of Sir F. Champneys, in vols. lxv, lxvi, and lxviii of the *Med. Chir. Trans.*, and his work on Artificial Respiration. The following are amongst the practical conclusions with which his pages abound: (1) Emphysema of the anterior mediastinum, often associated with pneumo-

incision into the trachea is either wrongly placed *i.e.* it is not in the same line with that in the soft parts or it is too small; perhaps two small ones have been made; very rarely is the emphysema due to too large an incision in the trachea. Or, the incision may have been correctly made, but some fault connected with the tube may produce the emphysema; thus it may have been originally too short, or have been pushed out of the wound by swelling of the soft parts or by coughing. As a rule this complication is not dangerous unless it be extreme in very young children, or unless it travel deeply.

(*d*) *Ulceration of the Trachea.* This is usually due to the pressure of a cannula faulty in length, or curve, much more rarely to separation of membranes or sloughs. There are no definitely characteristic signs of this complication; the following point to it: Streaks of blood expectorated a day or two after the operation, and perhaps discoloration of the lower end of the tube. This accident is especially likely to occur in cases of diphtheria, where antitoxin has not been given or delayed, as the vitality of the tissues is here much lowered. The tube should be left out if possible, or an india-rubber one substituted, worn as short as possible, and cut obliquely so that the end does not impinge upon the anterior wall of the trachea. If it is necessary to dispense with all tubes, attempts may be made to keep the edges of the tracheal wound stitched to that in the soft parts for a few hours, or Mr. Gobling-Bird's dilator may be worn.

(*e*) *Suppuration in Mediastina.* This is a rare complication. When it does occur it is liable to be very rapid. It results from a descending cellulitis from the wound. The only treatment is prevention by a well-performed operation, and by attention to the wound.

Other complications which are not surgical may, of course, be present, viz. extension of the exudation downwards, general infection, paralysis, albuminuria, broncho-pneumonia—a very frequent one, known by a rise of temperature with frequent respiration and dyspnœa, dulness on percussion, bronchial breathing, with bubbling and crepitant râles. The discharge becomes scanty, the child is restless with a tendency to lividity, and there is a return of the sucking-in in the supra-clavicular and epigastric regions, while no obstruction is found in the tube. The antitoxin treatment has very largely lessened the frequency of the above-mentioned difficulties and complications of the after-treatment.

INTUBATION OF THE LARYNX AS A SUBSTITUTE FOR TRACHEOTOMY IN MEMBRANOUS LARYNGITIS OR STENOSIS OF THE LARYNX

Attention was first called to this subject by Sir W. Macewen.[1] The tubes he used have been alluded to at p. 573. It was, later on, more prominently brought forward in America.[2]

thorax, occurs in a certain number of tracheotomies. (2) The conditions favouring this are, division of the deep cervical fascia, obstruction to the air passages, and inspiratory efforts. (3) The incision in the deep cervical fascia downwards should not be longer than needful. (4) The frequency of emphysema probably depends much on the skill of the operator, especially in inserting the tube. (5) The dangerous period during tracheotomy is the interval between the division of the deep cervical fascia and the inefficient introduction of the tube. (6) If artificial respiration is necessary, the tissues should be kept in apposition with the trachea, and any manipulations performed without jerks.

[1] *Brit. Med. Journ.*, July 24 and 31, 1880.

[2] Especially by the late Dr. O'Dwyer, whose paper appeared in the *New York Med. Journ.*, August 1885. Amongst many more recent papers are—O'Dwyer, *Arch. of*

The Advantages claimed. The chief of these, the easy and rapid introduction of a tube, has been substantiated of recent years, when the favourable conditions of special skill and experience are granted. On the presence of these conditions the whole question turns (p. 578).

(1) The consent of the friends will be more quickly obtained than in the case of tracheotomy. (2) Intubation requires no anæsthetic. (3) The tubes are easily and quickly introduced, and thus the operation is

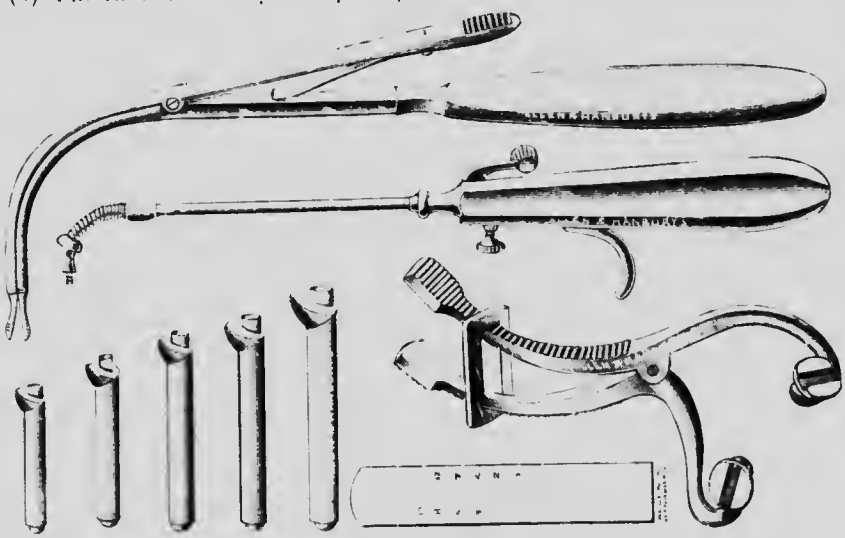


FIG. 252. O'Dwyer's intubation instruments, consisting of tubes, introducer, extractor, mouth-gag and measuring scale.

much more rapidly performed. (4) There is no severe or difficult operation as in tracheotomy. (5) The inspired air is drawn warm and moist through the natural passages: thus the depressing effects of a steam-tent are avoided.[1] (6) There is no open wound requiring careful treatment, and there is not the same difficulty in getting rid of the tube. (7) The after-treatment is, therefore, much less prolonged. This advantage is not to be expected invariably. It occasionally happens that after the original trouble for which intubation was done has disappeared, it is impossible to remove the tube from the larynx without dyspnœa returning, necessitating the return of the tube. Such a condition is termed "retained tube." O'Dwyer, the authority upon all matters pertaining to intubation, in a paper read before the American Pediatric Association in May 1897, said that "the cause of [illegible]stent stenosis following intubation in laryngeal diphtheria can be summed up in a single word—'traumatism.' Paralysis of the vocal cords may possibly furnish an occasional exception to this rule." The reason of the traumatism may be a tube that does not fit, one that is imperfect in its construction, or injury to the tissues by unskilled operators. Undoubtedly most of the cases of retained tube

Pediat., 1897, xiv. p. 481; those by Dr. F. Wright, of New Haven; Dr. Lovett, of Boston; Dr. Codd and Dr. E. W. Goodall, of this country (*Edin. Med. Journ.*, 1902, vol. i. p. 223). The last-mentioned writer is an authority not only on intubation but also on those diseases which may call for it. A paper by Dr. Bason (*Lancet*, July 13, 1901, p. 76) will also be found helpful with its cases and practical details. *See also* Fairbank, *Lancet*, 1903, vol. i. p. 1724.

[1] Codd, *loc. infra cit.*

are due to the tube being too large, notwithstanding the size for the age has been used. This condition has most frequently happened when the 3 to 4 size has been used. If the pressure is great enough seriously to interfere with the circulation, even if it does not cause ulceration, there will be an œdema of the surrounding tissues. The tube being withdrawn, the pressure is suddenly removed, and the submucous tissue becomes infiltrated, and, being surrounded with cartilage, can swell in but one direction, thus obstructing respiration by narrowing the lumen of the larynx. Sometimes the head of the tube, by making undue pressure upon the parts on which it rests, causes an abrasion from which granulations spring, and, as the tube is removed these drop down into the chink of the glottis and obstruct respiration. Dr. Goodall, who only met with ulceration of the larynx four times in 101 cases of intubation, concludes as follows: "Be very careful in the introduction of the tube. Do not intubate when the larynx is very much swollen. If in any case intubation is found to be difficult, do not persist too much in your efforts, especially if your experience of the operation is limited. Lastly, do not intubate the same case more than three times. If these rules are adhered to, I believe that ulceration of the larynx will occur no more frequently after intubation than it does after tracheotomy."[1] Intubation may fail, and its failure on any of the following grounds may necessitate tracheotomy (Goodall). (1) Intubation may not relieve. (2) Some time after the removal of the tube dyspnœa may recur, and the patient's condition be too serious to allow of re-intubation. (3) The tube may become suddenly blocked (*vide infra*). (4) Failure may follow an attempt at re-intubation. (5) The medical man called to the patient may have had no experience of intubation. (6) The larynx may be ulcerated.

Disadvantages. Difficulties, and Dangers. (1) In Dr. Codd's words, "The epiglottis may be very turgid, and the parts generally œdematous, and the point of the tube, though entering the upper part of the larynx, may fail to get through the glottis or even to get as far as it. This can be got over by thrusting the left index-finger firmly down to the glottis. I have nearly always found this to succeed, and it is not a bad plan to follow systematically. The inexperienced sometimes enter the ventricles of the larynx if they diverge from the middle line. (2) In introducing the tube, membrane may be dislodged into the trachea, causing fatal dyspnœa unless tracheotomy be performed at once." Dr. Goodall admits that the displacement of false membrane before the tube may occur, and that tracheotomy, requiring rapid execution, under these circumstances may be required. (3) There may be great difficulty in getting children to take sufficient food, as swallowing is for the first few days much embarrassed. The importance of sufficient food being taken has already been alluded to (p. 571). (4) Parts of the liquids taken find their way into air-passages. Dr. Codd considers the latter "a theoretic objection." The difficulty in feeding can be met by the Cassellbury method: "The child is placed on the nurse's lap, the head being down, and fed with a

[1] Bokay (*Deut. Med. Woch.*, 1901, No. 17) reports five cases in which removal of the intubation tube at the end of periods varying from 107 to 294 hours led to alarming symptoms, attributed to ulceration from pressure. In one case this diagnosis was confirmed by the subsequent development of stenosis. He advises that the portion of the tube between the neck and the body be coated with gelatine, into which, while it is still soft, powdered alum is pressed. This proves simple and effective, and is recommended in all cases where the intubation has lasted over a hundred hours, and when pressure ulceration is suspected. He considers that by following this rule secondary tracheotomy will usually be avoided.

spoon so that it swallows uphill." In Dr. Goodall's opinion, ample nutriment can be given either by a tube passed through the nose into the stomach or by rectal feeding. (5) The tube may be coughed out. In such cases, if the medical man is absent, death may occur in a few minutes. Dr. Goodall found that the tube was coughed up or pulled out by the patient in 28 per cent. of his cases. "Dyspnœa by no means always returns at once, and when it does there is ample time for the medical officer to reach the patient and re-insert the tube or perform tracheotomy. Intubation cases doubtless require the medical officer to be more at their beck and call than do tracheotomy cases; but this cannot be claimed as a serious objection." (6) The tubes are liable to become plugged with membrane. In Dr. Goodall's cases sudden blocking of the tube occurred in 12 per cent. He considers that in hospital practice there appears always to be time for a medical man to reach the patient early enough to remove the tube, and, if needful, open the trachea successfully. Recently special patterns of wider tubes have been recommended for use in cases where there is much loose membrane or discharge. Dr. Codd recommends "short cylinders. The largest possible size should be used and wedged into the larynx, and retained only a few hours at the most."[1]

Dr. Goodall in discussing the indications for intubation and tracheotomy considers that even cases with abundant faucial membrane are not necessarily excluded from intubation, "provided that there are no symptoms of profound toxæmia, and no œdema of the fauces to obstruct the upper opening of the tube in situ." With regard to the number of insertions of the tube that may be made before tracheotomy is resorted to, he would rule that "if three insertions, each of several hours' duration, fail to cure the obstruction, tracheotomy should be performed."

While Dr. Codd, in his candid and helpful paper,[2] has no hesitation in declaring that intubation is by far a better operation than tracheotomy—emphatically so in hospitals, and, he believes, also in private practice—his results scarcely bear this out. Of twenty-six cases of intubation for diphtheria, fourteen were fatal. All were treated with antitoxin. With regards to these results, which cannot be compared with those given by tracheotomy, combined with serum-treatment, in a large hospital at the present day, it is noteworthy that they are the outcome of the work of an operator who has evidently taken up the subject with much zeal and ability.

It is probable that while in those institutions where a special knowledge of the diseases which call for intubation exists, and where a mastery of the details needed can be obtained owing to the staff changing at long intervals, intubation at the present day will give as good results as tracheotomy, as shown by those obtained by Dr. Goodall and Dr. Waxham (*vide infra*); this is not the case in those hospitals where the service changes more frequently. In private practice it is not likely to be employed. It is only fair to add that the introduction of antitoxin has led to

[1] The question of tracheotomy has already been referred to at p. 576 and Dr. Goodall's opinion given. It is obvious that in hands less skilled than his ulceration and stenosis may occur, especially if the practitioner be prevented from visiting his patient at the time required. A case of fatal ulceration is candidly recorded by Dr. F. W. Carr (*Lancet*, vol. i., 1891, p. 713). The tube here was "somewhat large," a smaller one having been coughed out.

[2] "Intubation of the Larynx." *Birmingham Med. Rev.*, August and September 1898.

the same improvement in the results of intubation for diphtheria as it has in those of tracheotomy (p. 564).

TECHNIQUE OF INTUBATION

O'Dwyer's method. To prevent movements of the child,[1] it is wrapped securely in a blanket, and placed in an upright position on the lap of a nurse, the head resting on her left shoulder. The nurse holds the upper limbs securely with her hands, and the lower ones with her knees. An assistant standing behind, and to the left of the nurse, holds the head of the child inclined somewhat backwards, perfectly steady, and towards the operator. The latter, seated so as to face the patient, opens the mouth widely with a gag. At this stage the struggles of the child may so increase the respiratory distress that instant performance of tracheotomy is demanded. Cardiac syncope is now especially to be feared. The operator next, while his right hand holds an introducer with the tube of appropriate size fitted on and threaded, with his left index finger, protected with a finger-stall or a sealed gauze dressing, hooks up the epiglottis. The position of the glottis being thus localised, the tube is carried along the inner side of the left index, and then downwards and forwards by raising the handle of the introducer, which must be carefully kept in the middle line. When the tube is in place the left index finger gently pushes it down, and at the same time the introducer is withdrawn, the handle being gradually depressed. Any difficulty in introducing the tube may be got over by waiting for an inspiratory effort on the part of the patient, and then slipping in the tube. With his left index the operator then makes sure that the tube is in place, by feeling the posterior wall of the larynx between his finger and the tube. If this is not the case the tube will be found to be in the upper part of the œsophagus, it can be removed by the string, and the operation repeated.[2] Expulsive coughing and a peculiar rattling of mucus which immediately follow the introduction of the tube and the withdrawal of the finger usually denote that the tube is safely in situ. The gag is now withdrawn, and the child allowed to breathe quietly for a few minutes. If there be no obstruction to respiration the gag is again inserted, and the left index finger being placed on the head of the tube, so as to prevent its being displaced, the thread is withdrawn. George Wright[3] is of the opinion that "it is much better not to withdraw the thread, so as to facilitate extraction; usually it sets up little or no irritation."

Withdrawal of the Tube. Two points call for consideration here: (*a*) the date at which the tube may be dispensed with: (*b*) the mode of withdrawal of the tube.

(*a*) *The date at which the tube may be dispensed with.* No hard and fast rule can be laid down here. The following data will help to a decision: (1) The earlier antitoxin has been administered, the earlier will the membrane be loosened, and the sooner may the tube be removed. (2) A temperature falling to 99° or lower. (3) A generally satisfactory condition of the child. (4) If, in spite of every care in feeding the child,

[1] Dr. Codd, to prevent syncope, introduces the tube with the child in the recumbent position.

[2] Dr. Codd's advice here is to be remembered: "If you fail to hook up the epiglottis or get the tube into the larynx at the first effort, withdraw the finger, and, after a short interval, re-insert it. Do not make prolonged efforts."

[3] *Loc. supra cit.*

both in the recumbent and the erect position, food is badly taken, this, cæteris paribus, is an indication for removal of the tube. Dr. Codd [1] says on this point, "As a general rule four days suffice to leave the tube in, though re-intubation is often necessary." Carefully drawn-up tables by Dr. Goodall "point to the advisability of not removing the tube till the lapse of from thirty-six to sixty hours."

(*b*) *The mode of withdrawal of the tube.* This is somewhat more difficult than intubation. In the latter the operator has the tube under his command: in its withdrawal he has to get command of it. The position of the patient being the same, the surgeon hooks up the epiglottis with his left index, and rests the tip of the finger on the posterior part of the head of the tube. The curved extracting forceps is passed along the palmar aspect of the finger, being kept strictly in the middle line until it reaches the tube just in front of the finger. The handle of the extractor being gently raised, its point, aided by gentle movements of the left index finger, now finds the entrance into the tube and is dropped into it. The right thumb now presses on the spring, separates the blades, and the tube is withdrawn. Previous to introducing the extractor, the amount to which its point can be opened out must, by means of a screw on the under-surface of the instrument be carefully adjusted to the size required for the removal of the tube, otherwise much injury may be inflicted on the soft parts about the upper orifice of the larynx.

Stenosis. The tubes for the treatment of this condition are made in vulcanite as well as in metal. Intubation by means of these tubes, if obtainable, will be found preferable to the use of the gum-elastic ones of Macewen in the case of adults. The full account already given above will suffice here also.

OTHER INDICATIONS FOR TRACHEOTOMY

(i) **Syphilitic and Tuberculous Ulceration.** Of these tracheotomy is the more frequently called for in syphilis, in which also it is decidedly more useful. The conditions which demand it *temporarily* are, œdema of the glottis, setting in on old mischief: fibroid thickening, which may later yield to treatment: and more *permanently*, probably, deep ulceration, necrosis, and cicatricial contraction.

In tuberculous mischief, tracheotomy rarely gives much relief, dyspnœa being now a rarer misery than cough and difficulty of swallowing, both of which are conditions which may be intensified by the presence of a tube.

(ii) **Malignant Disease of the Larynx.** This subject is considered below (p. 600).

In all cases of tracheotomy where dyspnœa is present or likely to be brought on by the anæsthetic, save in little children (p. 567), local analgesia, by means of cocaine and adrenalin, should be employed (p. 582). This especially applies to tracheotomy for disease of the larynx, malignant bronchocele, and other growths which have caused narrowing of or a liability to spasm in the air-passages.

(iii) **Acute Laryngitis.** The rapidity with which this may run a fatal course, especially after exposure to cold in reduced constitutions, is well known. If treatment, including scarification of the aryteno-epiglotti-

[1] *Loc. supra. cit.*

dean folds and adjacent parts, fail to relieve the dyspnœa, tracheotomy should be performed at once to meet the increasing exhaustion.

(iv) **Certain Spasmodic Affections,** *e.g.* Thoracic Aneurysm and Tetanus. Owing to these diseases destroying life usually in other ways, tracheotomy is rarely called for here. Occasionally, however, the laryngeal dyspnœa which they may bring about calls for this operation.

Probably there is no form of dyspnœa more agonising to the patient, or more distressing to the friends, than that which may accompany thoracic aneurysm. The surgeon, however, when called upon to perform tracheotomy in one of these terrible cases, must remember that the dyspnœa may be due to direct pressure upon the trachea as well as to pressure or irritation of the laryngeal nerves, that it is in the latter only that operation will give relief, and that the difficulty of distinguishing between the two, though much diminished by the laryngoscope, is not entirely removed.

With regard to tracheotomy in tetanus, the same warning has to be given. In the rarer cases in which tetanus threatens life by asphyxia and not by exhaustion, the surgeon, before performing tracheotomy, must decide where lies the seat of the asphyxia. Asphyxia will probably be due to spasm of the muscles of respiration, including both those of inspiration and expiration, *i.e.* the abdominal muscles also. The fatal spasm thus usually not lying in the larynx, tracheotomy seems contra-indicated, unless it were done with the object of relieving, with the aid of artificial respiration, that congested, gorged condition of the lungs which is due to the continued spasm of the muscles of respiration. And it is to be feared that if these steps were taken, the gentle violence of artificial respiration would, as has happened with tracheotomy itself in this disease, only bring on further, and perhaps final and fatal, spasms.

(v) **Scalds of the Upper Aperture of the Larynx.** Tracheotomy is here usually deferred until late, and its want of success is well known. This is not, however, an instance of cause and effect, the mortality in these cases being rather due to the shock, pain, and inability to take sufficient food. Unless the patient is seen late, tracheotomy should not be performed in these cases till a trial has been made of scarification, or rather of acupuncture, by means of a guarded bistoury point, of the mucous membrane of the epiglottis and the glosso-epiglottidean and arytenoepiglottidean folds the left finger guiding the point of the instrument. In doing this the surgeon must remember the amount of dyspnœa which is already present, and the certainty that this will be increased by the struggles of the child, by the finger coming in contact with the inflamed parts; at any moment the child must be turned on its side, artificial respiration performed, or tracheotomy at once resorted to.

(vi) **Foreign Bodies in the Air-Passages.** The treatment of these serious accidents and the indications for tracheotomy are discussed on p. 603.

Tracheotomy under Local Analgesia. Before leaving the subject of tracheotomy, the above must be referred to, especially in its reference to cases of chronic stenosis of the larynx. In some of these cases the risk of the operation is greatly increased by the use of a general anæsthetic, especially where a patient who has been obliged to keep in one position in order to facilitate his breathing has a sudden attack of urgent dyspnœa when he is placed in the position for tracheotomy. Again, in some cases of marked stenosis, general anæsthesia, by abolishing the voluntary

respiratory movements, may render it impossible for sufficient air to be drawn through the narrowed larynx.

Sir St. Clair Thompson called attention to the advantages of local anæsthesia by cocaine and adrenalin.[1] Another useful solution for producing local anæsthesia for this and other operations is Schleich's solution which has the following composition: Cocain hydrochlor. ·2 grm., morphia hydrochlor. ·025 grm., sod. chlorid. ·2 grm., aq. dest. steril. ad 100 cc. This solution may be injected freely. Mc. Barker[2] recommends a solution of eucaine which has the advantage that it is practically non-toxic. The following solution may be injected: Eucaine lactate, gr. i, adrenalin hydrochloride soln. (1 in 1001) m v, sod. chlorid. soln. (·75 per cent.) ad ʒ x.

Novocain is also a very satisfactory drug for the production of local anæsthesia.[3] It is much more effective if combined with adrenine. A ·5 per cent. solution of novocain with 1 milligram of adrenine added to each 200 cc. will be found very satisfactory. As much as 2 l or 3 l cc. may be used if necessary. If a 1 per cent. solution of novocain be used, 1 milligram of adrenine should be added to each 100 cc.

Another drug which is employed for local anæsthesia is quinine and urea hydrochloride. A ·25 or ·4 per cent. solution may be used. The solution may be sterilised by boiling, but if freely used it may cause sloughing of the subcutaneous tissues.

EXTRA-LARYNGEAL OPERATIONS FOR REMOVAL OF GROWTHS OF THE LARYNX. EXCISION OF THE LARYNX, PARTIAL AND COMPLETE

It will be seen from the remarks made below that the value of some of these operations is still sub judice; much of the following will, therefore, require confirmation.

Indications. Carcinoma and sarcoma of the larynx, especially if intra-laryngeal in origin, and remaining so. This being the chief and almost the only indication for operative interference, any others will be very briefly alluded to (p. 604). The following questions call for an answer when the question of operative interference arises in cases of growths of the larynx: A. *Is the disease malignant?* B. *How far has it advanced? Is it now intra- or extra-laryngeal, and where did it originate?* C. *Which of the following operations is the wisest to be prepared for when the local condition of the growth and the general condition of the patient are duly weighed, thyrotomy, removal of the larynx, partial or complete, trans-hyoid pharyngotomy, or a palliative tracheotomy?* To give any helpful answer here, (1) the results of these operations and (2) the after-condition of the patients have to be duly weighed. There is scarcely any decision in surgery which is so beset with difficulties.

A. *Is the case one of malignant disease?* and, if so, B. *How far has it advanced?* The impossibility of always deciding early and positively whether a growth in the larynx is malignant by the laryngoscope alone is well known. As in the case of the tongue, in a certain proportion of cases it is impossible to say whether the trouble is papillomatous or epitheliomatous, if the former whether it is in the pre-cancerous condition, *i.e.* its base richly cellular; in other occasional cases, as in the tongue, whether an ulcer is carcinomatous, syphilitic, or tuberculous.[4] This difficulty raises the question of the value of previous intra-laryngeal

[1] *Brit. Med. Journ.*, October 11, 1905. [2] *Ibid.* 1904, vol. ii. p. 1682.

[3] For further information on the subject of local anæsthesia reference should be made to *Local Anæsthesia*, by Prof. Braun, 1914. Here will be found an account of the various drugs which may be employed, and full instructions as to the technique of the injection for the various operations.

[4] In Sir H. Butlin's words, "There are three classes of cases, the first in which every one can make a diagnosis, the second in which the more experienced can make it, and the third class in which the conditions are so obscure that no one can make a diagnosis unless the larynx is opened, and in some of which it is even then difficult to say what the nature of the disease is."

removal of portions of the growth for examination. As in the tongue, there are certain cases in which this step will not clear up the doubt, either because the incision does not happen to have been made deep enough to reach the part where malignancy is present, or because it has entered a part adjacent to it. Moreover, this mode of intra-laryngeal removal of bits of growth is not without its risks.

Dr. Newman, of Glasgow, sounded the following note of warning:[2] "Intra-laryngeal excision for microscopic purposes exposes the patient to very serious dangers by increasing the rapidity of secondary new formations. The incision of a cancerous growth, or its partial removal, has justly been regarded as a most dangerous procedure, probably because the absorption of the infective material takes place rapidly from a wounded surface. For instance, judging from my own experience of other similar cases, I should say that neither in case 2 nor 3 would the lymphatic glands have become involved for months had I not removed portions of the growth with forceps. In both cases the tumour was limited in size, and in both, within a very short time of the intra-laryngeal operation, the lymphatic glands became involved. . . . While conscious of the value of removing portions of a laryngeal neoplasm for diagnostic purposes, I desire to express my strong conviction that it should not be resorted to in cases suspected to be cancer unless the patient is willing to have a radical operation performed immediately after the diagnosis is completed."

This difficulty should be faced in the same way as elsewhere. Where a patient has suspicious symptoms, especially at a suspicious age, *e.g.* alteration in the voice, "soreness," pain, cough, haemorrhage, interference with breathing or swallowing—the same steps should be adopted which stand in such good stead in cases of doubtful malignant disease elsewhere and explore. Where such interests are at stake, there should be no hesitation in advising opening of the thyroid cartilage and examination of the larynx, at any rate in cases where endo-laryngeal examination and treatment are unsuccessful or inconclusive. If the growth is malignant, one of the operations mentioned above should be proceeded with at once, or a preliminary tracheotomy alone performed at this stage. If the disease is not malignant, it will very likely be the better for local treatment, which can now be effectually applied. If the thyroid cartilage be very carefully divided in the middle line, and no further operation done, it is known from experience, in adopting a similar step for the removal of certain foreign bodies, that no harm will happen to the cords, while the relief to the patient's mind will be enormous. It is only by this early and complete exploration that the disease can be attacked in a stage when it can be entirely removed.

B. *How far is the disease, if malignant, advanced?* In recent years the method of direct examination of the larynx by Killian's or Brüning's tubes has rendered this question easier of solution. It must be remembered, however, that when the growth is exposed during an operation, it is almost always found to be more advanced than was supposed at a preliminary examination.

C. *Is the disease intra- or extra-laryngeal?* The importance of this distinction—one not always possible to make—is enormous, owing to its bearing on the severity of the operation and its results immediate and later.

Under the term intrinsic carcinoma should be included those cases

[2] *Clin. Soc. Trans.*, vol. xxii.

in which the disease has begun in and is confined to the cavity of the larynx proper from the cords downwards. The extrinsic group should include those cases where the growth has started in the epiglottis, or aryteno-epiglottidean folds, or cricoid,[1] or when having begun in the pharynx, it has invaded the larynx, or *vice versa*. Here another warning is needed. In some cases it may be only possible to clear up this point at the operation.

It was shown by Krishaber and Fränkel that the intra-laryngeal form of carcinomata remains limited to the larynx for some time, and, while so limited, is comparatively slow in affecting the glands.[2] Extrinsic carcinomata, on the other hand, affect the glands at an early stage. The laryngeal sarcomata, though rapid in growth and with marked power of infiltration, have no marked tendency to spread by the lymphatics and affect the glands, thus affording an instance of the well-known variableness of sarcomata in this respect.

In deciding whether the disease is extra-laryngeal, the surgeon may be helped by a history of dysphagia, the passage of a bougie, by noting the mobility of the larynx laterally on manipulation and in deglutition, the involvement of lymphatic glands, and the date at which this involvement has taken place,[3] and by information gained by the passage of a finger from the mouth with the aid of encaine. Dr. Newman, in his instructive book,[4] writes: "When the disease is intrinsic, the prominent symptoms are aphonia and dyspnœa. The lymphatic glands are seldom affected; as a rule, cachexia is not a prominent feature during the earlier stages of the disease, and dysphagia is not a common symptom. In patients suffering from extrinsic growth, on the other hand, aphonia is not usually present at the commencement of the disease, and, indeed, there may be only slight alteration in the voice, while dysphagia is, as a rule, present as soon as the growth has reached any considerable size. Pain in larynx and pharynx, extending round the neck and to the ear of the affected side, is more characteristic of extrinsic than of intrinsic new formations. In the former the glands are also involved at an early period, and cachexia is usually pronounced."

While the subject of extrinsic malignant disease of the larynx is being referred to, the question of how far operations in these cases are justifiable arises. Interference here is one of those instances in which the surgeon may have a difficulty in deciding where to stop, owing to the extent of the disease. Where the pharynx, epiglottis, and surrounding soft parts have been extensively extirpated, the patient usually gains a prolongation of life, rarely a cure, at the cost, to put the matter moderately, of great discomfort.

Reference may be made to the illustrations accompanying Prof. Gluck's article,[5] and more particularly Figs. 19, 22, 23, 24, 25.

[1] Of those extrinsic carcinomata which begin in the laryngeal region, but not in the larynx proper, Dr. Chevalier Jackson (*Trans. Amer. Lar. Soc.*, 1904, p. 165) finds that the posterior surface of the cricoid is by far the most frequent site.

[2] While those who have worked at this subject are not agreed as to the exact lymphatic supply of the larynx, they are unanimous in declaring that the vocal cords are less richly supplied than the vestibular regions, and that the lymphatics of each half of the larynx are relatively independent of each other. Further, there is reason to believe that carcinoma is somewhat slow in destroying the cartilage.

[3] Dr. C. Jackson, in his remarks on infiltration of the glands (*loc. supra, cit.*), warns us, "If no adenopathy can be made out, even deep along the trachea and œsophagus, it does not exclude carcinoma, even if the growth be ulcerating."

[4] *Loc. supra, cit.*

[5] *Brit. Med. Journ.*, October 31, 1903, p. 1122.

The results demonstrate what especial experience may achieve with especial operative skill, but this is only half the picture. Such figures as the above, showing the steps in the technique by which such results may be attained, show also inevitable mutilations by which the patient's future must be rendered a sad one. Prof. Gluck's words (p. 1123), "First save and prolong the life of your patient, and do not trouble yourself too much about the post-operative state: the restitution of function will be a secondary care, the imminent danger once dissipated," are justified as far as they go, but they do not go far enough. His success seems to have begotten an enthusiasm leading him to forget that it is the patient, and not the surgeon, who will have reason "to trouble about the post-operative state," and that the degree of "restitution of function," the organs for it is not only the larynx which is concerned being most essential for the daily comfort of the patient, is, in the great majority of those who survive, very incomplete. Any one familiar with the literature of this subject will agree that this aspect of the case does not receive its rightful prominence with many writers. Without the least exaggeration, the fact remains that of all the mutilations inflicted by surgery that for extrinsic malignant disease is one of the most terrible. The most that can be said—and it is only fair to give both sides—is that if the patient survive he will be freed from pain, especially pain in the ears, from much of his cough, from toxæmia, and he will put on flesh. How far he can follow any occupation must depend upon the nature of this, and how far it requires the ordinary voice which has been lost.

While the decision here must be left to the patient, and while especial indications for running the necessary risks will occasionally arise, *e.g.* in the case of a pension, annuity, &c., there is scarcely any question in surgery which is so beset by difficulties.

D. *Which of the operations open to the surgeon is it wisest to perform in cases of intrinsic malignant disease?*[1] Here, in addition to the conditions presented by the growth in each individual case, (*a*) the state of the patient as to general vitality and the condition of his viscera, especially the lungs, (*b*) the results of the operation, and (*c*) the after-condition of the patient, have to be considered.

The operations are the following: (i) **thyrotomy**; (ii) **unilateral removal of the larynx**; (iii) **complete removal**; (iv) **trans-hyoid pharyngotomy**; (v) **palliative tracheotomy.**

(i) **Thyrotomy.** While this term is retained for the sake of convenience, it is here an incomplete one. Not only is the thyroid cartilage and, if needful, the cricoid divided as in removal of certain foreign bodies, but the growth, and with it a varying part of the larynx, is removed as well, the framework of the larynx itself not being taken away. The statistics and value of the operation have been much in dispute. In this country, owing to the support which it has received from authorities like Sir H. Butlin,[2] Dr. Moure, of Bordeaux,[3] and Sir F. Semon,[4] thyrotomy has been strongly advocated. By many Continental surgeons, on the other hand, this operation has been condemned, owing to its rate of

[1] *See* a paper by Dr. G. Emerson Brewer (*Ann of Surg.*, 1903, vol. I, p. 820) on the operative treatment of cancer of the larynx. Thyrotomy and total laryngectomy are discussed with a number of illustrative cases.

[2] *Clin. Soc. Trans.*, vol. xxii. p. 94, and *Oper. Sur. of Mal. Dis.*, p. 196.

[3] *Ibid.*, p. 1148.

[4] *Brit. Med. Journ.*, October 31, 1903, p. 1114.

mortality being much higher than has been found to be the case in this country, and also because the permanent results have proved themselves to be less favourable.

While thyrotomy is, when all the conditions affecting these operations are taken into account, at present the one most justifiable, it is doubtful whether for any cases save the very earliest, which will be few, it can be considered a sound operation, *i.e.* one based on those principles which guide us in our attempts to exterminate malignant disease elsewhere. Amongst these the most important are to include at the time of operation not only the growth itself, but a wide margin of healthy parts around, and, further, what is sometimes forgotten in the stress of an operation, *a sufficient depth of healthy tissue beneath the growth*. This step, always difficult, must be especially so with the subjacent cartilages.[1] Time alone will show whether on sound surgical principles the only operations before us are not partial and complete removal of the framework itself of the larynx.

FIG. 253. Thyrotomy. The larynx has been opened, and the halves of the thyroid cartilage separated. 1. Hyoid. 2. Thyro-hyoid membrane partially divided and separated. 3. One half of the thyroid cartilage. 4. Crico-thyroid membrane opened. 5. Cricoid. 6. Left ventricular band. 7. Ventricle of Morgagni. 8. Left vocal cord. 9. Growth upon the right vocal cord. (Moure.)

Indications for Thyrotomy. Dr. C. Jackson[2] gives the following: (1) an intrinsic growth, that is, one limited to the ventricular bands, the ventricle, the cords, and the parts below to the limits of the larynx; (2) a limited extent of disease; (3) malignancy, or a suspicion of malignancy justifying exploratory thyrotomy; (4) no extrinsic disease, not even involvement of the arytenoids or inter-arytenoid folds; (5) no perforation of the thyroid cartilage; (6) no glandular involvement. Others limit the disease farther. Thus, Dr. Moure, of Bordeaux,[3] holds that thyrotomy "should be reserved especially for tumours of one or other of the vocal cords. When one of the ventricular bands is affected, when there is a peripheral infiltration, still more when the corresponding arytenoid is fixed, or when there are signs of perichondritis, it is unsuit-

[1] "The operation must be thorough. No sentimental considerations concerning the amount of vocal power to be retained by the patient must interfere with the imperative necessity of removing a sufficient area of healthy tissue around the new growth in all directions. A violation on one single part of the periphery of the new growth of this rule may frustrate the entire purpose of the operation." (Semon.)

[2] *Loc. supra. cit.*

[3] *Brit. Med. Journ.*, October 31, 1903, p. 1148.

able." The same authority[1] considers the total laryngectomy is indicated in cases not limited to the cords and tending to become diffuse.

Dr. J. N. Mackenzie, of Baltimore, who holds that early extirpation of the larynx, with its lymphatics and glands, is here, as elsewhere, the safest step, considers that "very small growths, distinctly circumscribed, remote from the middle line, and not of an especially malignant type, may possibly be removed with safety by extirpation of half the larynx and lymphatics on the corresponding side."[2] Dr. Mackenzie's advice was almost the same: "He did not believe that any other than the most radical operation should be undertaken in cases in which disease was medially situated. An incomplete operation would be especially hazardous where the disease appeared as an infiltration." The next step will be to consider the *results of thyrotomy* (1) as to the *risks of the operation*, and (2) the *probability of a reappearance of the disease*, and the amount of voice regained.

There is probably no operation about the statistics of which so much care is needed as in those for malignant disease of the larynx. The chief fallacies arise from the way in which cases are grouped together, both those in which the disease has been intrinsic and extrinsic, those where an operation appears to have been strongly indicated, and those in which it seems, owing to the condition of the patient, to have been equally unsuitable, the frequent absence of important details, and the tendency to publish only successful cases, often prematurely. If the results of one operator, a man of especial experience, are taken, another difficulty arises. Such results have only been gained as the authority passed through different stages of increasing experience.[3] Men who have had very different opportunities must bear this in mind when patients or their friends, as is increasingly their wont nowadays, ask what are the risks of an operation.

And this tends to a statement with which many will disagree. Until these operations—and especially laryngectomy partial and complete—are placed upon a more satisfactory basis, they should only be performed whenever this is possible, and it usually is so, by those who combine a thorough mastery of general surgical technique and an especial training in laryngology.

Returning to the subject of the results of thyrotomy, as to the risks of the operation, and a probability of a reappearance of the disease, Dr. D. B. Delavan, of New York,[4] puts the permanent cures as high as 11 per cent., while the death-rate can be placed at about 11 per cent. Of the patients operated upon by Sir H. Butlin 66⅔ per cent. lived for more than three years after operation, while his death-rate was 9·5 per cent. As to the term "permanent cure" one half and, in some instances, two-thirds, of the patients reported alive and well at the end of the first year have died within three years. Statistics based upon alleged cures of less than three years' duration are therefore worthless.

Sir F. Semon's results are given.[5] He states that "my oldest successful

[1] Ann. de Mal. de l'Oreille, &c., 1904, t. xxx. p. 467.

[2] *Trans. York. Med. Rec.*, November 4, 1905.

[3] On this point the reader is especially referred to Prof. Gluck's results—earlier and later, candidly given (*Brit. Med. Journ.*, October 4, 1903).

[4] *Trans. Amer. Lar. Soc.*, June 1904; *New York Med. Rec.*, September 17, 1904, p. 442.

[5] *Brit. Med. Journ.*, *loc. supra. cit.*, and, with more detail, *New York Med. Rec.*, November 5, 1904.

thyrotomy dates back to thirteen years ago, and I have other patients in good health in whom the operation was performed twelve, ten, and nine years ago."

As to the amount of voice regained,[1] Sir Felix states: "The great majority have regained a surprisingly good, although, of course, more or less husky, voice: in a few cases only have their vocal powers been reduced to a whisper."

Operation of Thyrotomy and Removal of the Diseased Parts (Fig. 253). The points in the examination of, and the preparation of, the patient locally and generally (p. 591), must be attended to here.

The patient having been anæsthetised with chloroform,[2] is placed in the tracheotomy position, with a firm support under the shoulders. A vertical incision is made in the middle line from the hyoid bone to a point just above the sternum.[3]

As the incision is deepened precisely in the middle line, in the upper part the thyro-hyoid membrane and angle of the thyroid should be exposed, in the lower the septum between the sterno-hyoids. This is opened, the muscles gently retracted, any superficial veins tied, and the thyroid isthmus divided, between two ligatures if necessary. The angle of the thyroid cartilage is now exactly defined, the soft parts being gently peeled and pushed aside. The next step is to open the trachea low down. A trial of the position of Rose or Trendelenberg should now always be made. Hahn's sponge-cannula has been the one chiefly employed, but many authorities advocate an ordinary tube. This does away with any need of wasting ten or more precious minutes until the sponge has sufficiently expanded, and avoids the risk of over-distension of a slender trachea, and syncope with arrest of breathing (Monro). By means of india-rubber tubing with a curved mouthpiece to fit into the cannula at one end, and a gauze-covered funnel at the other, on which the chloroform is dropped, the anæsthetist is kept to one side. The crico-thyroid membrane is next opened in the middle line, and this structure and the thyroid cartilage divided completely, with one stroke if possible, by a pair of stout scissors or a pair of slender shears if the process of calcification is advanced. In these cases the use of a fine Gigli's saw has been recommended, this instrument being passed through openings in the crico-thyroid and thyro-hyoid membranes. It will require to be kept most steadily in the middle line, or needless laceration of the mucous membrane and faulty union will be the result. The alæ of the cartilage are next pulled apart, and held so with hooks or retractors. This step is not an easy one where the cartilage is much calcified. No force whatever is allowable, or a fracture may occur. If it be impossible to obtain a complete inspection—an absolutely essential point—by the above steps, the median incision in the larynx should be continued through the cricoid and upper two rings of the trachea. Transverse division of the thyro-hyoid

[1] See a case recorded by Sir Felix Semon (*Proc. Roy. Soc. Med., Laryng. Sec.*, vol. ii, 1909, p. 78), in which the right vocal cord was replaced by a cicatricial ridge, the patient subsequently having a remarkably good voice.

[2] Local anæsthesia throughout (p. 582) is preferred by some. The position of Rose or Trendelenberg has also been advocated. Local anæsthesia throughout would be indicated in patients of sufficient self control who have had bronchitis.

[3] This incision would appear needlessly long for a thyrotomy, but the trachea requires to be opened low down for two reasons: (1) to place the anæsthetist as much as possible out of the operator's way; (2) where advanced calcification of the thyroid cartilage is present, the cricoid and upper two rings of the trachea may require division, to enable an adequate inspection of the inside of the larynx to be made.

membrane affords additional room, but imperils the immobility of the two halves of the thyroid cartilage later on.

When the larynx is opened the entrance of mucus and blood into the air-passages, especially if an ordinary tracheotomy cannula has been employed, and if the breathing is much embarrassed at this moment, must be guarded against. The anæsthetist should follow Dr. C. Jackson's advice, and allow the patient to cough up mucus occasionally. Infection of the wound must now be prevented by gauze. The chloroform should also be discontinued towards the close of the operation, so that the patient recovers consciousness by the time that the last sutures have been put in. A sterilised sponge or gauze tampon, attached to silk, may be introduced into the pharynx above, and a smaller one into the lower angle of the wound, above the cannula.

As soon as the interior of the larynx has been thoroughly exposed, and any fluids dealt with, local analgesia should be employed. The proportions vary with different operators.

Prof. Glück prefers cocaine and antipyrin (5 per cent.), and carbolic acid (1 per cent.), in distilled water; Dr. Moure uses 20 per cent. cocaine and 1 in 10,000 adrenalin. If local analgesia is employed throughout, useful information will be found in the reference at p. 582. The solution used by Mr. Barker will be found here. Any fluid used will, of course, be sterile, and applied on sterile gauze or camel's-hair brushes. After a lapse of a few minutes the actual removal of the growth is proceeded with. Here Sir F. Semon's caution that the growth will always be found to be more extensive than was shown by the laryngoscope may be repeated. He thus describes the actual removal of the growth: "The operator ought to make two semicircular or elliptical cuts, uniting in front and behind, through the whole of the soft tissues and down to the perichondrium round the diseased area, and at a distance of about half to one inch from the periphery of the growth. . . . The area to be removed having been thus circumscribed, the removal ought to take place by the growth itself being held with dressing-forceps and the whole area being cut out with curved scissors, the points of which are firmly pressed against the inner aspect of the cartilage the mucous covering of which is to be removed. Unfortunately, it will be found that it is hardly ever possible to remove the whole of the growth in one piece, and, as a rule, the diseased portions will have to be removed piecemeal. The entire growth and part of its healthy neighbourhood if necessary, including portions of cartilage, having thus been removed, the base ought to be firmly scraped with a sharp spoon. In very rare cases only will it be found necessary to apply the galvano-cautery." Sir Henry Butlin "cuts out the included area right down to the cartilage, which is laid bare and finally scraped absolutely bare with Volkmann's spoon."

Dr. C. Jackson condemns the use of the curette as likely to cause infection at the time of the operation and so reappearance of the disease. "The curette may be likened to the harrow that buries the seed in the soil to ensure germination." He emphasises the need of cutting far out into healthy tissue, but does not specify how to meet the chief difficulty of ensuring removal of a sufficient depth of tissue beneath the growth. Dr. Moure uses both curette and therma-cautery. The bleeding can usually be checked by very fine ligatures of catgut and pressure with gauze, wrung out of very hot water or adrenalin solution. Hot sterile saline solution having been applied to the surface operated upon, the

alæ of the thyroid cartilage are now accurately united with salmon-gut or silver wire, the sutures not entering the cavity of the larynx. The tracheotomy tube can be removed as a rule at the conclusion of the operation; in these cases where the framework of the larynx and thus a sufficient airway is left, there does not appear to be any risk of subsequent œdema of the glottis. The upper half of the skin incision is closed with sutures of gossamer salmon-gut and horsehair; any sutures inserted in the lower half should not be tied for the first few days. Gauze dressings to be frequently changed as they become soiled, or, better, a boracic acid fomentation applied.

After-treatment. The patient is placed upon the side operated on, with the chin downwards and forwards, and only a low pillow under the head, to promote the escape of any fluids by the mouth and unclosed part of the wound. For the first forty-eight hours the operator or a skilled assistant should be at hand, so that, if needful, the tracheotomy tube may be replaced at once. Nutrient enemata are given, and, if the patient's condition require it, feeding by a tube must be resorted to. For the first twenty-four hours only sips of sterilised water or ice should occasionally be allowed by the mouth. "On the following morning the first attempt is made to swallow. The patient leans far forwards, with the head down, and the dressing is taken off the wound, under which a basin is placed. Cold water is drunk out of a glass. If the experiment is successful, all the water passes into the stomach. If it is only partially successful, some escapes into the larynx. But the posture of the patient ensures that it runs through the wound, and does not pass into the air-passages. As soon as water can be readily swallowed milk and other liquids may be drunk. The wound is generally closed within ten or twelve days" (Butlin).

Removal of half the Larynx (Figs. 254, 255). This operation may be strongly recommended for cases of intrinsic disease which are not suitable for thyrotomy, *i.e.* where the growth has extended widely, but is still confined to one half of the larynx. The epiglottis should always be preserved: indeed, Chevalier Jackson advises that if the growth has extended so far upwards as to call for removal of this cartilage, a complete laryngectomy is to be preferred. The reason for this is the very strong probability of aspiration-pneumonia when the epiglottis is removed as well as half the larynx.

Fig. 254. Epithelioma of the left cord. (Lennox Browne.)

The operation of hemi-laryngectomy is much less severe than complete laryngectomy, and the mortality is much less. The results as regards voice and breathing are nearly as good as after a thyrotomy. In one of Schede's cases[1] the patient was a dentist: he could, after a while, dispense with any cannula and follow his calling, his speech not attracting notice. As a result of cicatricial contraction, a prominent fold of mucous membrane had formed, immovable, but capable of performing many of the functions of the right cord, the left moving up to it, and thus forming a rima glottidis.[2]

[1] *German Surg. Congr.*, April 1884; *Lond. Med. Rec.*, 1884, p. 358.

[2] See also a case reported by Sir F. Semon (*Clin. Soc. Trans.*, vol. xx, p. 44).

Sir H. Butlin, writing in 1900,[1] puts the mortality at 21·3 per cent., or nearly three times greater than that of thyrotomy. About three years later Prof. Gluck,[2] as an instance of his improving results, said: "In one series of thirty-five hemi-laryngectomies I had three deaths, one twenty-four days after operation of heart failure, when the wound was already healed; another, independently of the operation, of phlegmon of the right gluteal muscle; the third of pneumonia five days after operation." When unilateral laryngectomy is performed these two points must be remembered. Carcinoma may reappear in the half left even after such a long interval as to suggest a fresh outbreak of the disease. Prof. Gluck[3] mentioned a case in which, nine years after the operation, "recurrence

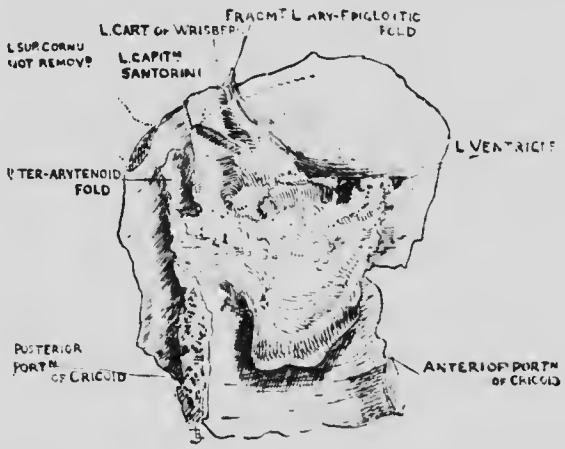


FIG. 255. Inner aspect of the portion removed. (Lennox Browne.)

took place in the other half of the larynx, and in the glands: after the second operation he lived over two years, and died at 76. The operations lengthened his life for eleven years." The second point is that, after removal of one half of the framework of the larynx, cicatricial contractions may bring about a degree of stenosis which necessitates the permanent use of a tracheotomy tube.

Operation of Removal of half the Larynx. The points which are insisted on as essential in the preliminary examination of the patient in the account of complete laryngectomy (p. 593) should be referred to, and several of the details of this operation, *e.g.* the position of the patient, cocainisation of the nerves, apply here also. The anæsthetic should be chloroform, and the advice given at p. 589 is to be remembered. A preliminary tracheotomy is performed, as at p. 593. A vertical incision is made from the hyoid bone to the cricoid cartilage, to which transverse ones must be added if the glands are to be removed at the same time. The soft parts are raised from the larynx either *en masse* or by separation in detail according to the extent to which they may be infiltrated.

Mr. Lennox Browne[4] in his case of removal of half the larynx, one

[1] *Oper. Surg. of Malig. Dis.*, p. 198.
[2] *Brit. Med. Journ.*, October 31, 1903, p. 1123.
[3] *Loc. supra cit.*
[4] *Brit. Med. Journ.*, February 5, 1887.

of the few at that time reported in this country[1] (Figs. 254, 255), having exposed it by subperichondrial raising of the soft parts divided the thyroid cartilage with cutting-forceps, removed the half by (*a*) thorough separation of the attachments to the pharynx with the raspatory aided by the knife-handle and finger-nail; (*b*) division of the thyro-hyoid membrane as close as possible to its thyroid attachment; (*c*) division of the left superior horn of the thyroid cartilage at its root by cutting-pliers; (*d*) division in the middle line of the cricoid cartilage, in front and behind: (*e*) the divided half of the larynx was then separated from the first ring of the trachea, and a few nicks only were necessary to remove it entire. The very slight oozing which ensued after the removal of the diseased part was checked by a light application of the galvano-cautery, which, it was thought, would also destroy any possible fragments of diseased tissues not removed. The left arytæno-epiglottic fold was divided close to the cartilage of Wrisberg, and the thyro-hyoid membrane close to its thyroid attachment, with the view of impairing as little as possible the action of the epiglottis. An ordinary tracheotomy cannula must be retained for some days. Whether the glands are dealt with now or later, as has been advised in the case of the tongue, must depend on the difficulties of the previous operation and the state of the patient.

Prof. Gluck's method[2] in hemi-laryngectomy is as follows: He raises a skin flap on the affected side by a median and two transverse incisions. The larynx is exposed, split in the middle line, and the affected half loosened out. "The defect thus created is so covered with the skin flap that its edges are sewn above to the mucous membrane of the sinus pyriformis and below to the trachea, and in the middle line to the plate of the cartilage. A large tampon of iodoform gauze is introduced into the cavity of the larynx. It must press tightly against the under-surface of the skin flap, and prevent the passage of food particles into the air passages."

Complete Laryngectomy. The progress that has been made in operations on the larynx in the last fifteen years by the few who have had opportunities for gaining a special mastery over the needful details is nowhere shown better than by Prof. Gluck's details.[2] "In my first series of ten cases only two were successful, and in nine cases of another series I had four deaths. . . . My most recent results show a series of twenty-two complete laryngectomies with one death—that of a man of seventy, who died on the eleventh day of iodoform poisoning. Of partial extirpation of the larynx and pharynx, generally combined with removal of infected glands, I can point to a series of twenty-seven cases with only one death. This was a case in which the carotid had been tied, and death occurred from hemiplegia five days after the operation. . . . At present I could show you thirty-eight living patients who have been cured by these operations. The oldest case was operated on thirteen years ago. Of those already dead, a number have lived 11, 8, 6½, 5½, 4½, and 3½ years after the operation in good health, and some have died of other illnesses not of recurrence."

Other authorities who have been candid enough to publish their results

[1] *See also* an interesting case recorded by Mr. Arthur Evans (*Proc. Roy. Soc. Med.*, Laryng. Sec., December 1908). Sir F. Semon has described a case (*Proc. Roy. Soc. Med.*, Laryng. Sec., Dec. 1908) in which an epithelioma of the left vocal cord treated by thyrotomy was followed by a recurrence; a hemi-laryngectomy was then performed with a satisfactory result.

[2] *Loc. supra cit.*

—and the small number of laryngectomies published by those who have special opportunities, and avail themselves of these opportunities, carries its own tale—have met with different success. The after-condition of the patients is referred to at p. 585. In estimating the value of the above conclusions, and in deciding upon an operation where a doubt is present, the tendency to make the best of cases must be remembered: and, further, when malignant disease reappears in situ two to four months after an operation even by skilled hands, the question arises whether such interference, necessarily incomplete, may not have hastened this result.

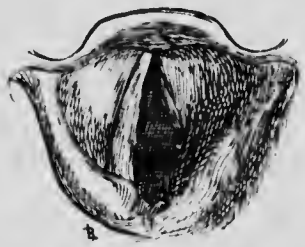


FIG. 256. Laryngoscopic view from the same patient four months after operation. (Lennox Browne.)

Indications for Complete Laryngectomy. Here both the local stage of the disease and the general condition of the patient have to be considered. The first has already been referred to under the headings of the operations of thyrotomy and partial laryngectomy. To put the indications briefly, it may be said that complete operation is indicated in cases of malignant disease of the larynx unsuitable for thyrotomy, partial laryngectomy, or pharyngotomy, cases in which the operator has grounds for believing that he can get away all the disease, including infiltrated glands, cases, finally, in which the general condition of the patient is favourable. Here the age of the patient (not only to be recognised by years), his power of meeting and recovery after an operation in which a peculiar form of shock will probably always be present (p. 596), the existence of any liability to bronchitis, broncho-pneumonia, asthma, his capability of assimilating food, the condition of his viscera, *e.g.* the presence of any albuminuria, or arteriosclerosis, the history of emaciation, and, by no means least, the temperament of the patient—have all to be most carefully considered.

Operation of Complete Laryngectomy. The first question that arises is the advisability of performing a preliminary tracheotomy. Of late years the use of a tube has been largely dispensed with during the operation. From what follows most will allow that the advantages of taking this preliminary step are considerable, and that in some cases its adoption is strongly called for. *Advantages.* (1) It gives great relief to any laryngeal stenosis and its results on the lungs. In cases of dyspnœa it is strongly indicated. (2) While it is probable that the diminished congestion of the lungs will lessen the risk of broncho-pneumonia, it is certain that when bronchitis is already present, and other treatment does not avail, this step should be taken (Billroth). (3) If it is intended to perform tracheotomy, and this step is employed beforehand, less time will be taken up at the operation, and no blood will enter the trachea from this source. (4) The trachea will have become adherent to the skin. In several cases, as in those mentioned by a French writer at p. 598, the necessary adhesions have not taken place. Dr. Delavan[1] adds the following: (5) By the rest given to the larynx and adjacent parts their congestion is lessened, and it becomes easier to distinguish between diseased and healthy parts. (6) The operation being done while the patient is in a quiescent state, he is less disturbed by the sudden change in his mode of

[1] *Loc. supra cit.*

breathing, and he is in a better condition to acquire experience in the management of the tube. The *objections* brought against this preliminary step are (1) that it is not necessary, which is certainly true of many cases in the hands of experienced operators; (2) that it exposes the patient to the risk of septic infection and broncho-pneumonia. These are rare after tracheotomy in patients in fair condition; they might certainly follow in patients whose vitality is much lowered, but it is doubtful if in these the major operation is justifiable. As to the date of the preliminary tracheotomy, this should be at least ten days before the laryngectomy, for the reasons already given. These outweigh the advantages claimed for performing it immediately before the main operation, viz. that the patient is thus saved two separate operations.

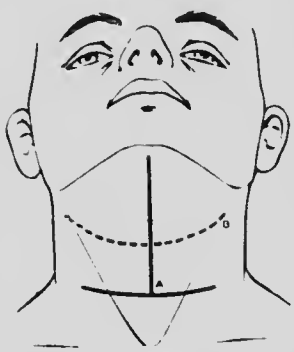


FIG. 257. A. Incision for excision of larynx. B. Kocher's "high" collar incision for excision of the larynx.

If it be important to avoid giving an anæsthetic twice, local analgesia (p. 582) should certainly be tried. The site of the tracheotomy should always be low, for, if performed high up, the lower end of the excision wound will come into parts infiltrated and altered, and thus difficult to distinguish at a critical stage of the operation, and likely to lead to needless hæmorrhage. The tracheotomy may be too near to the disease, and, further, bring the anæsthetist in the way of the operator.

The preliminary preparation of the patient as regards the general state of the lungs, power of assimilating food, &c., should be of the most careful kind. Not only is the area of the operation to be sterilised, but the mouth, teeth, and nose should be disinfected as far as possible. The temperature of the operating-room should be attended to and every precaution taken for preventing shock. An electric head-light will be found very useful. The means for administering oxygen should be at hand. Chloroform is administered with the precautions already detailed at p. 589. If tracheotomy has been performed it is given by the tracheotomy tube. If no tracheotomy has been employed, the anæsthetic is given as long as possible in the ordinary way, and later on, when the trachea is severed, by tubing fitting the inner tube of the tracheotomy cannula exactly. Whether the operation is performed from above downwards or vice versa, the Trendelenburg or Rose's position (p. 474) should be tried as soon as the larynx and trachea are well exposed. Removal from above downwards, by leaving the division of the trachea to the last, is held by some to avoid the risk of the escape of blood and lotions into the trachea, and thus to avoid any need of using expensive and sometimes unreliable tampon cannulæ. Sterilised sponges or gauze tampons attached to silk must be at hand to be placed in the trachea above the tracheotomy cannula and in the pharynx. If no tracheotomy is performed either some time previously or immediately before the operation, the median incision being made, the trachea is usually first isolated and divided, and then a large tube inserted. The plan of the operation must be carried out according to the conditions found when the interior of the larynx has been thoroughly well exposed. We will suppose at first that the disease

is too diffuse to allow of a unilateral laryngectomy, but that it has not infiltrated the framework of the larynx deeply. If the operation be begun from above an incision is first made from the lower border of the hyoid bone, exactly in the middle line, vertically down to the level of the first or second ring of the trachea, and a second at right angles to the first, either at the level of the hyoid bone, or below, in either case passing outwards to the sterno-mastoids.

The lower transverse incisions may give more room and prevent any need of prolonging the longitudinal wound down to the tracheotomy incision if this preliminary operation has been performed, a step which it is difficult to avoid in short necks.[1] The vertical incision should go down to the thyroid and cricoid cartilages and trachea, the thyroid and cricoid cartilages being carefully severed in the middle line with stout scissors or cutting forceps, the two halves separated with retractors and the interior examined. The soft parts over the thyroid and cricoid are then raised *en masse* by inserting a blunt dissector or raspatory so close to the cartilage that the perichondrium itself is lifted up, with its relation to the soft parts over it undisturbed. This separation is carried back as far as the middle of the junction of the larynx and pharynx. The thyroid isthmus is drawn downwards or, better, divided between two ligatures; the larynx is pulled to either side with sharp hooks, and the attachments of the inferior and lower part of middle constrictors and stylopharyngeus divided. All vessels, especially the superior laryngeal and superior thyroids, must be carefully secured. The trachea, separated from the œsophagus by the careful use of a blunt dissector, a curved periostcal elevator, or snips of curved blunt-pointed scissors, is cut through between the first and second rings. If no tracheotomy has been performed, two stout sutures of silk are passed through the whole thickness of the trachea, one on either side; and by these the tracheal stump is drawn downwards and forwards and secured by most careful suturing in the lower angle of the wound, or in a separate incision made for this purpose just above the sternum.[2] Two precautions are needed here. In freeing the trachea sufficiently to allow of its being brought downwards and forwards so as to diminish the risk of entrance of fluids, care must be taken not to bare it too much, and thus cut off its blood-supply. The sutures employed to keep it firmly and snugly in position should be of reliable catgut or kangaroo tendon. If of salmon-gut they must be left long, to facilitate their removal. Two stout silk sutures are now passed through the upper cut end of the trachea, and by traction on these the larynx is carefully separated from the œsophagus and pharynx from below upwards. The excision is completed by division of the thyro-hyoid ligament and the mucous membrane at the entrance of the larynx. The epiglottis and its folds should be left intact, if possible.

The above method of working very close to the cartilages with a blunt instrument only, has the conspicuous advantages of disturbing but little the soft parts and of causing but trifling hæmorrhage.[3]

[1] The operator can use a T-shaped incision, a vertical one with transverse cuts at either end, or a flap with its base upwards. This last method, used by Durante and Crile, is referred to below (p. 598). It is especially adapted to those cases where it is not possible to suture securely the pharynx and œsophagus. Other flap methods are given by Prof. Gluck (*Brit. Med. Journ.*, October 31, 1903, p. 1119).

[2] Gluck, *vide infra*.

[3] In thus raising the soft parts by keeping close to the cartilages of the larynx, care should be taken not to separate needlessly the soft parts from the trachea. Some of

Where the parts do not admit of the above step for instance, where the cartilages are infiltrated or where the parts outside, *e.g.* glands, are found involved, and the operator decides to go on with the operation (p. 584) much severer steps are necessary. The larynx must now be treated in the same way as a malignant growth elsewhere. Flaps of skin and fascia are reflected, and the larynx exposed as freely as possible. Any enlarged glands now seen should be removed, and superficial vessels secured. The sterno-hyoids, sterno-thyroids, and thyro-hyoids are next severed near the thyroid cartilage, and the lateral lobes of the thyroid gland carefully separated in the same way (*vide infra*), ligatures being tied at their junction with the isthmus if needful. The soft parts at the sides which contain the large vessels, &c., are now carefully retracted, and the larynx being drawn first to one side and then to the other, the inferior, lower part of middle constrictor and stylo-pharyngeus muscles are divided very close to their attachments to the cricoid and thyroid cartilages. The introduction of an œsophagus bougie may facilitate this step, and save needless "button-holing" now and in the separation of the œsophagus from the trachea. The superior laryngeal vessels are secured and divided as they enter the thyro-hyoid membrane. To produce anæsthesia of the nerves which may carry inhibitory cardiac impulses, Dr. Crile injected cocaine into the superior laryngeal nerve before dividing it in two of his cases published by Dr. Lincoln.[1] Information on this point has been given at p. 238. Further experience is needed before we can rely on this step for preventing the serious respiratory and cardiac disturbances which have followed during the raising up and dissection out of the larynx, and also for diminishing the shock afterwards.

The larynx is next severed from the trachea at the second ring, the stump of the trachea being dealt with in the manner already given. The detachment of the larynx from the œsophagus is then carried out from below upwards, with the precautions given above not to buttonhole it. As the dissection is carried upwards to the laryngo-pharyngeal junction the anterior and lateral walls of the pharynx will require partial removal in these more advanced cases. At this stage the following details given by Mr. Harvey will be found useful.[2] After the stump of the trachea has been stitched to the skin "the next step will be to dissect off the upper portion of the trachea from the œsophagus and the muscles from the lateral surface of the cricoid. The inferior cornu of the thyroid is next bared by detaching and reflecting the crico-thyroid and inferior constrictor muscles. The muscles and perichondrium in front of the thyroid will now be separated and reflected as far back as the superior cornu, which latter will next be freed by dividing the periosteum on its surface, and pushing it along with the lateral wall of the pharynx and the loose areolar tissue backwards until the posterior lateral border of the cricoid is reached. The outer two-thirds of the lateral portion of the thyro-hyoid ligament will then be divided transversely and cautiously at the junction of its middle and upper thirds: and when the adjacent mucous membrane is reached this must be picked up with forceps and divided, whereby the upper portion of the epiglottis can be seized and drawn forwards. The anterior wall of the pharynx is thus opened, and by pulling the epiglottis

these, *e.g.* the lateral masses of the thyroid gland, which are now also detached with a blunt dissector, are useful in preventing descent of the trachea. Sloughing of the tracheal stump and failure of union to the skin has followed in several cases (pp. 598 and 599).

[1] *Trans. Amer. Lar. Soc.*, 1903, p. 54. Dr. Lincoln relates the results in seven cases operated on by Dr. Crile.

[2] *Lancet*, September 21, 1901.

strongly forwards, and with it the whole larynx, the knife can be placed on the posterior surface of the cricoid, and by cutting downwards the anterior wall of the œsophagus will be opened. Care must be taken at this point to limit the cut to the parts which are covered in front by the posterior surface of the cricoid; if this is not done, the lateral wall of the pharynx and œsophagus will be unnecessarily encroached upon, thus rendering it difficult to approximate their edges. The whole larynx is thus completely detached, and the defect in the pharyngeal mucous membrane must now be made good by inserting sutures quite close to the cut edges, and so preventing in-turning of the epithelial surfaces.

"The sewing up must be water-tight, with fine catgut sutures, so as to form a **Y**-shaped stitched line; then a row of Lembert's sutures must be added, transfixing the muscular and cellular coats of the œsophagus and pharynx. The third layer unites the stumps of the pharyngeal constrictors, and the fourth brings together the divided sterno-hyoid and thyro-hyoid muscles." If closure of the pharynx be found impossible its cut edges must be united by numerous sutures of sterilised catgut to the soft parts about the base of the tongue and hyoid bone, secure union here, as in the case of the sutured stump of the trachea, being of the utmost importance to prevent infection of the wound by fluids from the mouth.

All hæmorrhage having been carefully arrested, drainage is supplied by securely packing any pockets in the wound with strips of iodoform gauze, which are led out above and below. The wound is sewn together over these strips, and a boracic acid fomentation supplied. A soft tube may be passed by the nose into the œsophagus at the time of the operation. If this occasion retching and coughing it must be passed as required.

As to the removal of glands, Prof. Gluck carries this out at the time of the laryngectomy. By most, considering the severity of the first operation and the thoroughness and time required if epitheliomatous glands in the neck are to be attacked to any purpose (p. 539), this proceeding will be deferred to a later stage.

The **after-treatment** is considered at p. 600.

Numerous modifications have been introduced in the **technique of laryngectomy** with a view especially of diminishing the risk of broncho-pneumonia.

Gluck [1] does not perform a preliminary tracheotomy. After the usual incision, exposure of the sides of the larynx, division of the muscles, separation of the thyroid gland, and ligature of the superior laryngeal artery, the patient is placed so that the head hangs over the end of the table, the thyro-hyoid membrane is divided and the pharynx plugged with gauze, so as to prevent the descent of saliva. The larynx is then drawn steadily forward as it is separated from the pharynx and œsophagus until the lower margin of the cricoid is reached, when the whole larynx can be drawn out of the wound. A transverse incision is now made above the episternal notch, and from this the skin is loosened upwards into the upper wound so as to leave a bridge of skin 4 to 5 cms. wide. Two strong threads are then passed through the trachea, the larynx is cut away close above the threads, and the stump of the trachea drawn by the threads under the bridge of skin into the buttonhole-like opening above the episternal notch. It is here fixed by sewing its edges all round to the edges of the skin wound. The opening in the pharynx is closed by one or more rows of sutures, and all the different pockets of the wound and mouth are packed tightly with iodoform gauze. The skin is sewn together over this packing. The patient is fed by an india-rubber tube passed through the nose.

[1] *Brit. Med. Journ., loc. supra cit.*

The advantage of thus separating the opening in the trachea by considerable distance from the wound is obvious, but nothing is said as to the difficulties which are apparently certain to arise in the administration of an anæsthetic if the above technique is followed. It is not stated that local analgesia is employed.

Le Bec [1] has followed Chiari in dividing laryngectomy into two stages. In the first, the trachea is detached from the larynx and sutured to the skin. In the second, performed eight to fourteen days later, the larynx is removed. He claims that by this method shock is diminished, and the risk of broncho-pneumonia greatly lessened. The trachea is exposed by an excision extending from below the cricoid to the sternum and isolated laterally, with care to preserve sufficient cellular tissue to ensure its nutrition. The tube, severed below the cricoid, is drawn downwards and forwards, and fixed to the skin by sutures which take up the trachea between its second and third rings. A tracheotomy tube is placed in the opening, and the wound closed with drainage. At the second operation the larynx is removed by the steps already fully given (p. 595). Dr. Le Bec's patient recovered.

Dr. Canzard [2] states that in the above case, after the removal of the silk sutures by which the stump of the trachea had been united to the skin, union failed to take place, but as this wound, by the adoption of the two-stage method, had become shut off from that of the major operation, re-insertion of a few sutures was sufficient. He mentions another case operated upon in one stage in which the patient was very restless. Sloughing of the divided trachea was followed by a fatal result two weeks after the laryngectomy.

Dr. Durante, the well-known surgeon at Rome, in order to prevent the risk of lung troubles, makes use of a flap intended to close the pharyngeo-œsophageal opening so that mucus and saliva shall be conveyed directly into the œsophagus, and the large wound remaining after laryngectomy be reduced to a minimum. An account of his operation, with excellent photographs, is given in a brief paper, in the International Clinics, 1905, p. 122. A large horseshoe-shaped flap consisting of skin and superficial fascia is raised by an incision which, starting at the right angle of the mandible, descends along the sterno-mastoid to a point 3 cms. above the episternal notch; thence, curving across to the left side, it ascends along the sternomastoid to end at the left angle of the jaws. The flap is raised as high as the hyoid bone, the larynx exposed, and, after the performance of a low tracheotomy, removed by the steps already given. When all bleeding has been arrested the flap is sutured "from above downwards to the edges of the pharyngeo-œsophageal mucous membrane, in such a manner that the rete Malpighii comes into more or less direct contact with the cut edge of the mucous and submucous coats of the pharynx and œsophagus. The lower end of the flap remains behind the tracheal stump, and is fixed to it with stitches so as to render it immobile. The whole bleeding surface is thus reduced to two lateral clefts which should be packed with gauze."

Both the patients on whom Dr. Durante employed this method recovered rapidly, one being able to swallow milk and water on the second day after the operation. The first died two months later with infiltration of the glands and hæmorrhage from the carotid artery. In the second an enlarged gland and "all the objective evidence of carcinomatous cachexia" appeared eight months after the operation. In this case it is to be noted that at the time of the laryngectomy "the carcinoma was rather circumscribed, and there was no evidence of metastasis."

Föderl endeavours to meet the dangers of pneumonia by restoring the lumen of the air tube. On the cadaver, and in one case of tracheal stenosis in which he operated with striking success, he found that the severed trachea was sufficiently mobile to admit of its being pulled up and united to the parts left about the hyoid bone.

A preliminary tracheotomy is performed. The larynx is removed by the steps already given, it being essential to retain the epiglottis and aryteno-epiglottidean folds. All hæmorrhage having been completely arrested, the mucous membrane on the posterior aspect of the severed trachea or the cricoid cartilage, according to the site of division, is united to the aryteno-epiglottidean folds. Anteriorly some of the sutures taking up the air tube below pass around the hyoid bone, beneath the mucous membrane, and also the base of the epiglottis, in order to prevent retraction. The sutures, mostly of sterilised catgut, are introduced from behind forwards, and none are tied until all are inserted. Tension on the deep sutures is relieved by drawing together the soft part with silk sutures where this is practicable. Two iodoform drains are employed, and the skin wound is sutured. Immobilisation of the head was not found necessary.

[1] *Ann. de Mal. de l'Oreille, &c.*, 1905, t. xxxi, p. 375.

[2] *Loc. supra cit.*, pt. ii, p. 165.

In a case in which V. Hippel tried this method the upper end of the trachea sloughed from ulceration and infection; the patient ultimately recovered.

Operation in Cases of Extrinsic Malignant Disease involving the Pharynx extensively. If, after careful consideration of the case, the vitality of the patient and his decision justify resort to such an operation, the following are the lines on which Prof. Gluck [1] carried it out:

"In order to extirpate the larynx with the pharynx, I expose first the whole larynx, and place the patient so that the head hangs down over the edge of the table. I then divide the membrane between the hyoid bone and the larynx, and draw the larynx forward in front of the wound. The inner surface of the pharynx is now well seen, and one can divide without difficulty the side walls and anterior edge of the pharynx straight through above the tumour. Next I push forward into the loose tissues between the pharynx and œsophagus and the vertebral column, and detach the pharynx from the vertebral column till I have reached the lower pole of the tumour. I cut the œsophagus straight off, as far as possible below the tumour, and then loosen the œsophagus from the trachea for a short distance. The larynx is then divided from the trachea as in laryngectomy, and the tracheal stump pulled under the skin-bridge and into the buttonhole above the episternal notch, where it is firmly stitched. The wound is closed towards the mouth by sewing the pharynx walls, or, if one has cut off the pharynx very high, by packing with iodoform gauze. An india-rubber tube is placed in the œsophagus." Prof. Gluck draws flaps of skin together by sutures over gauze; other surgeons leave the wound open.

The edges of this gradually become inverted, and the granulating surface slowly covered by epithelium until a deep furrow leads from the pharynx above to the œsophagus below. Narath [2] advises the closure of this by a plastic operation by double flaps, as in Duplay's operation for hypospadias (*q.v.*), some months later to convert the above furrow into a tube. Two flaps are marked out and dissected upon either side of the furrow. They are then turned inwards and sutured in the middle line. They should not contain any hair follicles. Over the raw surface of these, if the tissues of the neck are sufficiently lax, two other flaps are guided inwards. Further operations may be needed for fistulæ dating to failure of complete union.

Mr. W. S. Handley has recorded a case of complete transverse resection of the pharynx with laryngectomy for a carcinoma of the posterior wall.[3] The patient was a woman aged 44 years. There was a mass of fungating growth filling up the lower outlet of the pharynx. A preliminary gastrostomy was performed and a week later a low tracheotomy was done, the trachea being plugged with gauze above the tube. An incision was made along the anterior border of the left sterno-mastoid, and the upper end of the œsophagus was exposed; at the root of the neck it was free from growth. The left lateral incision was then prolonged to the mastoid process, and from the angle of the jaw on the right side a second incision was carried downwards and inwards to join the first one at right angles. After identifying and freeing the two superior laryngeal nerves the pharynx was opened by dividing the thyro-hyoid membrane. The insertion of a finger then showed that it would be impossible to separate the growth from the larynx. The pharynx was then divided above the level of the growth. The whole mass could now be pulled forward, and was removed by cutting through the trachea and œsophagus as low down as possible, after ligature and division of the isthmus of the thyroid. The infiltrated left lobe of the thyroid was removed in one piece with the larynx and pharynx. The trachea, the œsophagus, and the remaining upper part of the pharynx were respectively closed by sutures. A drainage-tube was inserted, lying in the line between the right and left angles of the mandible. The flaps were replaced and the wound sewn up. As Mr. Handley remarks, the operation is a terrible one, and is to be offered not urged. This is true of this, and of many of the other operations described in this and the preceding chapters.

Trans-hyoid Pharyngotomy. This operation is indicated in a few cases of extrinsic malignant disease, *e.g.* those where the mischief originates

[1] *Loc. supra cit.*
[2] *Arch. f. Klin. Chir.*, Bd. lv, S. 840.
[3] *Proc. Roy. Soc. Med.*, Clin. Sec., vol. i, p. 66.

in the region of the epiglottis, aryteno-epiglottidean folds, and is limited to these parts. The operation is described at p. 558).

Palliative Tracheotomy. This may be indicated in cases unsuited to attempts at extirpation, or where a patient declines these, with the object of retarding the rate of the disease and preventing or relieving dyspnœa. The chief guides are the general condition and vitality of the patient (p. 593) and the extent of the disease, *e.g.* to the pharynx widely, epiglottis and back of tongue, with evidence of infiltration and involvement of glands. While the relief given at first may be decided, the closing scene is often distressing, as when ulceration of the soft parts takes place, or when, owing to the downward extension of the growth, the tracheotomy tube becomes a source of constant irritation and distress, though absolutely necessary for respiration. In such cases, where suffocative cough and dyspnœa cannot be relieved by other means, the question of laryngectomy may arise after a palliative tracheotomy has been performed.[1]

After-treatment. As the best of all positions, the prone, is rarely endured, the foot of the bed may be raised for a day or two. The inspired air should be kept moist by means of a steam kettle. Discharges must be prevented from entering the trachea by packing gauze round the tube. Nourishment must be supplied for the first week, or until the deeper part of the wound is consolidated, by a soft tube passed either from the nose or mouth. If the repairing sutures in the pharynx give way, the use of the tube will be more prolonged. Feeding, save for the first few hours, by enemata alone is not reliable, considering the debilitated condition of these patients and the profound shock which accompanies the operation. When the wound is consolidated, the patient should be encouraged to take some semi-solid food by the mouth, liquid food thus taken having a greater tendency to get into the wound. Thirst must be met by ice in the mouth and sips of sterile water. The temperature of the room should be from 65 70 . Morphia should, if possible, be avoided. Secretion and coughing may be diminished by giving small doses of belladonna.

An artificial larynx has been tried but has met with but indifferent success. It consists of three parts, a lower tracheal and an upper or laryngeal tube, which lies in the pharynx and contains some form of vibrator or reed. As a rule the artificial larynx has been found to be liable to the following objections. Irritation is produced by pressure at a spot where all pressure is especially to be avoided; the vocal vibrator is liable to produce a sound, often noticeable and whistling with every respiration. It often becomes obstructed with mucus and saliva, and prolonged attempts at talking with such apparatus prove exhausting from difficulty in breathing. The patient is better content with a whispered voice, and the use of a writing pad.

Dangers and Causes of Death. These will have been gathered from the details already given. It may be well to recapitulate the chief ones: (1) Shock. (2) Exhaustion. (3) Broncho-pneumonia, abscess and gangrene of the lung, and empyema. The first two weeks are said to constitute the chief period of danger from lung complications. (4) Infective conditions, *e.g.* septicæmia, toxæmia, cellulitis, mediastinitis. (5) Secondary hæmorrhage. (7) Displacement of the tracheotomy tube. (7) In some cases a rapidly fatal result has followed when all has seemed to be doing well, perhaps from impulses conveyed along the cardiac fibres of the vagus, from changes in the cut superior laryngeal nerves, or in branches between the sympathetic and vagus of which but little is, at present,

[1] *See* a case reported by Sir H. Morris (*Trans. Clin. Soc.*, vol. xx, p. 37).

known. (8) Stenosis from cicatricial contraction. (9) Other risks inseparable from operations in which an attempt is made to extirpate infiltrated and adherent epitheliomatous glands in the neck. Finally other dangers inseparable from laryngectomy in some patients must be remembered, viz. the visceral and vascular changes usually present, and the mental misery from the isolation, the discomfort, and, at times, the degree of inanition daily from the escape of liquids where the pharynx has been extensively extirpated, and where the repairing sutures have not held, or where a plastic operation has failed.

Other Indications for Laryngectomy. These will be extremely rare. The operation has however been performed for tertiary syphilitic disease, for necrosis of the laryngeal cartilages, for an enormous myxofibrochondroma of the hyoid and larynx, and also in the course of an operation for a recurrent carcinoma of the thyroid gland.

CHAPTER XXVIII

REMOVAL OF FOREIGN BODIES FROM THE UPPER AIR PASSAGES AND FROM THE ŒSOPHAGUS

It is no exaggeration to say that within the last ten years this branch of surgery has been completely revolutionised by the introduction of direct vision tubes for diagnosis and treatment by Killian, of Bonn: the original tubes have been considerably modified and improved by Brünings and others. Before the introduction of these methods the death-rate was extremely high: as a result of their use the mortality has been strikingly reduced.

FOREIGN BODIES IN THE AIR-PASSAGES

The variety of foreign bodies which may be met with is great. Among these may be mentioned pins, portions of tracheotomy tubes, especially ill-made ones and tubes worn for too long a time, beans, pebbles, fruit-stones, parts of toy whistles, pieces of nutshell, &c.

Site of lodgment. In the pharynx foreign bodies may be caught in the vallecula (the fossæ bounded by the glosso-epiglottidean folds, between the tongue and the epiglottis), and the sinus pyriformis: in the larynx, between the vocal cords; in the trachea; and in the right bronchus,[1] rather than the left, owing to the larger size of the former, and the fact that the septum is a little to the left of the mid-line.

Evidence of a Foreign Body having lodged in a Bronchus. Perhaps there may be a history of a foreign body having been held in the mouth, though in the case of a child no history may be obtainable; there may be dull heavy pain behind the sternum at about its junction with the right costal cartilage. There will also be shortness of breath, cough, and expectoration. On examining the chest there will be more or less diminution of breath sounds over a portion of the chest wall;[2] increased breath sounds on the opposite side, râles, and later on evidence of inflammation and destruction of lung tissue.[3]

An X-ray examination should always be carried out, though the foreign body may be transparent to the rays and hence not show on

[1] While this is the rule, Dr. Cheadle and Sir T. Smith reported (*Lancet*, January 14, 1888) a case of occlusion of the left bronchus by a metal pencil cap in a girl aged 9. Urgent dyspnœa followed at once, there was great pain at the time and violent cough. By the eleventh day there was evidence of almost complete collapse of the left lung, this having commenced on the fourth day. There was no dyspnœa but occasional short cough. The cap was believed to have lodged in the left bronchus. Tracheotomy was performed and the trachea freely opened. A long probe detected the cap in the position diagnosed, with the open end uppermost. It was easily extracted with suitably curved forceps. A good recovery followed.

[2] Obstruction of the left bronchus usually produces absence of breath sounds over the entire left lung, but occlusion of the right bronchus usually produces absence of breath sounds over the right lower lobe only, the division of that bronchus taking place much nearer the bifurcation, and the foreign body rarely lodging above the point of division.

[3] In the case of a foreign body in the trachea there will very likely be spasmodic attacks of coughing during which the body may be felt to be forcibly driven against the under-surface of the vocal cords.

screen or plate. It must be remembered, too, that a small opaque body, such as a piece of bone or the root of a tooth, may not show owing to its small size and deep situation. Another important point to bear in mind is that though the foreign body may be supposed to be in the air-passages it may be in the œsophagus, and vice versa. A body which the patient describes as having been swallowed may have really been drawn down into the trachea, and one thought to have been inhaled may have been swallowed. In either case there may be a considerable time be an absence both of symptoms and physical signs, or these may be anomalous.

Foreign bodies entering the lung by perforation of the chest wall may become surrounded by a capsule of fibrous tissue and give rise to no further serious symptoms, but when entering by the air-passage they almost invariably set up some septic trouble, such as septic broncho-pneumonia, purulent bronchitis, abscess, gangrene, bronchiectasis, or empyema: actinomycosis may be caused by the inhalation of some foreign body such as an ear of corn or a carious tooth. Garre and Quincke [1] classify the treatment of foreign bodies in the lungs and bronchi as follows: (1) Alleviation of expectoration by position, external manipulation and emetics. (2) Extraction of the foreign body by bronchoscopy. (3) Low tracheotomy. (4) Interthoracic tracheotomy immediately above the bifurcation of the trachea. (5) Bronchotomy from the posterior mediastinum. (6) Pneumobronchotomy.

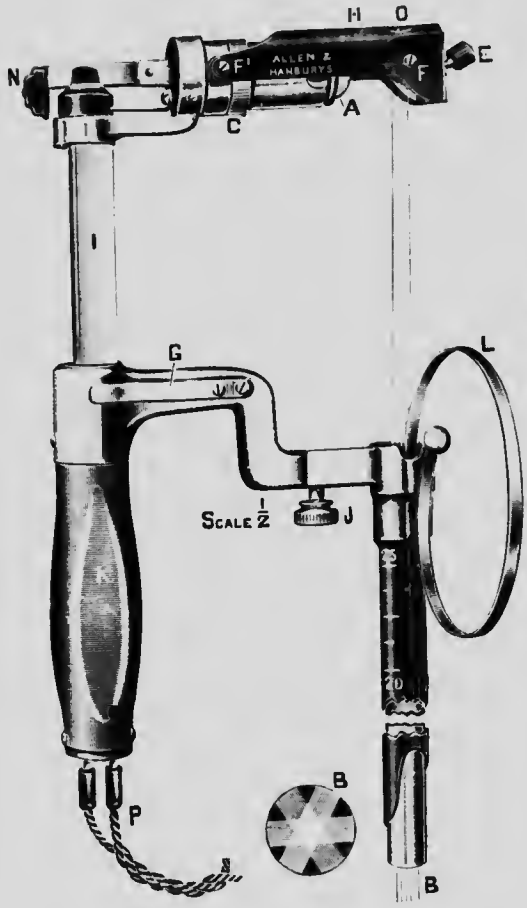
It will be best first to describe the **old method of treatment**, as, if the special instruments described below are not available, this is the only way of dealing with these cases. In any case, should a foreign body such as a piece of bone or a bolus of food become impacted in the larynx causing urgent dyspnœa, an immediate laryngotomy or tracheotomy must be done at once, and the foreign body be extracted later by one of the methods described below.

If the foreign body is in the trachea or a bronchus a low tracheotomy (*see* p. 567) should be performed, with as free an opening as possible. The edges of the wound in the trachea should be held open and the patient be allowed to come round from the anæsthetic, when attempts can be made to excite attacks of coughing by inserting a probe, with the hope that the body may be expelled. If provided with suitable instruments the surgeon may at once proceed to attempts at extraction, but it is well to remember that in a large proportion of cases that have done well after this operation that expulsion has not been effected until some time afterwards. Whenever a fit of coughing brings the body into view, the next inspiration will draw it back again, so that careful watching and prompt use of forceps, &c., will be required. If from its shape, or from the interval which has elapsed, the body is too firmly impacted to be expelled by exciting coughing, the following instruments may be resorted to, viz. Gross's flexible German silver tracheal forceps, long and slender and easily bent into any curve; or Durham's forceps, equally flexible and giving a better grip. Another forceps which has proved itself most useful in these cases is Tait's alligator forceps.

Mr. R. Anderson, of Nottingham, has recorded a case in which a nail was removed from the right bronchus in a child aged 2½ years by means of these forceps.[2] Mr. W. M. Willis [3] mentions another case in which the same forceps, after a low tracheotomy in a child aged 7 years, quickly removed a fruit stone from the right bronchus.

[1] *Loc. inf a cit.* *Brit. Med. Journ.*, April 12, 1902.
[3] *Lancet*, 1904, vol. ii, p. 1641.

Failing the above, stout silver wire should be bent into the form of a blunt hook, or a long probe fashioned into the same shape. The above instruments are first used as sounds and searchers, aided by the forefinger, which can be passed as far as the bifurcation of the trachea and the orifice of each primary bronchus, as pointed out by Dr. Sands.



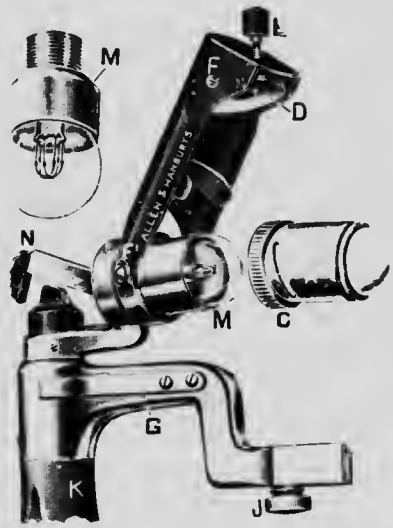


FIG. 258. A, Lens. B, Parallel rays of light concentrated by the lens and thrown by the mirror along the inner tube. C, Screw for adjusting lens. D, Perforated mirror. E, Screw for adjusting mirror. F, Screw which forms the axis about which the mirror rotates. G, Spring for securing (I) in position. H, Holder for mirror, which can be rotated around the axis of the screw F' to allow of cleaning the mirror and access to the lamp. I, Rod for adjustment of hand tight to handle. J, Screw for securing tube spatula. K, Handle. L, Watch spring of inner tube. M, Lamp. N, Switch. O, Eye piece. P, Terminals.

The operation should not be too prolonged especially if the parts are inflamed. When this condition has subsided, spontaneous expulsion will often take place.

Direct vision Laryngoscopy and Bronchoscopy.[1] This method should always be adopted for the localisation and extraction of foreign bodies, except in those cases where the severity of the dyspnœa calls for immediate

[1] A very large number of cases treated by this method have now been recorded. Reference to the *Proc. Lar. Sec. Roy. Soc. Med.* during the past five or six years will provide numbers of illustrative cases. Gottstein (*Über die Diag. u. Ther. der Fremdkörper in den unteren Luftwegen Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, Jena, 1907) gives an account of 135 cases; while Killian (*Direct Tracheobronchoscopy, Ann. Otol. Rhin. and Lar.*, New York, June 1907) has collected 159 cases. Killian points out the importance of distinguishing clinically between hard foreign bodies and soft. The latter are liable to swell, completely block the air-passage and cause pneumonia.

laryngotomy or tracheotomy. This means of diagnosis and treatment was put on a thoroughly practical footing by Killian, but his original instruments have been modified and improved by Brüning, and the modern apparatus bears the name of the latter.

Brüning's apparatus consists of the following parts. (*a*) *The tubular spatula* (Fig. 259), which slides over the dorsum of the tongue and the epiglottis and then can be made to enter or to pass through the larynx. Various lengths and sizes are supplied, each of which can be firmly screwed to the handle by means of which the instrument is manipulated.

(*b*) *The hand light*, which is attached to the handle by which the whole instrument is controlled. The arrangement of this will be understood on reference to Fig. 258. The lamp from a powerful electric lamp is concentrated by a lens and thrown on to a perforated mirror, from which it is reflected along the centre of the tubular spatula, when the latter is screwed in position. Both lens and mirror can be adjusted by screws so as to ensure the light being thrown in the right direction. The operator's eye, looking through the perforation in the mirror, can thus see, with a good light, the structures at the end of the tube spatula.

(*c*) *The inner tubes* (Fig. 260). These are of different lengths and of various diameters corresponding to the diameters of the spatulæ. Each inner tube is provided with a piece of watch spring, which, when the inner tube is introduced through the spatula, rests in a groove in the wall of the latter. Both the watch spring and the spatula are graduated, so that the distance to which the tubes have been introduced can easily be ascertained.

Indications for direct vision Laryngoscopy and Bronchoscopy. (1) For the diagnosis of diseases of the larynx, especially growths. Portions of doubtful material may be removed by means of cutting-forceps for histological examination.

(2) For the treatment of growths of the larynx, *e.g.* the removal of papillomata or of polypi.

(3) For the diagnosis and treatment of foreign bodies in the larynx, trachea, or bronchi.

(4) For the diagnosis of certain diseases of the trachea and bronchi, *e.g.* bronchial and tracheal fistulæ and ulcerations, also carcinoma of the bronchi.

(5) For the intra-tracheal insufflation of ether.

Indications for direct vision Œsophagoscopy. (1) For the diagnosis and treatment of foreign bodies in the pharynx (including the sinus pyriformis) and the œsophagus.

(2) For diagnostic purposes, *e.g.* strictures, malignant or otherwise, pouches.

(3) For purposes of treatment, *e.g.* the dilatation of fibrous strictures.

Anæsthetic. It is, of course, essential that while using these instruments there shall be no movements of the patient. In some adults it is possible to introduce the tubes and examine larynx, trachea, and bronchi after effective application of cocaine [1] to the pharynx and larynx. These parts, however, are exceedingly sensitive, and hence, even in adults, it is

[1] Novocain or alypin are also recommended as being less toxic. If the patient is not under the influence of a general anæsthetic, 10 or 20 per cent. cocaine to which a little adrenalin hydrochloride (1 in 1000) has been added should be deliberately painted over the back of the pharynx, the superior aperture of the larynx and the vocal cords by means of a laryngeal brush and a laryngeal mirror. If the patient is anæsthetised the brush is guided by a finger pushed over the dorsum of the tongue. Owing to the sensitiveness of the larynx cocaine is always necessary, even when a general anæsthetic is given.

generally more satisfactory to administer chloroform in addition to the local application of cocaine. In children chloroform is always necessary and here it must be remembered that a comparatively small amount of cocaine may have toxic effects in children. If dyspnœa is present oxygen may be given with the chloroform. Tracheotomy instruments should always be to hand, though, owing to the fact that the tubes hold the air-passage widely open, obstruction to breathing is seldom met with.

Position of the patient. The dorsal position, with the head slightly, but not too much, extended is best. The lateral position is equally satisfactory. In either case the operator should be provided with a low stool which enables him, without undue strain, to bring his eye to the level of the tubular spatula. For a short examination under local anæsthesia alone, the patient should sit on a low stool while the operator introduces the tube, standing in front of the patient.

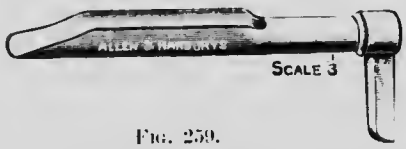


Fig. 259.

Examination of the Larynx and the Bronchi. A tubular spatula of suitable size having been selected and screwed to the handle, and the apparatus having been tested to ensure that all parts are in working order, and that the mirror and tube are accurately adjusted, the mouth is widely opened by a gag and the spatula passed in the middle line over the dorsum of the tongue. During this and the whole of the manipulation care must be taken to avoid injury to the upper lip and incisor teeth. The epiglottis soon comes into view and the spatula is made to pass over its free border. By pressing the spatula forwards the aryteno-epiglotti-

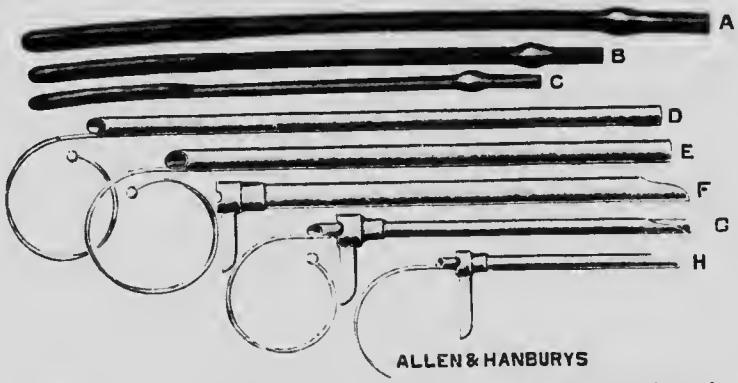


Fig. 260. A, B, C. Obturators for œsophageal tubes. D, H. Extending tubes for œsophagoscopy and bronchoscopy.

dean folds and the vocal cords come into view and the instrument is then pushed onwards through the superior aperture of the larynx. At this stage the vocal cords and the larynx may be examined with deliberation, and any foreign body, growth, or other disease can be detected and its position and extent ascertained. It will also be possible to see the whole length of the trachea and its bifurcation. The narrow extremity of the spatula is then directed backwards and is pressed onwards between the posterior extremities of the vocal cords into the trachea.[1] Care must now

[1] If there is any difficulty in passing the spatula through the glottis it may be rotated through a right angle, so that the long diameter of the end corresponds with the antero-posterior diameter of the glottis. The spatula is then rotated to its original position.

be taken that, as the spatula is pushed onwards, it passes along the lumen of the trachea and is not forced against its walls. The bifurcation of the trachea will now be clearly seen and also the right main bronchus. If further exploration of the bronchi is required a suitable inner tube must be introduced through the spatula and on into one or both bronchi. To explore a bronchus this must be brought approximately into line with the spatula and the trachea. To do this in the case of the left bronchus the upper end of the spatula must be pressed over to the right corner of the patient's mouth, and in the case of the right bronchus it must be pressed over to the left side. In this way the divisions of each bronchus to the pulmonary lobes may be brought into view and explored and also

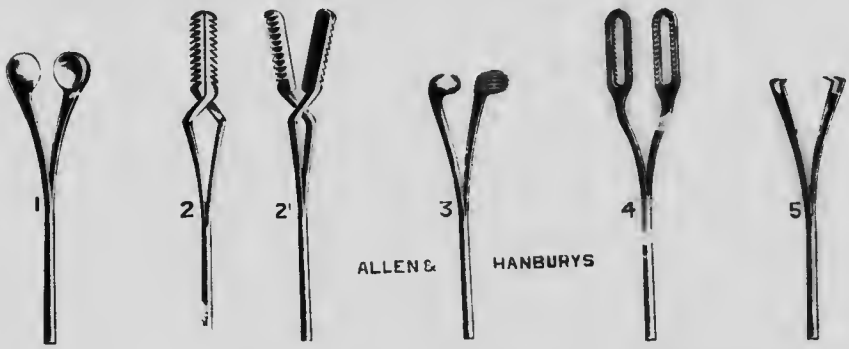


Fig. ... ulting ends for removing growths, &c. 2. Cross action for removing bodies, &c. 3. For removing needles, &c. 4. Oval-shaped, for ...ing bean-shaped foreign bodies. 5. Claw-ended forceps.

their larger subdivisions. Considerable difficulty may be met with in identifying the division of the right bronchus which passes to the upper lobe of the right lung: this leaves the main bronchus almost at a right angle, just beyond the bifurcation of the trachea.

The bronchi can also be explored by Brüning's tubes introduced through a tracheotomy wound, either specially done for the purpose, or on account of urgent dyspnœa. This is known as the "lower" method of bronchoscopy. The instrument should, generally speaking, be introduced through the mouth and the lower method reserved for cases where a tracheotomy has already been done.

Extraction of a Foreign Body. The foreign body having been brought into view it should be extracted by means of Brüning's forceps. These are of sufficient length to pass through the whole length of the spatula and inner tube and can be used under the eye of the operator looking through the perforated mirror. The instrument consists of a solid rod passing through a hollow tube. Forceps of various shapes appropriate to the nature of the body can be screwed to the end of the rod (Fig. 261). Thus there is a vulsellum forceps for grasping small solid bodies, "bean" forceps for grasping soft bodies, forceps for hollow bodies, a hook for encircling projections from irregular bodies, scoop-forceps for removing portions of growths, &c. for examination. Withdrawal of the rod through the tube closes the forceps, while pushing the rod onwards allows the jaws to separate. A small body may at once be drawn through the tube while a larger body may be displaced and drawn against the inner tube and then is gradually withdrawn as this is removed. If the field of

operation is obscured, as it very likely will be by pus, mucus, or blood, small pieces of sterilised wool may be fixed to the forceps and used as swabs.

During the whole manipulation every care must be taken to avoid the use of undue force, or serious laceration of the bronchi may occur and extraction be rendered still more difficult by the bleeding thus caused.

Foreign bodies in the larynx may be recognised and removed through the tubular spatula without the employment of an inner tube.

If attempts at extraction fail two courses are open: (*a*) To do a tracheotomy in the hope that the body will become loosened and that it will subsequently be expelled through the tracheotomy wound during a fit of coughing; (*b*) To remove the foreign body by mediastinal bronchotomy, or to open the pleural cavity and reach the body by incising the lung (*see* Operations on the Lung and Mediastinum, p. 792). The latter very serious steps will not be undertaken without a careful consideration of the nature of the foreign body, the time it has been in the bronchus, the evidence of abscess or gangrene, and the general condition of the patient.

Removal of Innocent Growths from the Larynx. These may be removed by means of special cutting-forceps, introduced through the tube spatula. The larynx should be thoroughly treated with cocaine and adrenalin applied by a brush through the spatula, in order to render the larynx insensitive and to make the operation bloodless.

Removal of Foreign Bodies from the Œsophagus. A great variety of foreign bodies may become impacted in the œsophagus. Among those more frequently met with may be mentioned toothplates, pieces of bone, fish bones, and coins. A great variety of foreign bodies may be swallowed by children and there may be the same difficulties about the diagnosis of these as mentioned in the case of foreign bodies in the air-passages.

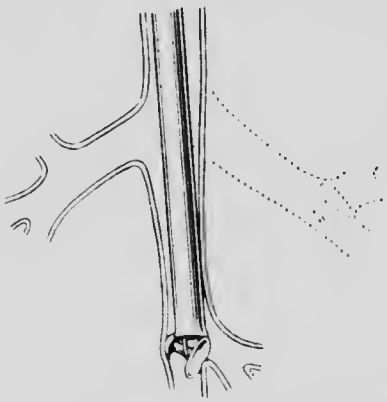


Fig. 262. Seizure of a foreign body with the aid of the bronchoscope (extension of the left bronchus). (V. Eicken.)

Site of Impaction. This will usually be at one of the three following places: (*a*) behind the cricoid cartilage, (*b*) where the left bronchus crosses the œsophagus, (*c*) at the lower end of the œsophagus, just above the diaphragm.

Diagnosis. There will usually be dysphagia and pain, and there may be some dyspnœa giving rise to some uncertainty as to whether the foreign body is in the œsophagus or the air-passages. Later there will be ulceration, suppuration, and eventually perforation with an abscess or cellulitis, deep in the neck or in the mediastinum.

Treatment. Formerly impacted foreign bodies were treated by the probang, or the coin catcher. Though coins or small foreign bodies may be extracted or pushed downwards into the stomach by these means, there is a serious danger of laceration of the œsophageal wall if they are employed for large or irregular substances. A remarkable reduction in the

mortality of these serious cases has resulted from the use of Brüning's œsophageal tubes, and extraction with the help of this apparatus must be regarded as the most desirable means of treatment. Special tubes are made of varying diameter suitable for the œsophagus of children and adults, and some are of sufficient length to reach to the lower end near the cardiac orifice of the stomach. The tubes are graduated so that the distance to which they are introduced can be easily seen. Similar forceps to those used for the bronchi, but longer, are constructed, and with their help foreign bodies can be loosened and withdrawn.

No special description of the mode of use of these tubes need be given as it closely resembles that given for the bronchi. When introducing the tube it must, of course, be made to pass across the superior aperture of the larynx and then behind the cricoid cartilage.

It must be remembered that it is possible to push the tube past the foreign body, and hence, if it is at first missed, the wall of the œsophagus must be carefully inspected during its slow withdrawal as well as during its introduction.

If firmly impacted attempts at extraction may fail. In this case extraction by œsophagotomy, either at the root of the neck or through the posterior mediastinum, must be employed. These severe operations, which will only be undertaken after the failure of simpler means, are described at pp. 649 and 792.

An irregular foreign body such as a tooth-plate firmly impacted at the lower end of the œsophagus may present very great difficulties. Should other methods not be successful such an object may be extracted by opening the stomach, seizing the foreign body by means of suitable curved forceps introduced into the œsophagus through the cardiac orifice of the stomach, and withdrawing it through the incision in the gastric wall.

CHAPTER XXIX

OPERATIONS ON THE THYROID GLAND

EXTIRPATION OF PART OF THE GLAND. ENUCLEATION OF ENCAPSULED TUMOURS. LIGATURE OF THE THYROID ARTERIES

A goitre or bronchocœle is the term generally applied to an enlargement of the thyroid gland. The enlargement may be due to one of the following causes: (1) General, or parenchymatous enlargement. Here there is generally a uniform enlargement of the whole gland. (2) Adenomata. The enlargement is usually asymetrical and may be confined to one lobe of the gland. (3) Cysts. These are often associated with, and are probably derived from, adenomata. (4) Exophthalmic goitre, or Graves' disease. (5) Malignant goitre, generally a carcinoma, but occasionally a sarcoma.

Frequently the enlargement is due to a combination of two of the above. Thus a combination of parenchymatous enlargement with adenomata or cysts, is common, and malignant disease may occur in a gland which already contains an innocent growth. It is always of great importance to ascertain the cause of the enlargement, as the treatment and the prognosis will to a great extent depend upon this.

Indications for Operation. These will have to be considered in detail for each of the above-mentioned varieties, but the indications may be summed up as follows: (1) *Dyspnœa*. This is a very common indication for operative treatment. Several varieties may be distinguished: (*a*) Shortness of breath on exertion. (*b*) Attacks of sudden, suffocating dyspnœa. A goitre, whether it be moderate in size or large, may from some sudden engorgement or rupture of its vessels cause sudden and even fatal dyspnœa. The first attack may then prove fatal.[1] The following ingenious explanation of these attacks has been given by Dr. Hurry: Owing to the slowly progressive enlargement of the thyroid, the dyspnœa may at first be very slight; one day some extra exertion calls into play the additional muscles of respiration, *e.g.* sterno-mastoid and infra-hyoid muscles, which pressing on the trachea, still further close its lumen, already narrowed by the progressive increase in size. This brings about additional dyspnœa, and so induces more vigorous contraction of the inspiratory muscles, and so further closure of the trachea, and finally fatal dyspnœa. Occasionally it may be an accessory thyroid, not the main gland itself, which is the cause of the dyspnœa, and perhaps of death. Such a case is recorded by Sir J. Bland Sutton.[2]

[1] Thus in one case, a woman with a goitre which, so far as was known, had not given previous trouble, waking out of sleep suddenly, was terrified by seeing her little child playing with a lighted piece of wood taken from the fire. Most urgent dyspnœa set in, and, before surgical relief could be given, death took place from suffocation.

[2] *Lancet*, 1895, vol. i. p. 462.

A man, æt. 36, was found lying on his back in a street adjoining the Middlesex Hospital, apparently in a fit. When brought in by the police he was dead. At the autopsy an accessory thyroid embedded in a thick fibrous capsule was found firmly fixed to the trachea from the fourth to the ninth cartilages. Though only about the size of a dove's egg, it had severely compressed the trachea and caused the fatal dyspnœa.

In other cases the dyspnœa may render it impossible for the patient to sleep lying down.

(2) *Dysphagia*, especially if associated with other indications.

(3) *Steady or rapid enlargement*, with or without dyspnœa, if the enlargement be in a downward direction so as to become substernal.

(4) Operation may be called for on account of *deformity* apart from other symptoms.

(5) With very large and weighty tumours there may be constant *dragging pain in the neck*.

(6) In selected cases of *exophthalmic goitre*.

(7) Some cases of parenchymatous goitre or adenomata where symptoms of *hyperthyroidism*, such as palpitation, cardiac dilatation, or muscular weakness and tremor are present.

(8) Suitable cases of *malignant goitre*.

Mr. James Berry in the Lettsomian Lectures on the Surgery of the Thyroid Gland for 1913[1] gives the following Table of the chief reasons for operation in a series of 351 cases :

Dyspnœa	209	operations
Deformity	17	,,
Discomfort or deformity (with minor degrees of dyspnœa)	57	,,
Malignant or papilliferous tumours	9	,,
Suspected malignancy	3	,,
Dysphagia	2	,,
Increasing size	3	,,
Typical exophthalmic goitre	17	,,
Palpitation, nervousness, &c., mostly with dyspnœa	34	,,

Parenchymatous Goitre. The whole gland here is usually uniformly enlarged. As is well known medical treatment such as the administration of iodine, potassium iodide, and thyroid extract is often successful in these cases. Only a small proportion will therefore require surgical treatment.

The special indications for operation in these goitres will be : (*a*) *Failure of medical treatment*. In spite of careful and prolonged treatment by drugs a large goitre may remain stationary, or even show a steady increase in size. (*b*) *Dyspnœa*. A large parenchymatous goitre may cause lateral compression of the trachea, and, as Mr. Berry points out, such pressure may easily lead to rapid and even fatal suffocation, especially in young patients about the age of puberty, where the soft and yielding nature of the tracheal wall readily permits of collapse. It may here be pointed out that the amount of dyspnœa does not necessarily depend upon the size of the goitre. A comparatively slight enlargement, if deep-seated and especially if it extends behind the manubrium, may cause the most serious dyspnœa. Increase of size in a downward direction, especially if passing behind the manubrium, is therefore an indication for operation. (*c*) A parenchymatous goitre may require operative treatment if associated with symptoms of *hyperthyroidism* : such cases have to be carefully distinguished from the exophthalmic goitre. (*d*) Operation is generally

[1] *See Lancet*, 1913, vol. i. pp. 583, 668, 737, and 738. These lectures should certainly be carefully read by those interested in this subject.

indicated in cases of *adeno-parenchymatous enlargement*. In some of these cases medical treatment may cause the parenchymatous enlargement to diminish and so render obvious the presence of a previously unsuspected cyst or adenoma.

Cystic and adenomatous goitres may be considered together. Here medical treatment will be of no effect, beyond, perhaps, diminishing any parenchymatous enlargement which may also be present. These tumours, though usually growing slowly and often remaining stationary for many years, may reach an enormous size. They then may cause excessive displacement and deformity of the trachea and the larynx. The present writer recently had a case of an enormous adenomatous goitre growing from the right lobe, which had been present for fifty years, and had displaced the larynx so that the thyroid cartilage was rotated through a right angle and could be felt between the angle of the jaw and the sternomastoid. Generally speaking, then, the treatment of this variety of goitre is essentially operative, especially if any symptoms such as dyspnœa or those of hyperthyroidism are present. Mr. Berry[1] advises that in young children operations for goitre should not be performed, unless serious symptoms are present, on account of the serious risk of interference with nutrition and growth, and also an appreciable immediate risk to life. An adenomatous goitre in an elderly patient, unless serious symptoms are present, should also, as a rule, be left alone.

FIG. 263. This figure shows one way in which the trachea may be narrowed by a bronchocele, and how great the stenosis may be. If in addition there were pressure on the opposite recurrent laryngeal nerve, or if an anæsthetic had to be given, it is obvious how easily a fatal result might follow. (Esmarch and Kowalzig.)

Intrathoracic goitres may also be mentioned here as they are generally adeno-parenchymatous, or may consist entirely of adenomata or cysts.

Mr. Berry, in his series of 351 cases treated by operation, had no fewer than 18 intrathoracic goitres. He quotes the following interesting case. "A gentleman, aged 62, had been the subject of slowly increasing stridor and dyspnœa for more than fifteen years. He had a small lump low down on the left side of the neck, scarcely visible or palpable except during deglutition. A skiagram, however, revealed the fact that on the right side there was a large intrathoracic mass. It extended as low as the level of the sixth rib behind. This tumour was removed in October last chiefly by means of a large scoop and an ordinary silver tablespoon. On the left side was a smaller mass, the size of a tangerine orange, which was also removed from the thorax. The total weight of the two masses was ten ounces. I saw him a few days ago and found him in robust health, without a trace of dyspnœa, and he is now enjoying himself on a tour in France."

Exophthalmic Goitre. (Graves's Disease, Basedow's Disease.) The question of operative treatment of exophthalmic goitre cannot yet be regarded as definitely settled. It has been much discussed in recent years, and widely divergent views have been expressed by different authorities on this disease. Probably one reason for this is that cases

[1] *Loc. supra cit.*

of parenchymatous, or adeno-parenchymatous, goitre, with symptoms of hyperthyroidism, have been confused with true exophthalmic goitre. As has already been pointed out such cases may have tachycardia, palpitation, tremor, nervous symptoms, and even some exophthalmos. It is admitted that these symptoms in such cases clear up after removal of a portion of the gland. The thyroid gland in exophthalmic goitre has certain definite and microscopical characteristics: the most marked microscopical change is the diminution or even complete absence of the normal colloid secretion. Histologically there is a considerable increase in the amount of epithelium so that the walls of the vesicles are often infolded, there is an increase in the blood vessels and a diminution in the colloid secretion. Only cases in which the gland has these typical characters should be regarded as true exophthalmic goitre. At the present day it is generally agreed that the disease is due to the absorption of some secretion from the diseased gland, the older view that it is due primarily to a disease of the nervous system having been practically abandoned. The object of operative treatment is, by removing a portion of the gland, or by ligaturing two or three of the arteries supplying it, to diminish the amount of secretion which by its absorption causes the disease. There is, however, without doubt, a very considerable risk attached to these operations.

In severe cases there is a very considerable danger of the patients dying shortly after, or even during the course of, the operation, and even in mild cases the risk is very distinct. The reason for this danger is easy to understand. In most fatal cases there is a remarkably large persistent thymus, and in some there is evidence of increase of lymphoid tissue elsewhere—often, for instance, in the cervical lymphatic glands (Kocher). In other words the dangers resemble those associated with the status lymphaticus (*q.v.*). Hyperthyroidism, too, is apt to lead to secondary degeneration of the viscera: thus the heart becomes dilated, and albuminuria and glycosuria are often present. Owing to these secondary visceral troubles patients with exophthalmic goitre are liable to die suddenly, quite apart from any operative interference. Though for these reasons there is a very considerable danger attached to the operation, there is no doubt that in a large number of cases operation is followed by rapid improvement and even cure. With improvement in the technique of the operation the mortality has, in the hands of those specially skilled in these operations, diminished to 4 per cent. or even less.

The question of *anæsthetic* is a most important one. While some surgeons favour a general anæsthetic others prefer local anæsthesia. Death may occur even with the latter, as in a case of Mr. Berry's.[1] Intratracheal anæsthesia (*q.v.*) is so satisfactory for the other varieties of goitre that it is worthy of an extended trial in these cases also.

The question to be decided is whether the benefit to be obtained from operative treatment justifies the risk which is necessarily run. To settle this important point it is necessary, first of all, to know the results that are to be expected from medical treatment. Most interesting information on this subject is contained in a paper by Dr. Hale White, on "The Outlook of Sufferers from Exophthalmic Goitre." Dr. Hale

[1] *Loc. supra cit.* See also a discussion on "Partial Thyroidectomy under Local Anæsthesia with Special Reference to Exophthalmic Goitre" (*Proc. Roy. Soc. Med.*, Surg. Sec., March 1912).

[2] *Quart. Journ. of Med.*, October 1910, and *Guy's Hospital Reports*, vol. lxv. p. 1.

White investigated the after-history of all the patients, 161 in number, who were admitted to Guy's Hospital between 1888 and 1907 inclusive. Of these 18 died in hospital, 94 could not be traced, and 49 were traced, of whom 8 were dead in 1910. Dr. Hale White also collected 55 private cases between 1894 and 1909, of whom 7 were dead in 1910. A comparison was made between the actual deaths and the Table of expected deaths according to the "Healthy Females Experience of 20 British Offices amongst assured lives." The comparison showed that the total number of deaths in hospital cases that could be traced was 8, whereas it should have been 5 according to the Table of expected mortality. In view of the fact, however, that there were no known deaths at all over age 45, and only one death under age 30, it is quite impossible to draw any conclusions as to the comparative rates of mortality at the older and younger ages. If we compare the mortality between the ages 30 and 15, excluding two cases in which the age at death is unknown, we find that the number of deaths was 5, and should have been 3 according to the Table. If a similar comparison is made with the group of private cases the mortality closely resembles that of the first group. There were 7 actual deaths whereas there should have been but 3 according to the normal table. In these cases there was only 1 death over 45 and 2 under 30. Comparing, as before, the mortality between ages 30 and 45 and excluding 1 death where the age at death is unknown, there were 3 actual deaths while there should have been only 2.

"The data are so few that it would be dangerous to draw any conclusions from the facts here set out, except, perhaps, the general conclusion that the mortality experience seems to be heavier than would be expected according to a well-known standard Table."

Dr. Hale White divides the cases that can be traced into three groups. Thus in the series of hospital cases, deducting the 8 patients who died and 1 who was known to be alive though [illegible] condition was unknown, there are 40 cases which Dr. Hale White arranges in the following groups: (1) Those that have done well, 26. (2) Those that are moderately well or better, 12. (3) Those that are not well, 2.

In the same way, of the 55 private cases there were 7 deaths, and little is known of 1 case, so that 47 cases are traced as before: (1) Those that have done well, 35. (2) Those that are moderately well or better, 9. (3) Those that are not well, 3. Adding the two series together there are 87 cases, of which 61 have done well, 21 are better and 5 are not better.

These results indicate that the prognosis is rather better than is generally supposed, especially in private cases who are able better to rest and undergo prolonged treatment.

Dr. Hale White's figures are confirmed by those of other physicians. Thus Dr. Hector Mackenzie[1] says: "The disease is, as a rule, so long drawn out that many cases are lost sight of, especially in hospital practice; and a good deal of uncertainty thus prevails as to the issue of them. I have tabulated the result in 33 patients under my own care in whom the disease either lasted over five years or ended fatally, and Dr. R. T. Williamson has done the same in 24 cases observed at the Manchester Infirmary."

[1] Allbutt and Rolleston's *System of Medicine*, vol. iv. pt. 1, p. 377.

RESULT IN FIFTY-SEVEN CASES

	Dr. Mackenzie's series	Dr. Williamson's series	Total
Fatal termination	8	6	14
Recovery complete	5	5	10
Recovery almost complete	9	2	11
Improvement considerable	9	4	13
Improvement slight	1	3	4
In statu quo	1	3	4
Alive but exact condition unknown	0	1	1

"Out of 900 cases collected by Buscham a fatal result was recorded in 105. In about 25 per cent. of the cases death results from the disease. In about 50 per cent., more or less complete recovery will eventually take place. In the remainder the disease continues in a chronic form during life. There does not seem to be any rule as to the duration of the malady, the symptoms of which may last from a few months to many years."

It is now necessary to consider the results of the treatment of exophthalmic goitre by operation. There is no doubt that the great majority of cases do show a great and often rapid improvement after removal of one lobe of the gland, and indeed are often benefited by ligature of one or more of the thyroid arteries. Mr. Berry[1] says: "Patients undoubtedly do improve in a manner that is not seen, as far as I know, after any other method of treatment. . . . Of my own operation cases, with the exception of the two that died, there is not one that has not benefited by the operation, although in one or two the benefit has not been great, and in one case at least there has been a slight relapse." Dr. Hector Mackenzie,[1] says: "Were it not for the considerable risk to life from the operation I should not hesitate to recommend it as the most rational and most practical method of treatment of the disease. In the milder forms there is, however, a good prospect of recovery under medical treatment, and there does not seem so much more to be gained by operation to warrant the incurring of the risk of a fatal result. The risk of death from operation is so high in severe and acute cases as to render it doubtfully justifiable, and few surgeons would be found willing to perform it."

What then is the mortality of the operation? This is not an easy question to answer owing largely to the fact that in many published statistics there is some doubt as to whether cases of parenchymatous goitre with symptoms of hyperthyroidism are not also included.

Mr. Jacobson operated on four cases of exophthalmic goitre before 1900.

The first of these was a female patient, aged 22, of Dr. Garrard of Rickmansworth. The right lobe and the isthmus were removed. Two years after she reported that the swelling in the neck was scarcely to be seen. The palpitation was better and the eyes not so prominent. She took her food well and could walk over ten miles without feeling tired. She was able to work at a machine dressmaking from 8 A.M. till 8 P.M. Subsequently there was some slight relapse. In the second case removal of one lobe was followed by immediate relief of symptoms, but the late result could not be ascertained.

The third case was a typical exophthalmic goitre with a pulse rate of 140 and much restlessness and irritability. Palliative treatment gave no good result. At the operation the right lobe and part of the isthmus were removed. The operation was followed by marked relief of the symptoms, which did not, however, disappear. In 1900, six years after the operation, the breathlessness had much improved, but the

[1] *Loc. supra cit.*

proptosis and palpitation on exertion were still present. The restlessness and excitability remained as before. Her general health was then good and she was able to walk eight or ten miles at a stretch; the slightest chill, however, produced breathlessness and palpitation.

The fourth case was suffering from severe symptoms of thyroidism at the time of operation as shown by great agitation and restlessness and a pulse-rate of 130. The right lobe and the isthmus were removed. After the operation the restlessness was very marked, the pulse-rate rose to 180, and the patient died suddenly from cardiac failure about twenty-four hours later.

Mr. Berry [1] says: "We should be very careful in drawing conclusions from mortality statistics, as given in published records, unless we know to what class of cases the statistics refer. Probably the only safe test is the pathological one. . . . Mortality statistics based upon such pathological findings are rare in medical literature at the present day. The number of patients upon whom I have myself operated for exophthalmic goitre is comparatively small, amounting up to the end of 1912 only to 26. These were all cases of undoubted Graves's disease, in which all the classical symptoms, including exophthalmos, were present, mostly in a very marked form. Of these 26 patients, 2 have died as the result of operation, 1 in 1901 after simultaneous ligature of three arteries, and 1 in 1911 after a bilateral excision. One patient with severe Graves's disease, who died before I commenced the intended operation of ligature of a superior thyroid artery, is not included in these statistics."

Kocher [2] says: "To the present time we have operated on 200 cases of Basedow's disease (including 10 cases of struma vasculosa and 60 of a mild type) with a mortality of 4·5 per cent., this mortality being higher than in other forms of goitre. We have, however, learned how to overcome the operative risks, which are almost entirely dependent on the condition of the heart, *i.e.* toxic myocarditis. Excision should not be undertaken when the disease is advanced, *i.e.* when the pulse, besides being rapid, is also small and irregular, or when the heart is dilated and œdema is present. If there is severe thyro-intoxication, the slightest excitement causing acceleration of the heart's action (180 beats or more per minute) with an increase in the dilatation, it is advisable to begin by ligaturing one or possibly two arteries, and to postpone the excision till the patient's condition shows distinct improvement. Even then the operation is attended with considerable responsibility and requires the utmost caution. The large vessels are very readily torn, and the goitre is exceedingly vascular, even the external capsule bleeding freely while it is often firmly adherent. Operation is thus a matter of greater difficulty, and attended with greater hæmorrhage than is the case in non-malignant goitres. The success of operative treatment in Basedow's disease depends on the patients being seen by the surgeon at an early stage, as with early operation brilliant results can be obtained." Mr. Berry also advises that operation should not be undertaken in acute cases where there is much thyroid intoxication as shown by great excitability, mania, or muscular weakness, or in those who are suffering from an acute inflammatory infection such as bronchitis. Albuminuria, glycosuria, diarrhœa, a constantly irregular pulse, and low blood pressure are also contra-indications, and should lead the surgeon to at least postpone operation if these conditions cannot be remedied by medical treatment, operation

[1] *Loc. supra cit.* A paper by Mr. Berry on the "Surgery of Exophthalmic Goitre" (*Brit. Journ. Surg.*, vol. i, p. 699), in which the indications for, and the results of operative treatment are discussed, should also be consulted.

[2] *Oper. Surg.*, 3rd English edition, trans. Stiles and Paul, p. 467.

should not be performed at all. Of all chronic complications, marked dilatation of the heart is perhaps the most common and the most serious.

Dr. Charles H. Mayo, of Rochester, gave, [illegible] experience of partial thyroidectomy for exophthalmic goitre [illegible] up to 40 cases. Of the 40 cases 6 died, 1 death occurring on the table and 5 [illegible] hours and 3 from 24 to 72 hours after the operation. [illegible] the same writer has published a [illegible] "The Factor of Safety in Operating for Exophthalmic Goitre." In this paper he says:

"The early operative mortality was 20 per cent. Our own mortality in our first sixteen cases was 25 per cent. [illegible] the past year we have operated on a consecutive series of 278 cases of exophthalmic goitre without a death. This is a marked gain on our earlier work, and I believe it has been caused by taking advantage of the so-called factors of safety in the treatment, preparation and operation of these patients. That factors of safety are becoming recognised is proved by the present mortality, which is at various times from 1 to 4 per cent. The estimated proportion of cures [illegible] on the examination of patients operated on and from letters and reports is about 75 per cent. He then proceeds to quote the following remarks by Dr. Thomas on the course of the disease: "If the average course of the disease be represented on a chart, the greatest height of the intoxication is found to be reached during the first week of the first year, and then drops rapidly to the twelfth month. In many instances it reaches the normal base line during the next six months, more often it does not, periods of exacerbation for the [illegible] exophthalmos may remain, but the course is very continuous for four years without distinct intermissions. The mortality begins gradually, then irregularly, marked by many secondary curves. The factors of safety are as follows: (*a*) As regards operating during periods of exacerbation, the mortality in these cases is frequently high, and it is sometimes necessary to treat with attention to heart, stomach, or intestines according to the special indications in each case. (*b*) Gastric crises and pain in the [illegible] should not be done until these have ceased. Dilatation of the heart which exceeds one and a half will give a [illegible] per cent. serious complication, while [illegible] inch and a half will give a per cent. of unavoidable mortality for [illegible] (*d*) Ligature has an accredited place in the treatment of exophthalmic goitre. (*e*) Serious risks are best treated by a single ligature of the vessels on the upper left pole. The reaction is about three quarters as severe as from a double ligature, but the missing quarter is an element of safety. If the reaction be very severe, a second ligature of the right superior thyroid vessels is made a week later. As compared with the first ligature the reaction following this one is slight. If the reaction be not severe at the second operation the right lobe, isthmus, and possibly a portion of the left lobe are removed."

The following operations have been performed for exophthalmic goitre:

(*a*) **Operations on the Cervical Sympathetic.** These operations, which now but seldom performed, are alluded to on p. 677. Excision of the superior cervical ganglion and division of the sympathetic trunk have both been tried.

(*b*) **Exothyropexy.** This consists in exposing one of the lobes of the gland and fixing it in the wound in the hope that the exposed portion will atrophy and the symptoms diminish. Though several successful cases have been reported the operation is but seldom performed.[4]

1 *Med. Record*, November 5, 1904, p. 734.

2 *Journ. Amer. Med. Assoc.*, vol. lix, p. 26.

3 The 278 operations are made up as follows: single ligature, [illegible] cases; double ligature, 13 cases; single ligature followed by thyroidectomy, 30 cases; two single ligatures followed by thyroidectomy, 21 cases; double ligature followed by thyroidectomy, 26 cases; thyroidectomy, 78 cases; thyroidectomy followed by ligature, 4 cases; thyroidectomy followed by ligature and by a second thyroidectomy, 1 case.

4 The objections to this operation are: (*a*) Its uncertainty as to the production of atrophy of the gland. (*b*) The certain risk of infection, in spite of the most careful

(*c*) **Excision of a Portion of the Gland.** This is the operation usually performed and which gives the most satisfactory results. It is usual to remove one lobe, though a portion of the opposite lobe may be removed, if necessary, on a subsequent occasion.

(*d*) **Ligature of one or more of the Thyroid Arteries.**[1] Ligature of one or both superior thyroid arteries is usually performed; one of the inferior thyroid arteries may also be tied. The latter may be a very difficult operation (*q.v.*). Though often followed by considerable improvement these operations are rather to be regarded as preliminaries to excision of a portion of the gland. They are especially indicated in severe cases.

The present position as regards the operative treatment of Graves's disease may be summed up as follows: (*a*) Operation, especially excision of a portion of the gland, is generally followed by a marked improvement and in many cases by a cure of the disease. (*b*) The operation is, however, attended with a very considerable risk, especially when visceral complications such as dilatation of the heart are present. (*c*) On this account indiscriminate operative treatment is strongly to be deprecated. (*d*) In severe cases where there is much tachycardia and where there is excessive cardiac dilatation operation is contra-indicated. (*e*) In all cases medical treatment should have a thorough trial: even in cases where it has been decided that operation is desirable, there should be a more or less prolonged period of rest and medical treatment. (*f*) The operation should not be performed while the thyroid intoxication is at its height.

Malignant Goitre. Both carcinoma and sarcoma may occur in the thyroid gland, the former probably being the commoner.[2] In either case it is unusual for the local condition to admit of successful extirpation of the growth.[3] There may be considerable difficulty in the diagnosis of a malignant tumour of the thyroid.[4] Rapid growth, fixity, hardness, are all suggestive of malignancy, especially if occurring in an elderly or middle-aged patient. In some doubtful cases an exploratory incision with histological examination of a portion of the growth will be desirable.

The two indications for operation are: (1) The growth must still be contained within the limits of the capsule of the gland. (2) The growth must not be adherent to the trachea. Hence it should move freely both with and on this structure. Unfortunately, as Mr. Berry points out, "penetration of the capsule usually occurs very early, especially in the inner and posterior part. Hence the early involvement of the recurrent nerve and fixation to the trachea and the œsophagus. Many a tumour

precautions. Patients with exophthalmic goitre are subjects very liable to infection. (*c*) Grave sequelæ, such as tetany, and those referable to disturbance of the recurrent laryngeal nerve, *e.g.* dyspnœa and pneumonia, have followed this operation. (*d*) What is known at the present day as the "cosmetic" result is likely to be bad.

[1] Removal of the isthmus, combined, if the condition of the patient admitted it, with ligature of the two superior thyroid vessels, may also be carried out in more serious cases.

[2] Limacher, of Berne, found the proportion to be forty-four sarcomata and thirty-eight carcinomata.

[3] A remarkable instance of a successful operation for carcinoma of the thyroid with extensive infection of the glands is afforded by a case recorded by Mr. Wilfrid Trotter (*Proc. Roy. Soc. Med.*, Clin. Sec., vol. iv. 1911, p. 118). The patient was free from recurrence three and a half years after the operation.

[4] A third variety of malignant disease is the mysterious malignant adenoma, only distinguished by the peculiarity of its metastases, which especially affect bones, *e.g.* the skull, sternum, &c. Further, it may be impossible to detect either in the apparently normal thyroid or the metastases in the bones or lungs any histological difference from the normal thyroid tissue.

which moves freely on deglutition and is apparently easily removable will be found at operation to be hopelessly incorporated with the wall of the trachea, the œsophagus, or the carotid sheath."

Alteration of voice, dysphagia, dyspnœa, pain, signs of involvement of the recurrent laryngeal and sympathetic nerves, are, on this account, early signs and symptoms.

In advanced cases a palliative tracheotomy will very probably be required.

Even in cases of malignant disease removal of the whole gland will not be called for. If the growth is so extensive as to involve both lobes it will certainly be inoperable. If the growth involves one lobe and is operable, recurrence does not take place on the opposite side of the gland, but in the tissues adjacent to the gland on the side originally affected. For this reason Mr. Berry advises that in all cases the upper pole of the opposite lobe should be left.

OPERATIONS ON THE THYROID GLAND

The following will be described: (1) Excision of one lobe with or without the isthmus. (2) Enucleation of growths or cysts. (3) Enucleation resection. (4) Ligature of the thyroid arteries. (5) Operations on the cervical sympathetic will also be briefly alluded to.

(1) **Excision of one Lobe of the Gland.** As has already been indicated this is the operation most frequently called for. It is indicated in most cases of parenchymatous enlargement requiring operative treatment, in some cases of adenoma or cystic disease, and in many cases of exophthalmic goitre calling for operative treatment.

The anæsthetic. The question of the anæsthetic is always an anxious one in all thyroid operations. The difficulties and dangers in Graves's disease have already been touched upon, but in all operations for goitre serious difficulties may arise in the course of the administration, especially when dyspnœa has been a troublesome symptom. Serious symptoms are particularly liable to arise during the stage described below as dislocation of the gland. During this stage the condition of the patient should receive the close attention both of the anæsthetist and the operator. The most suitable anæsthetic is still a matter of opinion, but in any case the administrator should be a skilled and experienced anæsthetist. The ideal method, if the necessary apparatus is available, and the services of an anæsthetist skilled in its use can be secured, is the intratracheal administration of ether, preceded by an injection of morphia and atropine. The advantages of this method are great. Even with very large goitres there is no obstruction to breathing in the course of the operation, and, what is of almost equal importance, the anæsthetist and his apparatus are not in the way of the operator. Failing this method, open ether preceded by an injection of morphia and atropine may be recommended. A few operators still prefer chloroform. In cases of exophthalmic goitre where there is much nervousness an injection of scopolamine may be given before the commencement of the administration, while in very bad cases local anæsthesia may be employed.

Sterilisation of the skin must be far-reaching and thorough, including a wide area over the sternum, and the cleansing of the axillæ, under which the bandages will pass for security.

To minimise the possibility of infection of the wound from the patients

mouth and from the anæsthetic apparatus the sterilised towels may be arranged as follows: A medium-sized towel is placed behind the head extending well down behind the shoulders; a second towel is then wrapped securely round the patient's head so as to enclose the whole of the hair, and is kept in position by towel-clips; a third towel, or, if

Fig. 264. The "bib" which has been tied round the upper part of the patient's neck is seen resting on the sterilised towel covering the chest. The tube for the intratracheal anæsthesia is also shown.

necessary, towels, are then arranged so as to cover the whole of the patient's body from the top of the sternum to the feet; another small towel, with a notch for the neck and tapes to tie behind, after the fashion of a child's bib, is then laid on the last-mentioned towel and over the patient's neck; an assistant then draws this upwards, so that the notch fits the junction of the neck and the floor of the mouth, and ties the tapes firmly behind in the suboccipital region (Fig. 264): the bib is then turned

Fig. 265. The "bib" has been turned upwards over the patient's face and exposing the goitre. The tube for the anæsthetic is seen passing beneath the "bib."

upwards so as to cover the whole of the head and to leave the front of the neck and the tumour freely exposed (Fig. 265). In this way the mouth and the anæsthetic apparatus are securely shut off from the field of operation. If intratracheal anæsthesia is employed the anæsthetist and his apparatus will be at some little distance, the tube through which the anæsthetic is administered passing beneath the bib well out of the way to the side. The anæsthetist will have only occasionally

to raise the bib to observe the condition of the patient, and there will thus be no obstruction of the field of operation, and no fear of infection of the wound from the mouth. If open ether or any other anæsthetic be preferred, it will be still possible for the anæsthetist to work beneath the bib, though in this case he may find it impossible to avoid, by his apparatus, or by his hand holding forwards the patient's jaw, hampering the operator's free view and access to the wound.

FIG. 266. "Collar" incision for goitre. The incision is carried to a higher level on the affected side.

The *incision* chosen must be sufficiently free to enable hæmorrhage to be efficiently met and every part of the lobe operated on to be seen. While an ample oblique incision along the anterior border of the sterno-mastoid curved over to the opposite side below will nearly always give all the room required and a scar that will be but slightly conspicuous, Kocher's "collar" incision (Figs. 266, 267) is now very generally employed. This is convex below and extends from the outer border of one sterno-mastoid to the outer border of the other. It is made at a higher or lower level according to the position of the swelling, in most cases just below the cricoid; in those which dip into the thorax it is placed just above the episternal notch. One end may be curved well upwards to facilitate the exposure of the superior thyroid vessels. In difficult cases such as inflamed goitres, malignant goitres, or Graves's disease, where the thyroid is likely to be adherent, Kocher recommends an angular incision (Fig. 267) beginning at the level of the thyroid cartilage over the prominent part of the sterno-mastoid, then carried forward to the middle line, and then vertically downwards to the suprasternal notch.

Exposure of the Goitre (Figs. 268, 269). The incision is carried through the platysma and the superficial fascia down to the deep fascia: several superficial veins will be met with, including the anterior jugular, often double, and oblique veins along the anterior borders of the sterno-mastoids. These must be tied and divided between ligatures. The infra-

hyoid muscles are now seen and must be widely exposed by dissecting up the skin and superficial fascia as high and as low as possible. The deep fascia is now divided in the mid-line and the infrahyoid muscles of the two sides separated. The layers of deep fascia met with vary much in strength, and, to a less degree, in number also. Every one of them must be divided in the full extent of the wound before any attempt is made to deal with the bronchocele itself. Inattention to this point will largely increase the difficulties met with. The goitre in its capsule will be recognised by its bluish-red colour and the large veins which stand out as they ramify on the surface of the gland.

Dislocation of the Goitre. We now come to this important stage of the operation, during which respiration may become obstructed: the

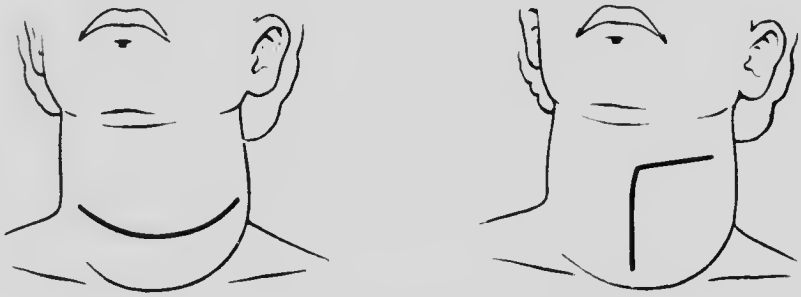


FIG. 267. Kocher's collar incision, and angular incision for adherent or malignant goitres.

operator should therefore always call the attention of the anæsthetist that this stage has been reached, and should himself also closely watch the condition of the patient. The finger should be inserted in the interval between the sterno-hyoid muscles and the fibrous capsule of the gland on the outside, and the gland and its capsule proper on the inside. The finger is then gently worked upwards and downwards and then backwards, so as gradually to free the gland and draw it forwards through the opening in the deep cervical fascia. The greatest care and gentleness must be exercised while doing this. If the capsule of the gland is torn and the gland substance lacerated there will probably be very severe hæmorrhage which it may be difficult to control. In the course of the separation, especially if the goitre is large, the finger will feel one or more fibrous bands passing from the goitre to the fascial sheath: these contain veins, often of considerable size, and must be divided between two pairs of Spencer-Wells forceps and subsequently secured by catgut ligatures. While shelling the enlarged gland from its bed, the greatest care must be taken to work gently and to keep close to the tumour,[1] the veins being often much enlarged and thin walled. If torn the proximal extremity is apt to retract outwards, close to the internal jugular vein; the bleeding will be profuse and the cut end will only be secured with difficulty. The shelling-out process will be aided by retracting the sterno-hyoid muscles; only

[1] The capsule proper of the tumour must be nowhere opened. Such a step not only leads to flooding of the wound with blood, but thus also obscures and may lead to damage of important parts, *e.g.* the recurrent laryngeal and the trachea. By the capsule proper is meant the thin sheath of the gland which gives off numerous septal processes into it. Every layer of fascia above this, including the sheath from the pretracheal layer of the deep cervical fascia, must be divided.

exceptionally will it be necessary to partially divide these transversely. As a rule, when the dislocation has been effected any dyspnœa which may have been present ceases.

Securing the vessels. The tumour is now only held in position by the superior and inferior vessels and the isthmus. The next step is to secure the superior thyroid vessels. These enter at the superior cornu of the gland: they are freed by separating the fascial capsule in this situation,

Fig. 268.

partly by the finger and partly by the blunt dissector, until the artery can be hooked forwards as a distinct pedicle. It is then divided between two pairs of Spencer-Wells forceps, and each divided end is at once secured by a catgut ligature. (Fig. 270.)

The inferior thyroid vessels which now have to be ligatured are brought into view by drawing the tumour well over to the opposite side. (Fig. 271.) The greatest care must be taken to avoid injury to the recurrent laryngeal nerve which runs upwards behind the artery. Owing to the fact that the trunk of the inferior thyroid artery does not come into relation with the recurrent laryngeal till both are close to the trachea, either the trunk of the vessel should be ligatured and cut at some distance from this tube, or its branches tied close to the gland. The latter procedure is recommended. The fibrous bands in which the branches of the artery run are freed by careful use of the blunt dissector, and are divided between two pairs of Spencer-Wells forceps close to the gland, and at once secured by ligatures. If the vessel be tied near the junction of the cricoid and the trachea, the nerve may very likely be included; and the same risk will

be run if, at this stage especially, the wound be not kept dry and bloodless. The inferior thyroid arteries having been secured, the lower pole of the gland is then examined and the thyroidea ima artery and veins, if present, are separated and ligatured in the same way.

Separation and division of the Isthmus (Fig. 272). The enlarged lobe is now only held in position by the isthmus. This is separated from the trachea by careful use of a director or blunt dissector. Care must be taken

Fig. 269.

not to injure the trachea, which is often closely adherent, as in the following case described by Mr. Spencer;[1] here the isthmus and the trachea were most intimately united, although the thyroid gland seemed the seat of fibroid and not malignant change.

The patient was a young woman with a thyroid normal in size and shape, but of marked hardness. The pulse-rate was 130–140. There was no exophthalmus. Stridor was present, loudest at the level of the isthmus. At the operation, no line of demarcation could be made out between the isthmus and the trachea, so the isthmus and the adjacent part of each lateral lobe were shaved away from the trachea, leaving a portion about as large as the end of the thumb. The trachea thus exposed felt like a soft tube, and was sucked in and blown out by inspiration and expiration. The cartilaginous rings had softened or disappeared. As the breathing was none the better for the removal of the isthmus, the trachea was opened immediately below the cricoid. The lumen below this point being seen to be narrowed to a chink, the incision was carried downwards through that part of the trachea which had been in contact with the thyroid, until cartilaginous rings were again met with. In a fortnight the patient was able to discard the tracheotomy tube, and she made a good recovery, though the pulse-rate was still 120 per minute.

[1] *Ann. of Surg.*, May 1895.

When the isthmus has been sufficiently separated it may be transfixed and ligatured by stout catgut, or it may be carefully torn through with the point of a director and each bleeding-point secured. The latter step will usually suffice.[1]

The amount of hæmorrhage met with in detaching and dividing the isthmus varies. If the separation is effected piecemeal, the bleeding is often very slight. This is probably accounted for by the fact that the

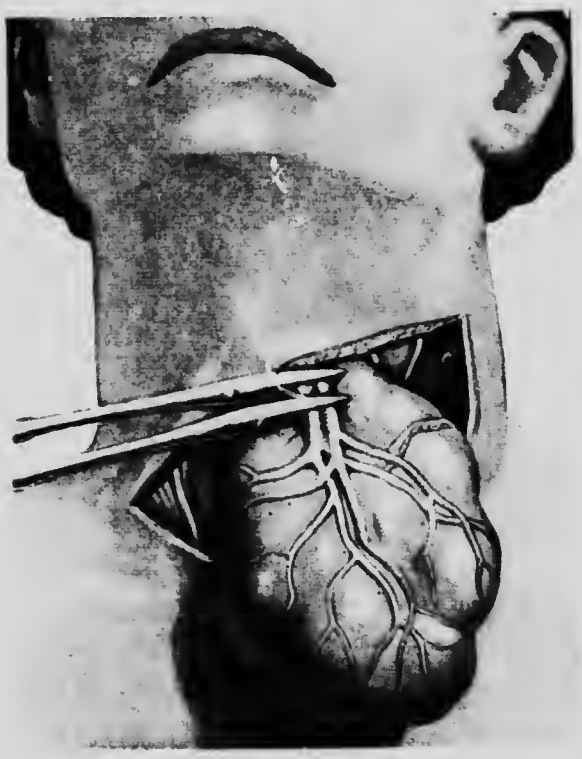


Fig. 270. Securing the superior thyroid artery.

intimacy of connection and continuity of structure between the halves of the thyroid and the isthmus varies much; also in many cases the connection is mainly by connective and a little glandular tissue with a very few vessels.

The tumour is now removed and the wound should be carefully examined for any bleeding-points, which should be secured and tied. Any general oozing may be checked by irrigation with hot sterile saline solution. All blood clot should be thoroughly sponged away and the wound carefully dried.

The question of drainage now arises. The wound left after the removal of one lobe only, if much enlarged, is often extensive and deep,

[1] If the pedicle seem too thick and vascular to treat in this way it may be crushed in powerful clamp forceps as advised by Prof. Kocher. When these are taken off only the connective tissue and vessels are left. The latter can now be ligatured *en masse* in the much-diminished pedicle.

the larynx, trachea, large vessels, and œsophagus being all exposed. In some cases the dome of the pleura will be seen rising and falling in the root of the neck. In such a wound, in spite of the most careful attention to hæmostasis, some oozing is likely to occur. Out his account, except in some cases of ordinary parenchymatous goitre, where the operation has been easy and the parts but little disturbed, drainage is desirable. Not infrequently after operations on any form of goitre, but especially after

Fig. 271. The goitre is drawn well over to the opposite side so as to bring the inferior thyroid vessels into view.

operations for exophthalmic goitre, symptoms of thyroidism such as rapid action of the heart, restlessness, &c., may appear. These are often attributed, but probably erroneously, to thyroid secretion being forced into the circulation as the result of rough handling of the gland; if this were the case, the symptoms would be present immediately after the operation, whereas there is usually an interval of some hours before their development. This points to the symptoms of thyroidism being due to the absorption of serum and thyroid secretion from the wound, and is an additional argument for drainage. A small rubber tube, about a quarter of an inch in diameter, is passed into the deeper part of the wound and made to emerge at the lower part of the incision just above the episternal notch. The divided deep cervical fascia is then brought together by a few interrupted catgut stitches over the drainage-tube, and if the muscles have been cut across they also should be brought together in the same manner. The edges of the wound should then be brought into the most exact apposition in order to promote early and sound healing with the least possible scarring. Fine salmon-gut and horse-hair are the most satisfactory materials. Over the sterilised gauze in immediate contact

with the wound, firm even pressure should be made with sterilised pads and absorbent wool, with the twofold object of distributing the discharges, and obliterating the cavity of the wound. And for the first week after the operation the same care should be taken to keep the dressings securely in position. This is especially difficult in a mobile part like the neck, and one which does not admit of much compression. The best plan is to pass the bandages under the axillæ (protected from chafing by wool) below, and

Fig. 272. Crushing the isthmus of the thyroid.

to wind them over the chin and forehead above, all being made secure by safety-pins or by stitching. This alone will prevent the dressings slipping down and exposing the upper end of the wound, which is thus readily infected. A piece of jaconet should be so arranged as to prevent soiling of the upper dressings by any vomited material or saliva as the patient is coming round from the anæsthetic.

After-treatment. The patient must be kept quiet and the head still to avoid any danger of displacement of ligatures. The dressing should be changed at the end of forty-eight hours, when the drainage-tube may be removed. The stitches should be removed on the eighth day. Complications and their treatment are described on p. 634.

After operations for exophthalmic goitre it is advisable to give plenty of water by the mouth, rectum, or even as a subcutaneous infusion. In ordinary cases of goitre where symptoms of thyroidism, such as pyrexia, tachycardia, restlessness, &c., appear, similar treatment should be employed. When these symptoms are very severe it may be necessary to

open up the wound, wash it out with sterilised saline solution and pack with gauze.

(2) **Enucleation of Thyroid Adenomata.** This method has been largely used by Porta, Billroth, Socin, Reverdin, Wolfler, and other Continental surgeons. Mr. Symonds [1] considered that it is sufficient and a much less severe operation to enucleate these instead of removing one half of the gland. In practising enucleation it is necessary, when the enlarged lobe

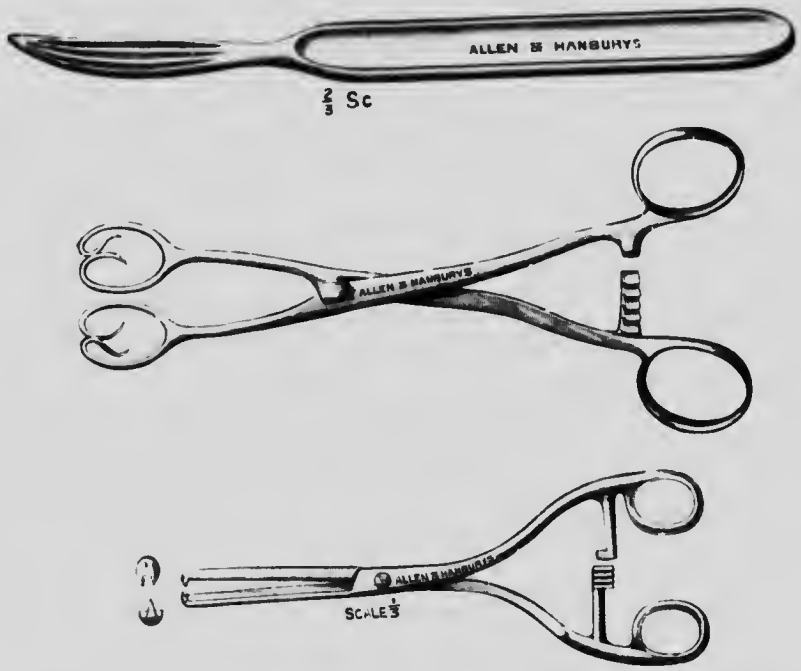


Fig. 273. Kocher's thyroid enucleator, goitre-holding forceps, and goitre-crushing forceps.

has been exposed and brought well up into the wound, to search for and define most accurately the capsule of the adenoma. The surface of the gland is exposed in the manner described above. The most prominent part of the gland is then incised until the capsule of the adenoma or cyst is reached.

In most cases it will be seen at once, but in a few the edge of the gland may have to be raised first. It is most essential to be sure that the smooth, white covering is exposed, for if not, and the dissection be carried outside it, troublesome hæmorrhage is sure to follow; in fact, the entire success turns upon this point. Any surgeon adopting this method will remember (1) the above danger—a very present one—of hæmorrhage [2]; the deeper the dissection has to be carried the more

[1] *Clin. Soc. Trans.*, vol. xxiii. p. 51.

[2] Wölfler, in his exhaustive monograph (Berlin: A. Hirschwald, 1891), shows that this method, while successful in a great majority of cases, has proved fatal from hæmorrhage. Mr. Berry (*Lancet*, May 3, 1902) has seen cases of death from this cause, and has heard of others.

severe this will be. (2) The fact that these adenomata may be multiple,[1] and that if one be left behind it may later bring about enlargement of the lobe; (3) that shrinking of the opposite lobe, which it is the aim of the surgeon to bring about by removing one lobe, is not so likely to follow on removal of an adenoma as it is when one lobe and half the isthmus have been removed; (4) that enucleation is not applicable to all cases, *e.g.* the gelatinous form of adenoma, the multiple cases or where a single one lies deeply.

To quote Mr. Berry,[2] the method is obviously suited only to those cases in which the adenoma forms a well-defined tumour embedded in the thyroid. Again, as pointed out by the same authority, it is only in the unilateral goitres that the enlargement is brought about either by adenomata or cysts. A careful examination of specimens shows that single adenomata are rare. They are generally multiple, and often too soft for enucleation. For the above reasons enucleation is not recommended. But the words of Prof. Kocher will be conclusive, "It is the simplicity of the procedure that frequently misleads the inexperienced into giving it the preference over excision. It is attended with more serious hæmorrhage than excision, because bleeding and general oozing occur from numerous small vessels in the capsule which is left behind. On this account, as well as from the fact that it does not ensure a radical cure, it is not a good method to employ." The same authority would only perform enucleation "(1) when the other half of the thyroid is atrophied, or has already been removed; (2) when only one or two isolated nodules are to be felt in otherwise healthy gland tissue; (3) when a single nodule exists which has caused extensive pressure atrophy of the surrounding gland structure, so that vascular tissue is only present to a limited extent, generally posteriorly; (4) when the goitre is very adherent to the external capsule as a result of inflammation."

Resection of the thyroid gland may here be briefly alluded to. In this operation the diseased portion of the gland is alone removed. It should only be carried out when there is a definite pedicle to the diseased portion. The gland is exposed in the way described above and the pedicle, after being crushed, is ligatured and then cut through. If the pedicle is broad several ligatures may be required. The chief objection to this operation is the danger of severe hæmorrhage; this may take place as the result of laceration of the gland by the forceps, or from cutting through, or separation of the ligatures.

(3) **Resection-Enucleation.** This operation has considerable advantages over pure enucleation or resection.

The operation is thus described by Mr. Berry [3] in the lectures before quoted. "Of late years I have been practising simple enucleation less and less, substituting for it the much more satisfactory operation known as resection-enucleation. This consists, as is well known, in proceeding as for extirpation in all the earlier stages of the operation, as far as the isolation and dislocation of the lobe. Pressure forceps having then been applied to the larger vessels visible on either side of the line along which it is proposed to cut, the gland is incised over a limited area, generally on the front and inner aspect of the tumour, until its surface has been reached. The shelling out is then performed at the inner and back part

[1] Wölfler (*loc. supra cit.*) mentions a case in which as many as thirty or forty adenomata were present. He states that recurrence took place in one case after this method had been employed, but that, as most of the cases are too recent, nothing definite can be stated on this point.

[2] *Birmingham Med. Rev.*, 1890, p. 332.

[3] *Lancet*, 1913, vol. i. p. 739.

of the tumour only, until the operator has got well beyond the region of the recurrent nerve. The glandular capsule is then again cut through and the whole tumour removed, together with most of the thin and functionally useless gland tissue covering it. By this means the size of the enucleation wound from which hæmorrhage occurs, is greatly diminished. If the tumour is a large one, or if for any reason the operation is likely to be accompanied by serious hæmorrhage, it is prudent to tie the superior thyroid vessels or even the inferior as well, before incising the gland. Personally, it is only in exceptional cases that I now do either, as I find it is usually quite easy to prevent hæmorrhage by placing forceps on the vessels on the surface of the gland before the latter is incised. It need scarcely be said that after placing forceps upon vessels in their continuity, care must be taken to cut round them lest the ligature should slip."

(4) **Ligature of the Thyroid Arteries.** Wölfler, who revived this method of treatment, showed (1) that considerable shrinking, with marked relief to the dyspnœa, should follow it, if successful, in a few days, and that there should be no reappearance. Splendid results are here opposed by utter failures. If in the latter cases all the four arteries have been tied, abnormal vessels have, perhaps, existed. On this point he quotes Billroth as to whether the atrophy will be permanent: "If all four arteries have been tied, yes; if the circulation is re-established either through one of the principal arteries or through the vasa vasorum, no." (3) Experience has shown that ligature of all the four arteries is not followed by gangrene of the thyroid. According to v. Eiselsberg, this method (in parenchymatous goitres) is frequently associated with recurrences: both tetany and myxœdema have been recorded as consequences.

According to Prof. Kocher, ligature of the thyroid arteries finds its chief application in the following: (1) In Graves's disease. In this affection a combined excision and ligature give still better results than ligature alone; but excision is often too dangerous, and one is very glad to leave matters alone after ligaturing the three arteries which are chiefly dilated. It has already been pointed out that ligature is especially indicated in the more severe cases of exophthalmic goitre. (2) In large vascular colloid tumours, especially of the diffuse kind, where excision is too serious an undertaking, first on account of the hæmorrhage, and secondly on account of the sudden loss of a mass of thyroid tissue which, though diseased, was still assisting to maintain an otherwise imperfect function. These vessels vary so much in situation and course, according to the size and growth of the goitres in different directions, that any directions for finding them must be uncertain. The chief points to bear in mind are the upper and lower parts of the enlarged lobe; the superior thyroid artery is often rendered superficial by the upper limit of the tumour raising it up. Both vessels may be enlarged and somewhat softened, and thus secondary hæmorrhage may readily occur unless the wound is kept sterile. The same free incisions as for a partial thyroidectomy may be required.

Ligature of the Superior Thyroid Artery. *Relations.* This vessel, the first branch of the external carotid, arises just above the bifurcation of the common carotid, about a quarter of an inch below the great cornu of the hyoid. At first, covered only by thin fasciæ and the platysma, it ascends slightly, and then curves downwards with a tortuous course, covered by the depressors of the hyoid bone, and the sterno-thyroid.

Operation. The patient's head being suitably raised, and turned to the

opposite side, an incision, about two inches long, is made along the anterior border of the sterno-mastoid, with its centre corresponding to the upper border of the thyroid cartilage. The superficial parts being divided, the sterno-mastoid and the large vessels are drawn outwards, and the omo-hyoid downwards and inwards, or this muscle may be divided. The artery is then searched for in the hollow between the larynx and the carotid. The ligature should be placed beyond the origin of the superior laryngeal branch. The chief difficulty will probably be the number and size of the veins which are met with. Some of these will have to be divided between two ligatures. The superior laryngeal nerve may be seen and should be carefully preserved. The artery itself should be divided after the application of double ligatures. Kocher advises that the lower ligature should be inspected to make sure that the posterior branch of the artery is not given off above the ligature.

The operation can be quite satisfactorily carried out under local anæsthesia.

Ligature of the Inferior Thyroid Artery. This operation may be a very difficult one, owing to the depth of the vessel and its intimate relations to important structures.

Relations. The artery, the largest branch of the thyroid axis, ascends along the inner border of the scalenus anticus. It then makes a curve with the convexity upwards, passing inwards behind the carotid sheath, entering the gland near the middle of the posterior border of the lateral lobe. Near its commencement it is in front of the vertebral artery, while the middle cervical ganglion of the sympathetic is in front of it as it curves inwards. At the lower extremity of the thyroid gland it is in close relation with the recurrent laryngeal nerve; the latter may be either in front of or behind the artery. On the left side the thoracic duct passes in front of the artery.

Guide. The carotid tubercle of Chassaignac, or the transverse process of the sixth cervical vertebra. The common carotid is also a guide.

Operation. The vessel may be secured either in front of or behind the sterno-mastoid. In the former case an incision three inches long is made along the anterior border of the sterno-mastoid extending down to the clavicle, as if for ligature of the common carotid low down: the deep fascia is opened and the sterno-mastoid and the structures in the carotid sheath drawn outwards. The head being now flexed to relax the parts, the goitre is raised and displaced inwards, the carotid tubercle is felt for, and the artery sought for below it, by carefully working here with a blunt dissector. All bleeding must be checked and the wound be quite dry before the artery is secured, or there is great danger of including the recurrent nerve in the ligature.

The artery may also be secured through a long incision along the posterior border of the sterno-mastoid. This method is recommended by Mr. Berry, who points out that it involves less disturbance of the gland and less trouble with the veins. The sterno-mastoid, the large vessels and nerves, are drawn inwards, and the scalenus anticus sought for, which may be recognised by the phrenic nerve crossing it. The artery will be found running diagonally upwards and inwards at the inner margin of this muscle after raising the goitre. The vessel should be exposed and the ligature applied as far from the thyroid gland as possible, so as to avoid injury to the recurrent laryngeal, which, as above stated, crosses over the trunk or ascends among its branches. The neighbourhood of

other important structures, *e.g.* the phrenic nerve and, on the left side, the œsophagus and thoracic duct, must be remembered.

Treatment of Intrathoracic Goitres. As has already been pointed out these goitres are especially likely to produce severe dyspnœa by pressure on the trachea.[1] An intrathoracic tumour of considerable size may be present with little or no swelling in the neck: the diagnosis may on this account, be difficult, in which case the tumour will probably originate from the lower pole of one of the lateral lobes.

The earlier steps of the operation are the same as those given already. Kocher's "collar" incision should be employed, as, until the tumour is actually exposed, it may be impossible to say to which side of the thyroid it is attached. The superior thyroid vessels should first be identified and ligatured. The isthmus is next separated, divided after being crushed, and tied. The depressors of the hyoid will have to be divided, and it may even be necessary to cut through the sternal head of the sterno-mastoid. All veins and fascial bands must be divided between ligatures. Attempts may now be made, by drawing on the gland, to pull the tumour up from the thorax. If these are not successful a finger should be introduced behind the manubrium, or Kocher's elevator, shaped like a blunt spoon, will be useful in freeing the intrathoracic portion. If this is not available an ordinary tablespoon with the handle bent to a suitable curve, as recommended by Mr. Berry, may be employed. Kocher's goitre forceps, with ring-shaped blades and hooks to prevent slipping, and giving a firm grip without causing hæmorrhage, are most useful for pulling on the tumour. If in spite of these procedures the tumour is too large to pass through the superior aperture of the thorax some steps must be taken to reduce its size. Thus, if a cyst is present this may be incised and the contents allowed to escape: if the tumour is solid it may have to be broken up (exenteration). The latter procedure is likely to be followed by severe hæmorrhage, and, if it has to be tried, the remains of the tumour should be drawn out as quickly as possible and any vessels at once secured.

The great danger of the operation is hæmorrhage. As many vessels as possible, including the inferior thyroid artery if it can be identified, should be tied, before attempts are made to withdraw the tumour from the thorax. If, in spite of all care, the inferior thyroid artery should be torn, Prof. Kocher points out that the bleeding may be stopped by firm pressure with the finger downwards and outwards, after which the vessel can be caught and secured.

Operation for a Goitre growing from the Isthmus. A cyst in this region may be enucleated. An adenoma will frequently be found to extend laterally into one lobe. As a division of the gland on each side of the tumour will be necessary the collar incision should always be employed. A pedicle will certainly be present on one side. This should be separated, crushed and ligatured. The isthmus is then cleared away from the trachea, any veins and branches of the superior thyroid artery being secured and ligatured. The pedicle on the opposite side is then crushed and, after one or more ligatures have been applied, is divided.

In some cases of severe dyspnœa, where for some reason any more radical treatment is deemed inexpedient, the isthmus may be excised or divided.

[1] See a paper by Dr. Walton Martin on "Large Intra-thoracic Cysts of the Thyroid causing Dyspnœa" (*Ann. of Surg.*, 1911, vol. liii, p. 737).

Cases of Goitre which persist or recur after operation. These are rare after removal of half the thyroid. After enucleation it is much more common. Brunner has shown that of 18 per cent. of recurrences after thyroid operations the majority were after enucleation. These recurrent cases are rendered difficult (*a*) by the presence of the scar of the previous operation, (*b*) by the fact that myxœdema and tetany are liable to follow complete removal.

Prof. Kocher's advice is as follows: The remaining lobe is isolated in the usual way, access being gained laterally; and where the cicatricial adhesions cause much difficulty, the scar should be removed with that part of the goitre which is resected. If the upper part of this appear healthy, the superior thyroid vessels are not tied: sufficient of the gland is left connected with them, its junction with the rest being crushed through; the crushed lower part is then ligatured and removed according to the directions already given. If the upper part is diseased, the superior thyroid vessels are first tied, the goitre is then displaced, the thyroidea ima veins ligatured and the goitre separated from the trachea. Partly by crushing, partly by careful enucleation of colloid material from within the capsule, a pedicle may be formed which can be ligatured. Thus sufficient thyroid tissue is left below, nourished by the inferior thyroid artery. The upper portion is removed. Some form of efficient crushing forceps is essential.

Treatment of Thyroid Cysts. These are sometimes of much importance owing to their size, their important relations and occasional vascularity.

As has already been pointed out, these are best treated by enucleation or by enucleation-resection. Where there are many cysts, or where a cyst is combined with much disease, the whole portion of the thyroid affected—usually half the gland—had better be removed. Where excision is impossible—a rare condition—the method of incision may be employed. The soft parts having been duly sterilised, an incision is made through them down to the cyst, and any bleeding-points secured. The cyst is then slit open and its interior examined. A cyst may vary considerably both as to its thickness and contents, and the vascularity of its lining membrane. Thus the contents may be a serous, mucoid, gelatinous or grumous material, or coagulated blood clot. The amount of vascularity is of twofold importance: if of very long standing the cyst-wall may be so fibrous and evascular that sloughing of it may readily take place, especially if the wound becomes infected. On the other hand, it may be extremely vascular, in which case such abundant hæmorrhage will take place as will leave no time for suturing, and require immediate plugging with gauze.

In the few cases at the present day where incision is called for it will generally be done as a preliminary to excision, as in the cases alluded to at p. 632. If for any reason further treatment is considered undesirable, the interior may be gently curetted, the cavity plugged with sterile gauze, and the cut margin of the cyst sutured to the edge of the skin. The obliteration of the cyst will certainly be very tedious, and a sinus will persist for a long time.

Formerly thyroid cysts were sometimes treated by blistering, or by the injection of substances such as perchloride of iron, or tincture of iodine. These methods must be regarded as obsolete.

Question of Operation in Malignant Disease of the Thyroid. Both sarcoma and carcinoma may be met with, and a third variety of malignant disease is

the mysterious "malignant adenoma," characterised by the peculiarity of its metastases which especially affect the bones, *e.g.* skull, sternum, &c. These metastases may appear while the thyroid itself appears normal, and in some cases it may be impossible to detect either in the apparently normal thyroid or the metastases any histological difference from normal typhoid tissue. The operative steps to consider are attempted removal and palliative tracheotomy. With regard to the former the remarks on p. 618 should be referred to, and it may again be insisted upon here that such an operation is only likely to be successful if the disease has not extended beyond the capsule of the gland. Unfortunately this usually happens at a very early stage and generally posteriorly so that the trachea, carotid sheath, œsophagus, and the nerves are invaded by the growth. A palliative tracheotomy will be called for to relieve dyspnœa, but it will be a difficult and dangerous operation. The tracheotomy will be a low one, and a long cannula, such as König's flexible tracheotomy tube, will probably be required.

Dangers of the Operation, Immediate and Later. (1) *Hæmorrhage.* This can usually be met by paying careful attention to the details given above in the account of the operation. One of the most important points is to expose the growth thoroughly, (*a*) by a sufficient incision, (*b*) by adequate retraction or division of the overlying muscles, and (*c*) by identifying the capsule itself. A mistake is often made here, and the difficulties of the operation are largely and needlessly increased. The layers of deep cervical fascia over the thyroid vary in individual cases. Every one must be divided, in the whole extent of the wound, before the goitre itself is dealt with. This will be recognised by its peculiar colour (reddish-purple), its consistence, and the way in which the vessels ramify and stand out on its surface. The arteries are usually easily commanded; it is the veins which give trouble, being numerous and thin-walled, and, in the severer cases, met with at every step of the operation. In these cases, also, when the growth is soft as well as vascular, any opening of the capsule is liable to give rise to flooding of the wound with blood, which makes it difficult to find the bleeding-point, thus incurring risks of including in a ligature or otherwise injuring important structures such as the recurrent laryngeal. Even in the removal of a small tumour, if soft and rapidly growing, most severe hæmorrhage may be met with, especially if the capsule be opened.

Thus, Mr. Foy,[1] after shelling out a tumour the size of a hen's egg, met with such copious bleeding that the application of seven clip-forceps gave no appreciable check to the flow. The wound was plugged with sponges, kept in place by uniting the wound with figure of eight sutures. The patient recovered.

Occasionally, even though there be no bleeding when the wound is closed, severe hæmorrhage may occur some hours after the patient has been returned to bed. This is probably due to some ligature having been displaced by the movements brought about by swallowing or vomiting, though sometimes a clot may be displaced by an increase in the blood pressure. Blood will probably escape through the drainage-tube and soak the dressings, while a hæmatoma, possibly as large as or even larger than the original tumour, may form in the loose tissues of the neck. The only treatment under these circumstances is to open up the wound, to sponge away the blood clot, and to hook for, secure, and ligature any bleeding-point. General oozing may be stopped by irrigation with hot saline solution. When the bleeding has been satisfactorily stopped infusion will most likely be necessary. As a prophylactic measure against

[1] *Dub. Med. Journ.* 1888, vol. i. p. 242

this recurrent hæmorrhage the patient's head should be kept as still as possible for the first twenty-four hours.

(2) *Injury to the recurrent laryngeal nerve*, asphyxia, aphonia. This most grave accident has happened with sufficient frequency to put any surgeon on his guard. The injury may be due to including the nerve in a ligature, cutting the nerve, or seriously bruising it. Aphonia after the operation may be due to one of the following causes: (*a*) Wound of the recurrent laryngeal nerve; (*b*) dragging on this nerve; (*c*) perhaps section of the crico-thyroid branch of the superior laryngeal; (*d*) months after the operation it may come on from inclusion of the recurrent laryngeal nerve in the cicatrix; (*e*) when the laryngeal symptoms are progressive, from ascending neuritis. This may be present before the operation, and so, too, may be (*f*) compression of the recurrent laryngeal by the goitre. Whatever be the exact cause, it is certain that the dyspnœa and aphonia are not always permanent. Thus, this complication occurred, but subsequently cleared up, in a patient on whom Mr. Jacobson operated in June 1894.

The patient was aged 35, the subject of an ordinary solid bronchocele, of large dimensions, the right lobe being seven inches long. The voice was decidedly weak before the operation, but while this presented no difficulties and was not accompanied by any cyanosis, dyspnœa, &c., it was followed by marked aphonia, the voice being reduced to a loud whisper. The right vocal cord was now found to be motionless. Complete recovery had taken place in April 1895. In February 1899 the patient was seen again for a Colles's fracture. Her voice was then good though a little weak.

Injury to the nerve is especially likely to occur under the following conditions: (*a*) Where the growth is huge; (*b*) when it is very fixed or where it has a broad base; (*c*) when it is ill-defined; (*d*) when it encircles the œsophagus and the trachea closely; (*e*) when it is malignant. Advice as to the avoiding of this complication is given in the description of the operations.

(3) *Cellulitis*, leading to purulent and diffuse mediastinitis. This is very liable to occur if the wound becomes infected. In such cases the latter complication is almost certain, even in small goitres, if they dip down behind the sternum, owing to the difficulty of providing adequate drainage. The accompanying symptoms are pain in the region, coming on soon after the operation and increasing, followed by feebleness of the pulse, distress, dyspnœa, and speedy death.

(4) *Myxœdema*, both acute and more deferred. This condition, which unexpectedly overclouded otherwise successful operations for complete removal of an enlarged thyroid gland, was first noticed and published by Kocher and Reverdin.[1] The probable explanation is the one which Sir V. Horsley brought before the profession in his lucid and convincing Brown Lectures of 1885.[2] The following extract is of interest to the operating surgeon:

Effects of Excision.—Phenomena following complete thyroidectomy in monkeys. "At a variable period after the operation, but averaging five days, the animal

[1] *Arch. f. Klin. Chir.*, Bd. xxix, S. 254, 1883.

[2] *Brit. Med. Journ.*, January 17 and 31, 1885. 'The Thyroid Gland: its relation to the pathology of Myxœdema and Cretinism, to the question of the surgical treatment of Goitre, and to the General Nutrition of the Body.' Further detailed and most interesting information is given by Sir V. Horsley: "The functions of the Thyroid Gland," *Brit. Med. Journ.*, 1892, vol. i, pp. 245, 265, and in his report as a member of the Clinical Society's Committee on Myxœdema, 1888.

is found to have lost its appetite for a day or two, and, on closer examination, to exhibit slight constant fibrillar tremors in the muscles of the face and hands and feet. These tremors disappear at once on voluntary effort. At the same time the animal is noticed to be growing pale and thin, in spite of the appetite returning quickly; rapidly the tremors increase, affect all the muscles of the body without exception, the animal becomes languid, paretic in its movements, and imbecile. Then puffiness of the eyelids and swelling of the abdomen follow, with increasing lebitude. During these last stages the temperature becomes subnormal and then the tremors disappear as they came. Meanwhile the pallor of the skin often becomes intense, and, leucocytosis having been well-marked, oligæmia follows, and the animal dies perfectly comatose in a variable period, but usually about five or seven weeks after operation."

Mr. Berry, in his Lettsomian lectures, quoted above, says that provided that one leaves the patient a sufficiency of healthy thyroid tissue, a quantity which may be estimated at from a sixth to a quarter of the gland, there will be no danger of myxœdema, or of the next possible sequela to be described, tetany.

At the present day it is thoroughly recognised that complete removal of the gland is an unjustifiable proceeding, and hence this complication, except occasionally in a slight and transient degree, is practically unknown.

In the laborious report of the Clinical Society on myxœdema it is stated that myxœdema followed in about 33 per cent. of all cases of complete thyroidectomy. Doubtless in some cases regarded as complete removal of the gland sufficient thyroid tissue has really been left behind. The existence of residual and also of accessory thyroid tissue probably account for many of the cases where complete removal has been stated to have been followed by no ill effects.

(5) *Tetany.* It has been stated that tetany is likely to occur especially if the parathyroids[1] have been removed in addition to the diseased portion of the thyroid. Though tetany may follow complete, or nearly complete, removal of the thyroid, there is no clinical evidence to show that this depends upon removal of the parathyroids. Mr. Berry says, "For many years I have been in the habit of removing such portions of the thyroid gland as seemed advisable without paying any attention whatever to the parathyroids. I never remove the whole thyroid, but I have often removed both inferior horns, or both superior horns, or the whole or nearly the whole of one lobe together with a half or even more of the opposite lobe, either the upper or the lower half. In no single case have I seen tetany, although I have been fully aware of the possibility of its occurrence after too free a removal of the gland, and have been constantly on the watch for it."

The following is a most instructive case of fatal tetany after what amounted to a complete removal of the gland, published by a surgeon of large experience, Prof. Madden, Cairo School of Medicine.[2] A girl, aged 12 years, had a large trilobed goitre, so easily shelled out that the operator was tempted to remove it entirely, leaving a piece of the isthmus the size of a walnut. On the third day there were signs of tetany, which disappeared when thyroid tabloids were given. As marked emaciation followed, maltine was substituted. On the twelfth day the tetany reappeared. Thyroid tabloids were again given, but with no effect.

[1] The parathyroid question is discussed by Dr. Chas. H. Mayo in a paper in the *Ann. of Surg.*, 1909, vol. i, p. 78. In 1200 operations for goitre the writer has seen no case of tetany. Should tetany follow the operation, he recommends the administration of calc. lactate in 4 or 5 per cent. solution, either by mouth, rectum, or intravenously.

[2] *Lancet*, June 20, 1903, p. 1729.

Twenty-four days after the operation death took place in an attack of tetany, general, but especially affecting the respiratory muscles. The necropsy showed no trace of thyroid tissue. The small portion left had completely atrophied.

Operation for Lingual Goitre, or Accessory Thyroid[1] at the base of the tongue. These tumours arise in connection with the thyro-glossal duct, which, in fœtal life, extends from the foramen cæcum of the tongue to the isthmus of the thyroid. The operation here must be either through the mouth, or by the transhyoid or suprahyoid routes. In making his choice the surgeon must not attach too much importance to the fact that accessory thyroids of the tongue usually occur in female patients, and that the intra-oral operation leaves no external scar. He must remember the position of the growth far back close to the aperture of the larynx, the vascularity of the region, and the need of total enucleation, otherwise recurrence of the trouble is certain. Such tumours may be removed through a median incision extending from the symphysis of the lower jaw downwards to below the hyoid bone. Dermoids and small encapsuled growths may be removed in this way, but if they are of large size, or if malignancy is suspected, it will be necessary to divide the symphysis of the inferior maxilla and to retract the two halves. The muscles are divided and separated in the mid-line and the tumour enucleated by a blunt dissector. This route gives good access, is well removed from the aperture of the larynx, gives good drainage, and the median scar left is not disfiguring. If the growth is certainly malignant the advice given on p. 554 for removal of growths at the base of the tongue should be consulted.

The intra-oral route may be preferred by some when the mouth is large, the tongue slim and not bulky, and where the growth projects well on its dorsum.[2]

All hæmorrhage must be arrested absolutely owing to the position of the wound, and this should be partially closed with a few catgut sutures.

[1] Cases of lingual thyroid tumours have been published by Mr. W. E. Spencer (*Proc. Roy. Soc. Med.*, Lar. Sec., December 1910), Mr. Stuart Low (*Proc. Roy. Soc. Med.*, Lar. Sec., May 1909), and Dr. R. A. Stirling (*Ann. Surg.*, 1907, vol. xlvi, p. 826).

[2] Storrs, *Ann. of Surg.*, 1904, p. 323.

CHAPTER XXX

OPERATIONS FOR THE REMOVAL OF LARGE DEEP-SEATED GROWTHS IN THE NECK, TUBERCULOUS GLANDS, LYMPHANGEIOMATA, THYROGLOSSAL AND BRANCHIAL CYSTS. REMOVAL OF CERVICAL RIBS

BEFORE deciding to undertake the removal of one of these, the surgeon should consider carefully the following points:

A. The nature and surroundings of the growth.

B. His operative skill in these cases, and his knowledge of anatomy.

C. His experience in aseptic surgery, and in keeping a large wound sterile.

The chief growths which call for a decision are the following: The (rarely met with) more innocent ones, *e.g.* fibromata, glandular tumours including the tubercnlous; sarcomata, very likely cystic, originating in the neck apart from the cervical glands, sarcomata of the tongue, lip (p. 548), &c. Of the three points above mentioned, it will only be needful to consider separately the first; the importance of the two others will be sufficiently shown in the remarks on the operation and after-treatment.

A. **The Nature and Surroundings of the Growth.** In examining into these, careful attention should be paid to the following: Duration, rate of increase, amount of fixity. How far this last was early estaldished, and how far it is absolute, are of the utmost importance. The gravest cause of fixity is, of course, a growth with a wide base, or numerous root-like processes extending into important parts. The fixity should be tested by seeing how far the finger-tips can be insinuated beneath the growth how far it can be lifted up, and the amount of its connection to parts such as the jaw and larynx, the head being steadied by an assistant while the growth is lifted up and its deep processes put on the stretch as much as possible. The outline: is this well marked or indistinct, and, if the latter, is it in dangerous regions, such as the parotid, the zygomatic, and other fossæ, that the growth is lost? Its relation to important structures, and the degree to which it blends with them: thus, any evidence of pressure on vessels and nerves, trachea and pharynx, &c., should be carefully looked for, *e.g.* weakness of the temporal pulse, engorgement of veins above, alteration of pupil, numbness of upper limb,[1] dyspnœa, or dysphagia. Does the growth dip near or into the thorax? How far under the sterno-mastoid does it go? Are the glands enlarged as well? Is the skin involved? This last point, together with fixity, indistinctness of outline, rapid growth, softness, and fusion with surrounding parts, is of chief importance, and, if co-existing to any extent, will usually put any operation out of the question.

[1] Growths springing from the lower vertebræ or the first rib may interfere with the nerves and vessels of the arm. Such a case was brought before the Medico-Chirurgical Society, January 12, 1886, by Dr. Bruce and Mr. Bellamy.

MAIN POINTS IN THE OPERATION ITSELF

(i) **Free Exposure of the Growth.** The incisions should be sufficient, the flaps turned back, V, T, or X in shape. Thus, if the growth be in the anterior triangle, not encroaching on the posterior, a V-shaped flap with the base upwards, one limb along the sterno-mastoid and the apex above the sternum, may be employed, or one with the long limb inside the entire length of the above-mentioned muscle, and another at right angles to it at the level of the thyroid cartilage, curving upwards towards the chin. If the growth invade both triangles, and it be necessary to divide the sterno-mastoid, an incision obliquely across both triangles, and over the muscle, from mastoid process to sternum, and then a second to make it crucial, will be the best. Where it is not needful to divide the muscle the incision going by the name of Dr. Beatson, of Glasgow, will be sufficient and leave a less noticeable scar. It begins in the submaxillary region near the angle of the jaw, is carried outwards across the sterno-mastoid and the posterior triangle as far as the anterior border of the trapezius. It is then carried down the anterior border of this muscle as far as the clavicle and then forwards over the sterno-mastoid, again to end at the sterno-clavicular joint. The large flap is turned forwards, and access thus gained to both triangles. It is always to be remembered that inadequate exposure of the tumour will lead to groping in the dark, bruising of the soft parts, and injury to important structures.

(ii) **Deeper Dissection.** In this attention must be paid to: (*a*) Working as much as possible with a dissector. Kocher's elevator (p. 628), or using blunt-pointed scissors partly to cut with and partly closed as a blunt dissector, and keeping the instrument used close to the growth. The dissection should be begun either where the growth is most free, and where its relations are not important, or by at once identifying the most important structures, *e.g.* the carotid sheath and internal jugular vein.

(*b*) Clamping or tying with sterilised ligatures every vessel before it is divided, not only to minimise the loss of blood, but also to avoid the risk of air entering the veins, especially low down in the neck.

(*c*) Of the important structures to be remembered several are alluded to in the next section. Others must be remembered.

Injury to the Vagus on one side. Accidental ligature or clamping of this nerve has been followed by perilous interference with respiration and the heart's action. Division or resection of the trunk below the origin of the superior laryngeal nerve will lead to hoarse, diminished voice from paralysis of the recurrent laryngeal branch, while after injury higher up, in addition to these laryngeal symptoms, there will be diminished sensation of the mucous membrane of the larynx. While not of itself immediately fatal, injury to the vagus is a serious addition to the dangers which a patient, usually of diminished vitality, and often advanced in years, has to pass through after a prolonged operation for the removal of a large growth of the neck.

Sir R. Godlee[1] showed a child in whom, during the removal of a deep-seated growth, the nature of which was doubtful and which was pressing upon the pharynx, the cervical sympathetic had been wounded. The only results were, that the pupil on that side was smaller but not stationary, and that the ocular slit was also smaller.

[1] *Clin. Soc. Trans.*, vol. xix, p. 321.

Wounds of the Thoracic Duct.[1] In the extirpation of deep tuberculous or malignant glands, especially if adherent and breaking down, extirpation of malignant growths, in ligature of the first part of the left subclavian artery, this complication has been several times recorded. Its occurrence may be discovered at once, the surgeons seeing fluid like watered milk issuing from the depths of the wound; the first intimation may be given a few hours after the operation by the dressings being found soaked; or several days later, the wound having healed superficially, a large fluctuating swelling may appear, on opening which a similar fluid escapes. If the wound is a partial one lateral ligature or suture with very fine silk or catgut is the ideal treatment. Deanesley [2] transplanted the severed duct into the wall of the vein. If the injury be complete, the distal end of the duct should be ligatured, but these steps are difficult and liable to failure. The treatment best adapted to the largest number of cases is pressure by a graduated tampon at the root of the neck, the wound having been first carefully sutured without drainage, if possible. The prognosis in these days is good. Even in those cases where the discharge has been profuse and loss of flesh has been rapid, recovery has usually followed. In some cases this favourable result has been due to the main duct subdividing before its termination.

(*d*) If possible, the growth-capsule, which is often soft and delicate, must not be ruptured. On examining the growth after removal, the capsule should not only be entire, but any process should be blunt and rounded, not soft and ragged as if torn away from parts left behind.

If the surgeon feel doubtful as to any portion being left, as in the fossæ, about the base of the skull, he should use a sharp spoon and Paquelin's cautery, or diathermy (*see* p. 396) may be tried.

(*e*) Throughout these operations, which may necessarily be prolonged and attended with loss of blood, and in which important parts may be disturbed and pulled upon, the surgeon should keep himself informed as to the effects of the anæsthetic.

(iii) **Closure of the Wound and Application of Dressings.** After completely removing the growth and any outlying glands, the resulting cavities are thoroughly dried out, and drainage provided in accordance with the position which the patient will occupy. Tubes of sufficient size being in position, the wound is brought together and the dressings applied with the precautions already given at p. 627.

OPERATIVE TREATMENT OF TUBERCULOUS GLANDS

This may be given here owing to the greater frequency and importance of this disease in the neck.

Question of Operative Interference. The following abundantly justify something more vigorous than mere palliative treatment: (1) The fact that one gland has power to infect others, even when the local starting-point may have been cured, though too late to prevent extension. (2) The disease, if merely palliated, is often extremely tedious, keeping the patient from the enjoyment and activity of some of the best years of

[1] See a paper by Dr. H. P. de Forest (*Ann. of Surg.*, 1907, vol. xlvi, p. 705). Dr. de Forest concludes that the thoracic duct has collateral branches which are probably able to perform the functions of the main duct, should this be injured. He recommends that a wound of the duct should be treated in the same way as a wound of a blood-vessel, i.e. that it should be sutured, if possible, or ligatured.

[2] *Lancet*, 1903, vol. ii.

life. (3) The scars which follow on a natural cure are far more disfiguring and extensive than those after a well-planned operation, especially one in which primary union has been secured by strict aseptic precautions, and by operating before caseation and suppuration have altered the normal condition of the parts. (4) The long years a natural cure requires; the repeated suppurations and the blighted days cause grave deterioration of the general health, which may persist for life, long after local cure has taken place. (5) The poor vitality thus induced, and the actual presence of the tubercle bacillus, render the patient very liable to such diseases as phthisis. (6) The chief indication for operation is persistence of the disease, in spite of careful general treatment, and the slightest evidence of commencing caseation. (7) There are a few and very occasional cases in which operation is to be deferred or avoided. For instance, where (*a*) there is advanced disease elsewhere, and (*b*) there is threatening of a general outbreak. Here the temperature will be a valuable guide. (8) In advising operative steps in tuberculous glands of the neck, any thoroughly qualified surgeon is justified in impressing on the friends (*a*) that the treatment of the case will be shortened; (*b*) that convalescence will be hastened; (*c*) the result will be more permanent; (*d*) if it be performed early, less of an operation will be required.

The Chief Groups of Glands must be remembered. (1) The parotid or pre-auricular. Some of these are embedded in the salivary gland. While the greater part of the pes anserinus will be protected by a sufficient layer of salivary gland tissue, its proximity is not to be forgotten, and most operators will keep exceedingly close to the capsule of the diseased gland, and, if it be adherent, scrape rather than dissect. (2) Posterior auricular. (3) Suboccipital. (4) Submaxillary. Some of the deepest of these lie in the folds of the submaxillary salivary gland. This structure should be extirpated in all doubtful cases. (5) Submental, a small group often overlooked. (6) Superficial cervical. A group running with the external jugular superficial to the sterno-mastoid, and along its posterior border. When these are adherent the presence of the spinal accessory coming out into the posterior triangle must be remembered. (7) Deep cervical, lying along the carotid sheath. Their relation to the large veins is alluded to below. (8) Glands in the posterior triangle, continuous with the superficial cervical above and (9) the supraclavicular below. If these last have become affected, extension to the glands in the axilla is extremely probable. (10) The suprasternal gland in Burns's space. (11) The retro-pharyngeal group.

By far the best is (A) Excision. (B) Curetting or scooping out the glands is very inferior, and only to be made use of in those advanced cases where excision is impossible.

A. **Excision.** *General Principles to be remembered.* These refer chiefly to advanced cases. (i) Antedate, if possible, caseation and suppuration. If these have been allowed to run on before an operation is permitted, the parts will be matted, adherent, altered: relations will be difficult, perhaps impossible, to make out: important structures, such as the internal jugular vein, will easily be damaged; primary union will be rarely secured, and the scar will, therefore, be needlessly prominent. Where one or more glands are softening, opening the abscess and thorough curetting may suffice; but as a rule a sinus is left, and further glands may enlarge. If the surroundings are favourable the suppurating area may be

removed through a free incision. As a rule, it is best to open the abscess, and, two or three weeks later, to deal with its remains together with the rest of the disease.[1] Where a sinus is present this should be first curetted and sterilised, as far as possible, with pure carbolic acid. At the time of the operation sterilisation should be thorough, the hair shaved, and kept out of the way with prepared towels. (ii) Wherever possible, the incision should be placed along some natural crease or in some sulcus, so that the scar should be less noticeable. But (iii) the incision must always be sufficiently free. The scar will be little larger, and much handling through a small incision impedes primary union. Moreover, a free incision enables the operator, in cases where caseation has already taken place, to find one or more spots where the anatomy is normal, and where he can start with important relations, *e.g.* the internal jugular vein, easily recognised.

Transverse incisions following like folds leave less disfiguring scars, and should be employed in slighter cases. But this fear of scars can be overdone. The too wide adoption of transverse scars will certainly defeat its object by leading to repeated operations. While longitudinal wounds may leave thicker scars, and ones more liable to be keloid, there are other conditions in their productions which must be remembered. It is the more advanced cases which call for free incisions; patients or their relations, by postponing the operation on account of the fear of scars, are often largely responsible for the conditions which these incisions have to meet; finally, in some cases deficiency in the technique of the operation must bear some of the responsibility. Several incisions have already been mentioned (p. 639); the two chiefly useful are one along the cervico-submaxillary crease and another along the anterior border of the sterno-mastoid. In extensive cases it is always well to begin with deeper work below where the anatomy is usually normal; to define the internal jugular vein here and work upwards at first. The flaps must be raised carefully, owing to superficial glands being often affected, which must not be cut into. Any infected skin or disfiguring scars should be left to be removed with the subjacent glandular areas. The flaps when raised are to be wrapped in sterile gauze. Especial care must be taken with the upper one that it is not infected by the manipulations of the anæsthetist, or by saliva from the mouth. (iv) The chief structures to be remembered are (*a*) the **internal jugular vein.** As in all operations on the neck where this is likely to be involved, the first point is to define it. This, for the reason already given, is best done below. The edge of the sterno-mastoid having been defined, the deeper layer of deep fascia is incised here, the sheath opened, and the vein well exposed. By working upwards towards the more affected area the glands can usually be peeled off from the vessel by insinuating a Watson-Cheyne dissector, the closed ends of blunt-pointed curved scissors, or an elevator such as Kocher's (p. 628).

Frequently, when the glands seem quite adherent, careful, patient working is successful in leaving the vessel unopened. Where the glands are too adherent to admit of this and the vein is torn, the opening, caught with Spencer-Wells forceps, may be tied up, or sutured laterally with fine catgut. To admit of this being done a sufficient area of the vessel must be exposed to allow of pressure being made on it above. Where these

[1] When caseation occurs the gland becomes adherent to the deep fascia, perforates this, often by a minute opening, and thus leads to the formation of a subcutaneous abscess. If this alone is incised and scraped a sinus is certain to persist. Generally speaking, it is best to deal with the caseating gland in these cases at a second operation.

steps are not available, where the anæsthetic is causing anxiety, or where a gland has ruptured and part remains adherent, the vein should be resected between double ligatures securely applied. But this step is not to be as lightly undertaken here as in the removal of epitheliomatous glands. While resection of the internal jugular greatly facilitates extirpation of the glands, it is doubtful whether the loss of the vein makes no difference to the patient. This step should certainly not be adopted as a matter of routine, as one of the improvements of modern surgery. Those who have seen much of these cases know that, in children especially, it is not very unusual for tuberculous cervical glands to be bilateral. Let us suppose that the internal jugular has been resected on one side. A little later like mischief appears on the opposite side: and a surgeon holding advanced views adopts the same step on this side also. The effect of this on the intracranial circulation of the child might be instructive; it would scarcely be harmless.

(*b*) **The spinal accessory** is often embedded in a mass of glands,[1] and this opportunity may be taken of saying that where the posterior and the anterior triangles of both contain tuberculous glands they should be operated upon on different occasions. The nerve should be defined where it enters the sterno-mastoid at a point which is about opposite to the angle of the jaw, the upper part of the sterno-mastoid freed by dissection and drawn inwards, the point of exit of the nerve into the posterior triangle found, and a probe passed downwards and outwards along its course as a landmark. In the posterior triangle it is easy to mistake one of the descending branches of the cervical plexus for the spinal accessory. Division of the sterno-mastoid, always permissible in the removal of epitheliomatous glands, is rarely needed now, if the muscle is well retracted first to one side and then to the other. If division of the muscle is really needful, the point chosen should be below that of entrance and exit of the spinal accessory. If the case heals primarily a good muscle results, but usually it is for the removal of extensive adherent broken-down masses that its section is necessary, and these are just the cases which heal slowly and leave a depression at the point of healing. Disability or torticollis does not follow its division.

(*c*) The position of the **phrenic nerve** on the scalenus anticus is always quite easy to identify.

(*d*) The **inframandibular branch of the facial** is frequently divided in clearing out the submaxillary group. Some weakness of the lower lip follows, but disappears in about six weeks. The patient or friends should be prepared for this.[2] The possibility of injury to (*e*) the **thoracic duct** has been referred to at p. 640. In operations low down in the neck the risk of entrance of air into the veins is always present; if this accident should occur the wound should always be flooded with sterile saline solution before artificial respiration is resorted to, and in this region, to avoid dangerous hæmorrhage, every vessel should be secured before it is divided, otherwise it may retract out of reach.

(*v*) Each group of glands should be removed, as far as possible,

[1] This, therefore, is one of the few occasions on which the operator must depart from the rule of removing infected glandular areas as far as possible *en masse*.

[2] Dr. Dowd, of New York (*Ann. of Surg.*, July 1905), gives rules for avoiding this nerve. The chief are that, as the nerve runs just below the mandible and lies between the platysma and deep fascia, the skin incision should be made an inch below the bone, and the muscle and deep fascia should be divided a little below the level of the skin incision; they should then be retracted upwards with the filament between them.

en masse. (vi) Tuberculous mischief is to be dealt with, here as elsewhere, as if it were malignant, and all diseased tissues eradicated as if this, the first opportunity, were going to be the last. (vii) Careful asepsis must be maintained throughout. (viii) In all doubtful cases drainage is to be employed. Thus a tube should always be employed in cases where a caseating gland has ruptured during removal, and may have infected the wound in spite of careful washing out. Again, where the cavity is a large one, of uneven base, with many pockets or recesses, where much oozing is present, a drainage-tube should be employed for two or three days. All surgeons of experience must be familiar with cases where, after securing primary union, the swelling has soon reappeared, and, on opening up the diseased area, structures which at the first operation, *e.g.* part of the sterno-mastoid, diagastric, &c., were absolutely healthy, are now covered with greyish granulation tissue, the structures being only recognisable by their position and outline. Another result of infection of the wound by tuberculous material left behind is rapid breaking down of the scar, not a reappearing deep swelling. The risk which the drainage-tube entails of infection from outside can be met by careful dressing and regular resterilisation of the adjacent skin during the time that it is needful to retain the tube. (ix) Pressure is always to be well applied, for the same reasons and in the same way as given at p. 626. But where there is any doubt about the wound being sterile, boracic acid fomentations should be used at first. (x) Sufficient rest of the parts is most essential here. Sir F. Treves has insisted on this point in the after-treatment. It is one of very great importance, if a small and sound scar, and obliteration of any tuberculous material possibly left behind, are to be secured. The patient should rest absolutely in bed for the first fortnight. When the parts are thus kept at rest, the child should live out of doors in the best air available. (xi) The patient is to be kept for a long time under observation, owing to the risk of persistence and reappearance of the disease. Nowhere do the wise words of Verneuil find better application, that in dealing with the tuberculous we must be prepared for "half successes, incomplete results, and unfinished cures." A wise surgeon, when an advanced case is brought to him, will do well to undertake only his fair share of responsibility for the result. The patient or the friends must be prepared for more than one operation.

(B) **Curetting or Scooping out the Glands.** While its value has been clearly proved in the instructive papers on "Scrofulous Neck and the Surgery of Scrofulous Glands" put forth by Sir T. C. Allbutt and Mr. Teale as clinical lecturers at the Leeds School, from which so much good surgery has already come, it is very inferior to aseptic treatment by excision, for the reasons given below. The following are Mr. Teale's conclusions as to the surgical treatment of these cases: (1) That surgery can secure the healing in a very few weeks[1] of gland cavities and sinuses, even though they have existed for years. (2) That, in dealing with sinuses, gland abscesses, and decayed or semi-decayed lymphatic glands, the action of the surgeon must be vigorous and thorough. (3) That the visible abscess, which should often be called, and treated as, a tuberculous suppurating gland, is, as a rule, merely a subcutaneous reservoir of pus, its source a degenerate gland, being not subcutaneous, but sub-fascial, *i.e.* under the deep cervical fascia, and sometimes even submuscular, the communication between the two being a small opening just large enough to admit a probe or director. (4) That it is utterly futile merely to incise or puncture such a subcutaneous abscess dependent upon a degenerate gland which lies beneath the deep fascia. (5) That when a damaged or suppurating gland has been got rid of before the overlying skin is thinned by advancing suppuration the resulting scar

[1] In severe cases several operations—three or more—will be needed. After the first one or two the general condition is said to improve rapidly.

is insignificant and not an eyesore. (6) That, in dealing with a sinus, the channel should be enlarged by the knife or a "Bigelow's dilator," and the whole of its granulating surface scraped out. Where the skin is thin and blue this should be scraped away, and any cutaneous overhanging edges trimmed off with scissors. (7) That, in dealing with a sinus or an abscess, the surgeon should not rest content until he has discovered and eradicated the gland, always remembering that, if it be not obvious, there is sure to be a small track leading to it through the deep fascia. This should be enlarged so as to admit a sharp spoon. (8) That, when a gland has suppurated or become caseous, the capsule should be freely opened and the contents scraped out. This is sometimes easy, the enucleation leaving the stiff capsular case virtually cleaned out. Sometimes it is very difficult to get rid, even by the most vigorous scraping, of a tough living stump of gland firmly adherent to the capsule. It is well to dissect this remnant away with a scalpel, if the risk of injuring important structures be not too great. (9) That sometimes, when such an empty capsule is left, the finger detects in its wall a bulging contiguous gland. This should be punctured through the wall of the cavity, and so reached and enucleated. In this way, in more than one instance, Mr. Teale has emptied from one external opening a group of three or four glands, suppurating or broken down. In the event of sinuses persisting the injection of an emulsion of bismuth carbonate may be tried. Vaccine treatment and the injection of tuberculin may also be employed in conjunction with surgical treatment on the above lines.

The above method is much inferior to that of aseptic excision, for the following reasons: (*a*) It is limited to cases where one or two glands are involved. Cases such as these form a small minority of tuberculous cervical glands. (*b*) It deals only with caseating and suppurating glands.[1] (*c*) In the majority of cases there are glands, often numerous, which are infected and which will certainly give trouble, though not as yet softened. Such can only be removed by a sufficient incision and dissection. (*d*) It is an operation in the dark. This is an objection of great weight when the gland lies deeply and may be attached to important structures, *e.g.* the internal jugular. (*e*) This operation is much more likely to call for repetition than a well-planned aseptic excision on lines widely, carefully, and thoroughly carried out.

CYSTIC HYGROMA; CONGENITAL LYMPHANGIOMA

Unless these growths are clearly spreading or causing dyspnœa, they should not be operated upon in early life. The poor vitality and the subsequent restlessness of the patient and small size of the parts, contra-indicate such interference. Where this step is rendered necessary, free incision and drainage of the chief cyst or partial removal of the larger ones, in a multilocular case, and drainage are the wisest steps. But the risk of infection is always great. Where a lymphangioma involves the face, and the presence of the facial nerve is an additional contra-indication, the surgeon's choice, if he be compelled to interfere, lies between multiple incisions, electrolysis, and injections, *e.g.* of iodine diluted.

THYROGLOSSAL CYSTS

These, and occasionally solid growths, are derived from the embryonic thyroglossal duct, which passes from the foramen cæcum to the isthmus or pyramidal lobe of the thyroid gland. Their liability to form discharging fistulæ in the middle line of the neck, usually situated between the

[1] In some extensive cases where there is much matting and infiltration of surrounding tissues with several sinuses, and where the tuberculous disease has extended widely beyond the glands, dia-thermy (see p. 396) may be tried after thorough use of the sharp spoon.

cricoid and the thyroid cartilages, is well known. The only treatment is complete removal of the cyst or fistula with that portion of the thyroglossal duct which remains patent. This is liable to be a matter of some difficulty. A median incision having been made from the hyoid bone down to the upper rings of the trachea, the deep fascia is opened, and the cyst dissected out. If a sinus is present, a fine probe should be passed upwards along its whole length as a guide. It is usually arrested at the body of the hyoid. The puckered skin below and around the opening of the sinus should be removed as well. Sir J. Bland Sutton found in one case that the duct bifurcated below, one portion ending at an opening in the middle line of the neck, the other in a blind pouch. The duct usually becomes obliterated at or behind the body of the hyoid, it being impossible to pass a piece of fine silver wire beyond this point. Probably a fibrous tract replaces the rest of the thyroglossal duct up to the foramen cæcum. Rarely it extends behind the hyoid bone upwards into the muscles of the tongue, and its removal is then a matter of considerable difficulty. The incision must then be continued towards the chin, the hyoid divided with a fine saw, two halves and the genio-hyoids separated, and the entire tract which is patent removed. Drainage should be employed in these cases. Excellent illustrations of median cervical fistulæ dating to a patent thyroglossal duct are given by Sir J. Bland Sutton.[1] He refers to an instructive paper by Marshall describing the anatomy of the parts in a child æt. 5.[2]

Congenital Branchial Fistulæ. These are most commonly seen at the anterior border of the sterno-mastoid a short distance above the suprasternal notch. They are generally minute, scarcely noticeable openings from which a quantity of mucoid fluid exudes. Occasionally they become infected and then the discharge is purulent. If a fine probe be introduced it will pass upwards for a considerable distance: indeed, the upper end of the fistula may be intimately connected with the wall of the pharynx above the level of the hyoid bone. The upper part of the track is very deeply situated; not uncommonly it passes between the internal and the external carotid arteries.

The treatment will depend upon the symptoms which are present. If there is only a slight amount of inconvenience the fistula is best left alone. If the inconvenience is great, or if the fistula is infected, it should be removed, though, on account of its intimate relations to important structures deep in the neck, this should not be lightly attempted. A fine probe is introduced into the fistula and an incision is then made along the anterior border of the sterno-mastoid, encircling the opening below. The whole track is then carefully dissected out, care being taken to avoid the large vessels and also, above, the superior laryngeal nerve. When connected with the wall of the pharynx, the upper end, which is almost certainly fibrous, should be ligatured and divided. The extensive wound should be drained by a small tube for forty-eight hours. More rarely congenital branchial fistulæ are found in front of the ear. These are best left alone unless suppuration should occur, when incision and drainage will be required.

Branchial Cysts. These are occasionally found along the anterior border of the sterno-mastoid or in the submaxillary region. The only treatment is removal, but, as in the case of the fistulæ described above,

[1] *Tumours, Innocent and Malignant*, pp. 380 and 383.
[2] *Journ. of Anat. and Phys.*, vol. lxxvii.

they are likely to be in intimate relation with the large vessels and nerves and also to extend upwards behind the ramus of the jaw. The surgeon must therefore be prepared for a long and tedious dissection.

Dermoid Cysts and **Sebaceous Cysts.** Both these forms of cyst may occur in the neck. Dermoids are usually in the mid-line and may be found either above or below the hyoid bone, and sometimes at the root of the neck just above the suprasternal notch. In removing these cysts the incision should always follow one of the natural folds or creases of the skin. In the case of a large dermoid at the root of the neck an incision similar to Kocher's collar incision for thyroidectomy should be employed.

Lipomata. These tumours, which may reach a large size, are not uncommon, especially at the root of the neck. Their removal by an incision in the long axis of the tumour is easy. The objection to this method is that a very long incision is required if the tumour is large. If this is regarded as of importance the following method may be employed. An incision is made through the skin, superficial fascia and capsule into the tumour itself. The lipoma is then firmly grasped and squeezed as firmly as possible. The fatty masses can in this way be forced through the opening in the capsule, and a large lipoma can then be removed through a comparatively small incision.

With either method it will be necessary to apply pressure by a firm bandage over carefully arranged dressings in order to obliterate the cavity. In the case of very large tumours drainage for the first forty-eight hours will be desirable.

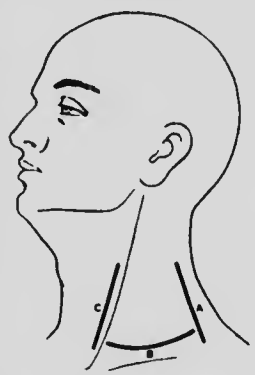


FIG. 274. A, Vertical incision for removal of cervical rib. B, Transverse incision for removal of cervical rib. C, Incision for œsophagotomy.

Removal of Cervical Ribs.[1] Considerable attention has been directed in recent years to this subject, and it is now recognised that the presence of a supernumerary rib is not infrequently the cause of more or less severe symptoms owing to pressure on the subclavian vessels or the brachial plexus. The abnormal rib may give rise to a swelling which can easily be felt in the posterior triangle, but, on the other hand, in many cases nothing abnormal may be detected on palpation. In the latter cases a diagnosis can only be made after a radiographic examination. Though the cervical rib may be felt, it is very rare for it to give rise to any noticeable deformity, and it is seldom, if ever, that operation will be called for on this account alone. The more serious symptoms may be divided into the following groups: (*a*) Nervous symptoms. Under this head may be included cutaneous hyperæsthesia, pains often severe, of neuralgic character, muscular cramps, paralysis and atrophy of muscles, especially those supplied by the ulnar nerve, even giving rise to the "main en griffe." Anæsthesia is also occasionally present. (*b*) Vascular symptoms. Coldness, with either anæmia of the fingers, or with redness and congestion. In some cases there may be threatening or even actual gangrene of the fingers simulating Raynaud's disease. If either of these groups of symptoms are present to any extent operation is always indicated. Not infrequently the onset of the symptoms is sudden. There is no relation between the size of the rib and the severity of the symptoms.

The following anatomical points are of importance. (*a*) Occasionally the

[1] For further information on this subject the reader is referred to an interesting discussion on cervical ribs before the Clinical Section of the Royal Society of Medicine in February 1913 (see *Proc. Roy. Soc. Med.*, Clin. Sec., March 1913, p. 96). Here much valuable information as to the anatomy, diagnosis, symptoms, treatment and results will be found. Numerous illustrative cases are also described.

abnormal rib may be a rudimentary first dorsal and not a supernumerary cervical rib. (*b*) The anterior extremity of the rib terminates in a variable manner. It may reach the sternum, or it may join the normal first rib; a fibrous band may connect it with either of these structures, or it may end freely. (*c*) The relation of the subclavian artery to the abnormal rib is variable; in some cases, but not in all, the artery passes over and is raised up by the rib; in some cases it passes beneath it; not uncommonly the artery lies in a groove on the first rib just anterior to where the rudimentary rib fuses with it. (*d*) The brachial plexus crosses over the rib, the lower trunk being usually in immediate contact with it and is often tightly stretched over it, especially when the shoulder is depressed. The suprascapular nerve crosses the rib and is in danger of being damaged during the operation.

Operation. A cervical rib may be removed either through a transverse or a vertical incision. Both of these incisions have their advocates, but a long vertical incision extending upwards from the clavicle along the anterior border of the trapezius can be recommended as giving a good exposure of the rib, though the resulting scar will probably be more noticeable. If the transverse incision be employed it should extend from the sterno-mastoid to the trapezius and should not be too low down, or there will be difficulty in exposing the vertebral attachment. The transverse cervical and suprascapular veins will probably require ligatures. Whichever incision is employed it is best first to identify the rib and trace it to its vertebral attachment, which is divided or freed. The brachial plexus is gently drawn downwards by a broad retractor, special care being taken to preserve the suprascapular nerve. These structures must be handled with the greatest gentleness throughout the operation in order to avoid bruising, stretching or other injury, which may leave most troublesome after-effects. To expose the articulation of the rib with the vertebræ the sterno-mastoid and scalenus anticus may be retracted inwards. The vertebral extremity having been freed, the adjacent structures are separated from the rib until its junction with the first rib or the terminal fibrous band are reached: this is then divided with scissors or gouge, and the rib removed. There is some difference of opinion as to whether the rib should be removed subperiosteally; if this is done there is less danger of wounding the pleura and other important structures which are in contact with it, and Sir Rickman Godlee, who recommends this procedure, states that he has never seen any trouble from re-formation of the rib.

All bleeding-points should now be secured, and, as a general rule, the wound should be closed without drainage.

After-treatment. In those cases where muscular weakness and atrophy are present electrical treatment and massage should be employed as soon as the wound is soundly healed.

Results. Provided that the symptoms are not very severe and that they are not of long duration, the results of the operation are usually very satisfactory. In old-standing cases and those with severe symptoms, especially of muscular paralysis and atrophy, though considerable improvement is probable, complete cure is unlikely. In the discussion mentioned above, Dr. Hinds Howell sums up the results of operation as follows: "In a large proportion of cases some symptoms, such as pain and weakness in the arm, may be expected to follow the operation, but not to last more than three months or so. The vaso-motor symptoms, which are present in almost all the cases, will be certainly improved, and in the majority of cases pain will be relieved or cured. With regard to muscular weakness and atrophy, the expectation is that the operation, if it is not too long delayed, will greatly improve this condition. There is not, as a rule, complete restoration of the wasted muscles, nor complete recovery from the vaso-motor disturbance.

☛ Some surgeons advise that only that part of the rib which is in relation with the nerves should be excised, or even that the fibrous band only should be removed. If this is done the vertebral attachment of the rib will be left.

CHAPTER XXXI

OPERATIONS ON THE ŒSOPHAGUS

ŒSOPHAGOTOMY, ŒSOPHAGOSTOMY, ŒSOPHAGECTOMY, ŒSOPHAGEAL POUCHES

ŒSOPHAGOTOMY

Indications. This is required for foreign bodies, *e.g.* tooth-plates, bones, coins, &c., as have resisted careful attempts at extraction by other methods: bodies which are certain, if left, to lead to grave results, *e.g.* sloughing, deep cervical suppuration, &c.

As in the case of foreign bodies in the respiratory passages, the diagnosis and treatment of foreign bodies in the œsophagus has been, within recent years, completely revolutionised by the use of Killian's and Brüning's direct-vision tubes. A description of these tubes and of the indications for their use, and the method of using them, will be found at p. 601.

Foreign bodies are likely to become fixed at one of the following three places: (1) behind the cricoid cartilage, (2) where the left bronchus crosses the œsophagus: (3) at the lower end of the œsophagus.

The diagnosis of a foreign body in the œsophagus may present considerable difficulties. There will usually, but not always, be pain and dysphagia, and in children there will very possibly be no history obtainable of such a body having been swallowed. A metallic substance, such as a coin, will be revealed by an X-ray examination, but it must be remembered that, as in the case of foreign bodies in the respiratory passages, many of the bodies will not be opaque to X-rays and thus will not show on screen or plate. Even opaque materials such as a tooth, or a small piece of bone, may not, owing to their deep situation, be revealed by a radiographic examination. The best method of diagnosis is direct examination by a Brüning's tube, when the œsophagus can be inspected through its whole length. Even here care must be taken to mop away all mucus and secretion, which may conceal some small body such as a fish bone. It may here be insisted upon that in every case an attempt should be made to remove the foreign body by manipulations through the Brüning's tube. In the great majority of cases this will be successful. The advantages of extraction in this way are obvious: there will be an immediate relief from all symptoms, there will be no external wound, and there will be no danger of cellulitis or mediastinal suppuration which so often prove fatal after œsophagotomy.

At the same time the operation of œsophagotomy can scarcely be regarded as obsolete, though it will be less frequently called for than formerly. Thus the foreign body may be too large or too firmly impacted for removal through the Brüning's tube, or the accident may happen where these special instruments are not available. In any case the body

should be removed as soon as possible: if left, ulceration, perforation of the œsophagus, and deep suppuration in the neck may very quickly occur.

It must be remembered that the precise site of the foreign body is not always marked by any external swelling or resistance, nor by accurately referred pain;[1] furthermore, bougies occasionally give very slight indications of the presence of bodies (even rough ones) in the œsophagus or pharynx.

Operation. The head being somewhat extended and turned to the right[2] side, and the skin of the neck sterilised, the surgeon makes an incision three inches long from just above the thyroid cartilage to within half an inch of the sterno-clavicular joint,[3] a little in front of the anterior border of the sterno-mastoid (Fig. 274). Skin and fasciæ being divided, the anterior jugular or its branches secured, the cellular tissue in front of the above-mentioned muscle is opened up with a director, and the pulsation of the artery and the bodies of the cervical vertebræ, fifth and sixth, felt for. The omo-hyoid may be drawn down, but it is best to divide this muscle at once, and, if it be needful to seek for the foreign body low down in the neck, the sterno-hyoids and sterno-thyroids also. The sterno-mastoid and large vessels are now drawn outwards, and the trachea[4] inwards, with retractors, the thyroid gland probably showing plainly on the inner side, and the internal jugular, if distended, on the outer. The presence of the inferior thyroid behind the carotid sheath, and that of the recurrent laryngeal running up in the groove between the trachea and œsophagus, must be remembered. Throughout these steps of the operation the bleeding must be most carefully arrested, and the deeper part of the wound, with the important structures around it, kept quite dry.

If the foreign body cannot be felt projecting in the œsophagus, *e.g.* behind the cricoid, the mouth should be opened with a gag, and a bougie or probang passed, as the flaccid tube walls are naturally in contact. When the œsophagus lies unusually deep, following round the thyroid or cricoid cartilage with a sterilised finger will find it.

When the site of the foreign body has been made out, or when, failing this, it is decided to open the œsophagus low down and to pass probes, &c., a clean incision must be made as far back as possible, so as to avoid the recurrent laryngeal filaments.[5]

When the tube has been opened, and any bleeding from its walls arrested, the opening is dilated by dressing-forceps, by a probe-pointed

[1] In a case recorded (*Brit. Med. Journ.*, May 7, 1904) by Dr. A. Fullerton, a halfpenny had remained lodged in the œsophagus for seven months without definite symptoms till three weeks before the child's admission, when ulceration probably commenced and the child brought up foul fluid. A radiographic examination showed the coin to lie opposite the third and fourth thoracic vertebræ. An attempt to remove it by the mouth was unsuccessful. A week later the coin was successfully removed by œsophagotomy; it lay four and a half inches below the opening in the œsophagus, and was hooked up to this by a bent probe. The wound in the œsophagus was sutured by catgut. Feeding by the mouth was commenced in forty-eight hours. Mr. G. H. Makins has recorded a case of œsophagotomy for the extraction of an impacted tooth-plate (*Clin. Soc. Trans.*, vol. xxxi, p. 11).

[2] The œsophagus lies more to the left side, and operating on the left side allows of freer movement of the right hand, while the left is at liberty to move the larynx, &c.

[3] If the neck is very stout, or if the parts are swollen, &c., the incision may be from just below the angle of the jaw to close to the sternum.

[4] The larynx should not only be drawn to the right, but tilted over to this side also, as this brings up the œsophagus.

[5] Mr. Cock (*Guy's Hospital Reports*, 1868, p. 3) drew attention to this point. Both his patients were in the habit of singing; in the first case (*Ibid.*, 1858, p. 229) a fine tenor voice was replaced by a bass; in the second, in which the œsophagus was opened farther back, the voice did not suffer.

bistoury, or by curved forceps passed from the mouth and expanded in the wound. Even after a free opening has been made it may be impossible to dislodge the body, if this, a tooth-plate, has projecting clips, or if it is tightly embraced by the contraction of the œsophageal fibres. In such a case the body should be (if a tooth-plate) divided with bone-forceps and removed in two portions, care being taken to keep hold of each portion with forceps.[1]

If, after exposing the œsophagus, the foreign body cannot be felt — which will rarely happen—metallic probes or soft bougies should be passed through the wound in the œsophagus, and the lower cervical and the upper thoracic portions of this tube carefully explored. The question may now be considered: How far down from the œsophagus can a body be extracted? The most accessible part is, no doubt, its junction with the pharynx, opposite to the cricoid cartilage, and the first two inches below this point.

Mr. Bennet May gives the following example of successful extraction of a foreign body at a low level.

Here a child, aged 7, had swallowed a halfpenny three and a half years before. The coin had ulcerated through the œsophagus and opened the right bronchus,[2] lying partly in this and partly in the œsophagus. It was removed successfully by œsophagotomy.

A foreign body firmly impacted at the lower end of the œsophagus which cannot be dislodged by other means, may be removed by opening the stomach (gastrotomy) and introducing suitable forceps upwards through the cardiac orifice.

When the foreign body has been removed, the question of introducing sutures into the œsophagus will arise. These should only be used when the wound in the gullet is clean-cut, not bruised, and when the obstruction has been quickly removed; the sutures should be of fine sterilised gut. Only the upper part of the skin wound should be closed, the rest being left open to the bottom to allow of free drainage, owing to the danger of sloughing, pent-up foul secretions, and blood-poisoning (p. 649). A drainage-tube should be inserted to the bottom of the wound, a few sutures placed in the edges of the wound, dry dressings applied, viz. antiseptic gauze, salicylic wool, &c., if the wound has not been much probed about, and there is thus good reason to expect early union. But if ulceration of the soft parts has been found, if they are inflamed, emphysematous, &c., the wound should be left open, drained to the very bottom, and boracic acid fomentations frequently applied.

After-treatment. If the patient is in good condition, if the foreign body has been removed early, or if the patient has been able to swallow liquids in the interval between the accident and the operation, he may be fed for the first few days by nutrient enemata and nutrient suppositories, and only a little ice given occasionally by the mouth. But if the

[1] Lawson. *Clin. Soc. Trans.*, vol. xviii, p. 292.

[2] The proximity of important parts to the thoracic portion of the œsophagus is well known. Thus, in *Path. Soc. Trans.*, vol. xix, p. 219, is recorded the case of a man who swallowed a bone which lodged in the œsophagus opposite to the arch of the aorta. Death took place suddenly on the fifth day from perforation of the aorta and hæmorrhage, after a slight exertion. Mr. Eve (*Clin. Soc. Trans.*, vol. xiii, p. 174) gives a case in which a fish-bone, impacted in the œsophagus, wounded the heart fatally. It was thought that the position of the fish-bone was perhaps due to previous use of the probang. Dr. E. G. L. Goffe has recorded and figured (*Proc. Roy. Soc. Med.*, Children's Sec., January 1915, p. 36) a case in which the arch of the aorta was perforated by a safety pin impacted in the œsophagus.

strength is not satisfactory at the time of the operation, or if the enemata are not retained, a soft feeding-tube must be made use of. This should be passed by the mouth and retained, if not very uncomfortable to the patient, or passed at intervals. Towards the end of the first week, perhaps earlier if the wound is healing well, the patient may be allowed to swallow a little diluted wine or milk.

CHIEF DIFFICULTIES

(1) A fat, short neck.
(2) Enlarged veins.
(3) Wide depressors of hyoid bone.
(4) Enlarged thyroid gland.
(5) Unusual depth of œsophagus.
(6) Detecting the site of the foreign body.
(7) Firm gripping of the body by the œsophagus.
(8) The foreign body may be dislodged during the operation.

Dr. Lediard[1] records the case of a man in whom emetics and several attempts at removal had failed to dislodge a tooth-plate; emphysema of the neck was present, and some blood on the forceps used. Just before œsophagotomy, a bougie was thought to "scrape" as it was withdrawn. Nothing being felt when the œsophagus was exposed, a bougie was passed, and the œsophagus incised behind the cricoid cartilage; the finger now could detect nothing, and a bougie passed on seemed to feel the plate near the stomach. The plate was passed nineteen days after its impaction; it measured an inch and a half by three-quarters of an inch, carried one incisor, and had "numerous sharp points, and a formidable-looking hook at one end." Though there were no laryngeal symptoms, the plate must have been lying behind the lower end of the larynx, as the mucous membrane of the gullet showed here several ecchymoses. The dislodgement of the plate took place either during the passage of the bougie or in the administration of the anæsthetic. The patient made a good recovery.

Causes of Death. These are chiefly:

(1) Septicæmia, the wound having become emphysematous, sloughy, and the discharge most foul.

(2) Exhaustion, when the body has been long impacted, and the patient's health has run down before the operation.

(3) Cellulitis.

(4) Extension of suppuration to the mediastinum.

Œsophagostomy. This has been proposed as a substitute for gastrostomy. Mr. Reeves, who brought the subject before the Clinical Society[2] recommended this operation as less dangerous than gastrostomy, and in his belief that cancer of the œsophagus is most frequently met with in the upper part of the tube. The objections, however, are so great as to have prevented any adoption of this operation. They are: (1) The risk of coming close to a mass of cancer, which will not only not admit of dilatation, but which will be rendered more active, sloughy, &c., by the necessary irritation. (2) The fact that important parts are close by, and that the relations of these may very likely be much altered. (3) The probability of finding the œsophagus altered near the disease, and thus, perhaps, readily perforated, admitting fluids into the pleura, &c.

Œsophagectomy. This is another operation introduced only to be abandoned. Prof. Czerny's case, it is true, was temporarily successful, the patient living rather more than a year after the operation. But cases equally suitable from the site of the disease—only just out of reach of the finger introduced from the mouth—with no glands involved, and no adhesions to adjacent parts, though symptoms had lasted five months, must be quite exceptional. Several of the risks given above would

[1] *Clin. Soc. Trans.*, vol. xvii. p. 297.
[2] *Ibid.*, vol. xv, p. 26.

be intensified here, and there would be present as well the need of keeping the fistula patent.[1] De Quervain has collected a number of cases.[2]

REMOVAL OF POUCHES OF THE ŒSOPHAGUS

This affection has in former years been considered a very rare one. Sir H. Butlin, who was one of the earliest operators, and the first in this country,[3] published [4] six cases which he has seen, two of which were

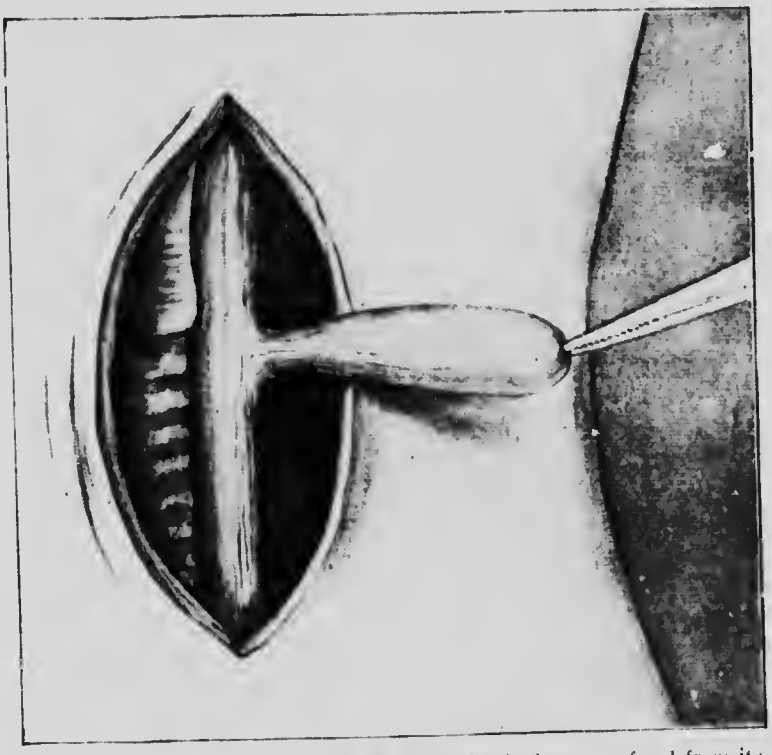


Fig. 275. Diverticulum in Dr. M. R. Richardson's first case, freed from its connections and brought out of the wound.

operated on by him, and with success. In the same periodical (July 11, 1903) he has published eight similar cases. Dr. Maurice Richardson in a paper [5] stated that fifty-six cases had then been recorded; of these eighteen had been operated upon, in most with success. Sir H. Butlin, in his second paper, states his belief that "the rarity of this condition has been greatly exaggerated, and for this reason: the symptoms of the pouch are not generally known, and are usually mistaken for those of a

[1] Sir H. Butlin (*Oper. Surg. Malig. Dis.*, 2nd ed.) gives a case of Prof. Billroth's, where death was caused by the passage of the bougie into the tissues round the œsophagus, the opening where the lower end of the œsophagus had been stitched to the skin having contracted. In Sir H. Butlin's opinion the results of the fourteen operations collected by De Quervain and others are very discouraging. Dr. Chas. H. Mayo has published a paper in which he considers the diagnosis and treatment of œsophageal diverticula (*Ann. Surg.*, 1910, vol. li. p. 812).

[2] *Arch. f. Klin. Chir.*, 1899, S. 858.

[3] *Trans. Med.-Chir. Soc.*, 1893, vol. lxxvi. p. 269.

[4] *Brit. Med. Journ.*, January 1, 1898.

[5] *Ann. of Surg.*, May 1900.

yet rarer condition, viz. pouching of the œsophagus above a stricture, whether innocent or malignant. Both in Whitehead's case[1] and Chavasse's,[2] gastrostomy was performed under the impression that the patient was suffering from stricture of the œsophagus, and the real nature of the condition was only discovered after the death of the patient."[3] The following are the chief symptoms, as given by Sir H. Butlin in his paper quoted above.

The pouch starts, usually, at the back of the junction of the pharynx

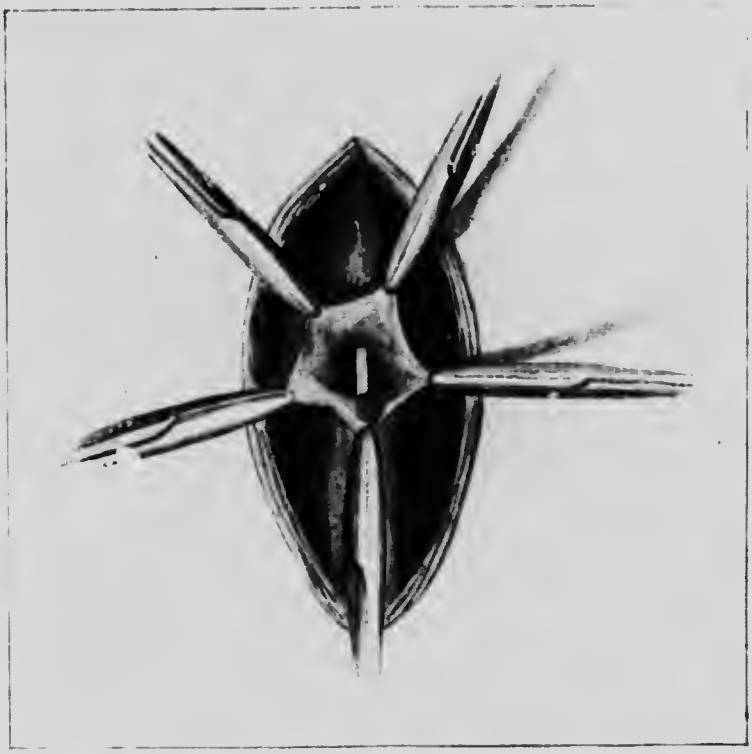


Fig. 276. Isthmus of diverticulum in Dr. M. R. Richardson's first case after excision of the main portion. The probang is visible in the œsophageal opening.

and œsophagus (Fig. 275). It occurs much more frequently in males, and the symptoms do not appear to have been noticed before the age of 40. Return of fragments of undigested food is the one constant symptom in every case, not immediately after the food has been taken, but many

[1] *Lancet*, 1891, vol. i, January 3, p. 11. [2] *Path. Soc. Trans.*, 1891, vol. xliii, p. 82.

[3] In Mr. Whitehead's case, the woman, æt. 57, whose symptoms had existed eight years, died six years after a most successful gastrostomy. Growing weary of this mode of feeding and believing her old trouble to be cured, she resumed feeding by the mouth, and allowed the gastrostomy wound to close. Gradually the old dysphagia returned, and she sank from exhaustion. In Mr. Chavasse's case, the man, æt. 49, applied for relief too late. He was much emaciated from starvation, and sank two days after the gastrostomy. In a case of Landauer's (*Centr. f. inn. Med.*, April 22, 1899), a Röntgen photograph, taken with thin leaden sounds in situ, gave more exact information as to the situation of the diverticulum. At the present day in all cases of œsophageal obstruction a radiographic examination should be made after the administration of bismuth emulsion.

hours after. The return of food is sometimes associated with severe attacks of coughing. After some time a larger quantity of food is returned and the patient becomes aware of some difficulty in swallowing, especially solid food. Pressure on the side of the neck, usually on the left side, causes fragments and liquids to return into the mouth, and if not, yet causes the escape of gas which is developed and collects in the pouch, and occasions much annoyance by gurgling up at frequent intervals during movements of the head and neck. If the pouch pro-

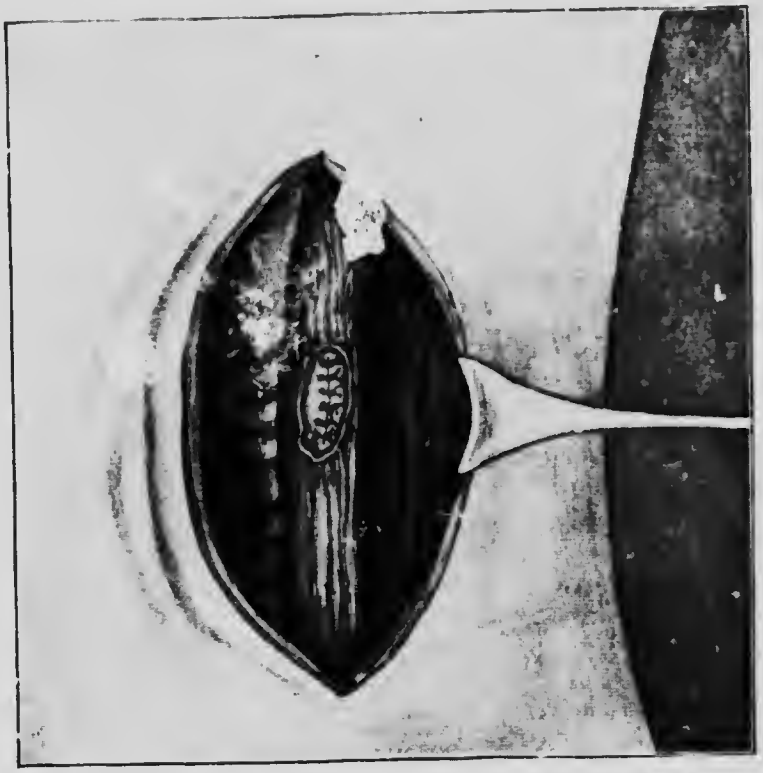


Fig. 277. The mucous membrane of the neck of the diverticulum has been inverted and united by interrupted Lembert's sutures of catgut. (Dr. M. B. Richardson's first case.)

duces bulging in the posterior triangle, about the level of, or below the cricoid cartilage, this is a very important sign, but the absence of bulging does not in the least affect the diagnosis. A bougie is arrested at a distance of about nine inches from the teeth. It may perchance pass into the stomach, gliding over the orifice of the pouch, but the rule is that it passes into the pouch; and, as the affection becomes more pronounced, it may be impossible to pass an instrument down the œsophagus. If the bougie be of metal and slightly curved, its end may be made to project so that it can be felt and seen in the side of the neck (almost always the left side), behind the sterno-mastoid. Wasting and loss of weight are rarely, if ever, observed until the late stages of the disease. In fact, the patient may suffer from unmistakable symptoms for years without any

sensible loss of weight. Of course, in those cases in which the condition is gradually producing death by starvation, wasting slowly occurs during the last months or years. The course of the disease is very slow. The size and position of the pouch are generally well shown by an X-ray examination after the patient has swallowed a dose of bismuth emulsion.

Operation. The patient being under the influence of an anæsthetic,[1] it would be well, if this has not been already done, to adopt Sir H. Butlin's advice and pass a slightly curved metal bougie into the pouch, and, if

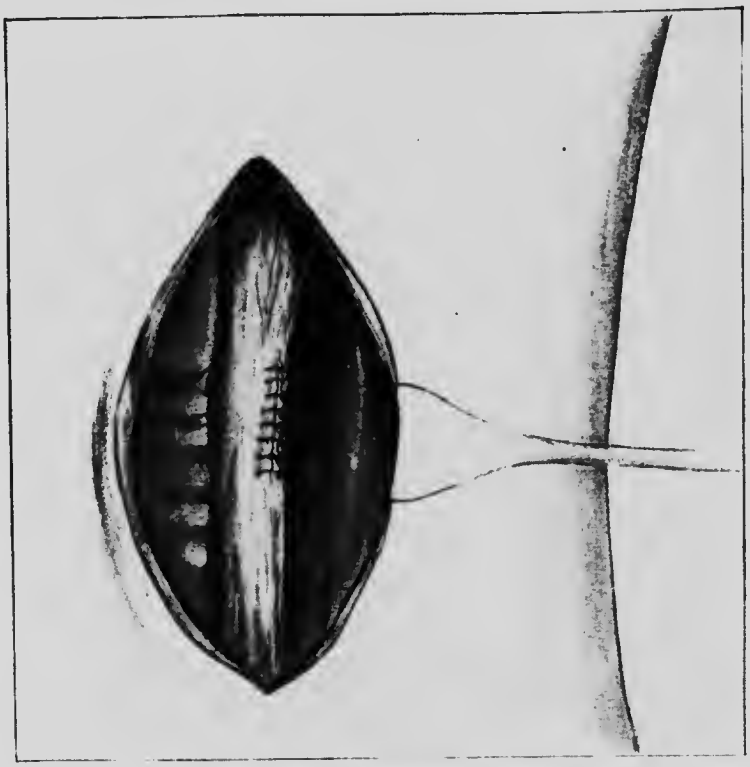


Fig. 278. The outer layers of the œsophagus have been closed with silk sutures. (Dr. M. R. Richardson's first case.)

possible, make its end appear in the posterior triangle, thus obtaining the clearest proof of the presence of a diverticulum. If possible, a bougie should also be passed beyond the orifice of the pouch into the stomach, so as to prove that there is no stricture of the œsophagus. A long incision is then made along the anterior border of the left sterno-mastoid from the hyoid to just above the sternum. The omo-hyoid is divided, the superior thyroid vessels severed between double ligatures, the carotid sheath drawn outwards, and the larynx rotated on its long axis by drawing forward the left ala of the thyroid cartilage with blunt hooks.

The pouch is then usually easily found lying behind the junction of

[1] Dr. M. R. Richardson, acting upon a suggestion of Dr. Cushing, had a hypodermic injection of atropine given before the ether was administered, in order to keep the mouth and throat dry. "This plan worked admirably."

the pharynx and œsophagus and projecting to the left side. If it be not found at once, careful dissection, aided by the passage of a bougie, will detect its position. It is then grasped by forceps, separated from the surrounding tissues, and drawn upwards out of the wound. The following are some of the methods of dealing with it. Sir H. Butlin in his two cases cut away the pouch from above downwards, the margins of the wound being drawn together with eight sutures of fine silk as the sac was cut away. Bleeding does not seem to give any trouble at this stage. Another

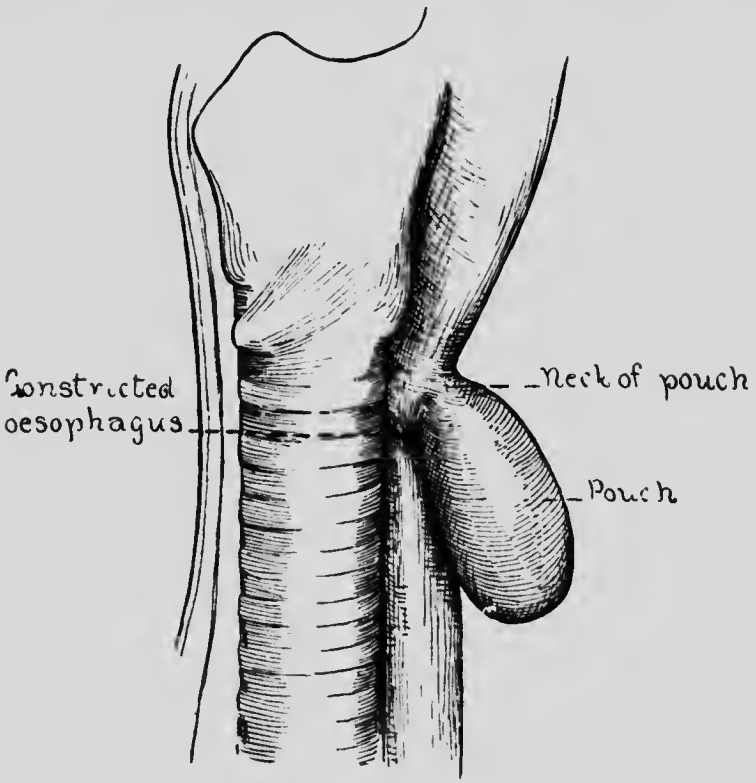


FIG. 279. The situation, shape, and size of the diverticulum in Dr. M. R. Richardson's second case.

method, that of Mr. Barrow,[1] is that of turning back a cuff of the fibrous coat of the œsophagus and suturing this over the gap left in the mucous membrane after the removal of the pouch.

Quite a different method is that employed by Girard, of Berne.[2] To avoid opening the œsophagus, he has twice invaginated the pouch so that it projects into this tube. The orifice, which after inversion points externally, is closed by three layers of sutures. Both of these cases were successful, though in one a fistula followed which closed later. The pouch probably becomes atrophied, as it no longer obstructed the passage of food. Dr. A. E. Halstead, of Chicago, relates a case successfully treated by this method.[3]

[1] *Lancet*, April 8, 1905.
[2] *Congr. Franc.*, 1896.
[3] *Ann. of Surg.*, 1904, vol. i, p. 171.

As he states, it is only adapted to diverticula of small size, and cases where the lumen of the œsophagus below the diverticulum is normal. He was able to demonstrate one source of the obstruction caused by the diverticula: "The lower border of the neck of the diverticulum acted as a valve, projecting into the lumen of the œsophagus. Upon introduction of the sound, it came into contact with this valve-like projection, which, upon further pressure, was forced down and completely obstructed the œsophagus, and diverted the sound into the diverticulum." The technique adopted was as follows: After the sac had been freed from its attachments, "a purse-string suture of catgut was passed round the neck with the sound in the sac. The sound was then withdrawn, and the sac inverted and invaginated

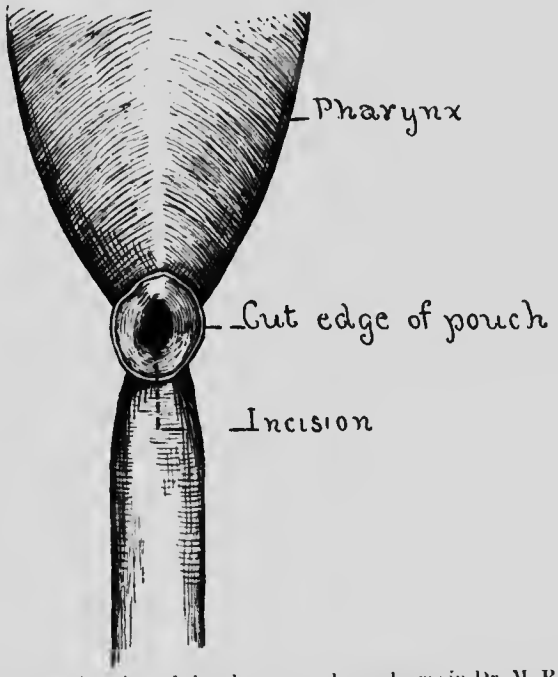


FIG. 280. Posterior view of the pharynx and œsophagus in Dr. M. R. Richardson's second case. The pouch has been cut off, leaving a circular margin. The dotted line shows the incision through the neck and margin of the pouch, and the constriction of the œsophagus.

into the œsophagus. The purse-string suture was then tied. Three sutures of catgut were then passed through the neck of the inverted sac. These did not penetrate the lumen of the diverticulum. Over these sutures the longitudinal muscular layer of the œsophagus was united by interrupted catgut sutures. A third layer of catgut sutures transverse to these was introduced. By these the inferior constrictor was brought down, covering the first sutures. A large-sized bougie could be passed without difficulty into the stomach." For five days nutrient enemata alone were given. After this milk was swallowed easily, and without leakage.

Dr. Richardson treated his cases shown in Figs. 275 to 282 as follows:

In the first case (Figs. 275–278) "the tip of the index finger could be thrust into the œsophagus through the circular base of the pouch. This was removed by cutting through the isthmus close to the pharyngeal opening. The mucous membrane was inverted into the œsophagus and fastened together by a few interrupted fine catgut sutures. The other layers were also inverted and fastened by interrupted Lembert's stitches of silk."

In the second case (Figs. 280-282) when "the index finger was passed carefully through the neck of the pouch into the œsophagus a constriction (Fig. 280) lined with friable mucous membrane was found here. Passage of the finger through this constricted portion resulted in a longitudinal tear, which seemed to involve the greater part of the lining. The probang, after being passed by this constriction, could at one time be passed into the stomach; at another it could not. The œsophagus just below the opening of the pouch had the diameter of a lead pencil; externally, from the diverticulum to as far as the dissection extended, it was perfectly normal. Although the mucous membrane seemed normal, it was not, for it gave way under the gentlest pressure of the finger. There was constriction at

Fig. 281. The pouch and œsophagus after the incision. (M. R. Richardson.)

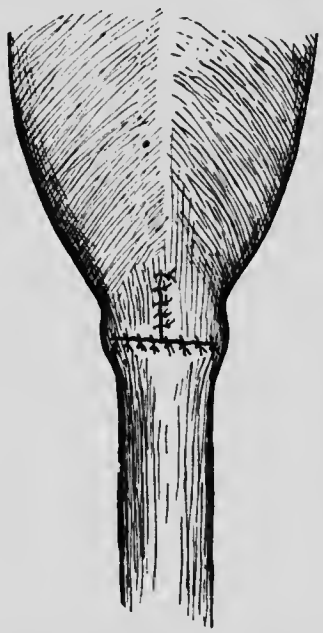


Fig. 282. The condition of the parts after vertical suturing of the pouch and transverse suturing of the œsophagus. (M. R. Richardson.)

that place, caused either by real pathological changes or disuse. The tear in the œsophagus was converted into a longitudinal slit by extending the incision downwards in the posterior wall through the lower border of the isthmus of the sac, and through the constriction (Figs. 280-281). Fearing the formation of a permanent organic constriction at the site of the laceration, a portion of the pouch was utilised to enlarge the diameter of the contracted œsophagus. To accomplish this end a considerable circular margin was left about the opening of the sac (Fig. 280). The lower portion of the margin was brought downward and placed in the gap made by the divided posterior surface of the narrowed œsophagus. The effect of this procedure was to increase the lumen of the œsophagus by the small area of tissue taken from the pouch (Fig. 281). The subsequent effect of this plastic operation showed its advantage, for at no time was there the least obstruction to the passage of the probang into the stomach. After making as good a joint as possible at the beginning of the œsophagus, I closed the mouth of the pouch by inverting the margins remaining after excision, uniting them by interrupted Lembert sutures." As was expected, leakage took place, the wound giving escape to about half the quantities swallowed. The wound ultimately closed entirely, the patient regaining normal deglutition and perfect health.

Owing to the very great risk of leakage, some form of drainage must be provided in every case where a diverticulum has been removed.

Either a drainage-tube or gauze wicks, or both, or gauze packing must be employed. Only the two ends of the wound are to be closed, though salmon-gut sutures of reserve may be placed in the rest of the wound, to be tightened when the necessity for drainage has ceased, as the wound is sometimes very slow in closing.

Sir H. Butlin's advice [1] on the closure of the wound and the after-treatment is as follows: "The less the tissues below the pouch are disturbed, the better. If they are widely opened up, there is a liability to septic inflammation spreading down into the posterior mediastinum. No attempt should be made to close the external wound, however carefully the opening of the neck of the pouch has been stitched up. It should be drained by a soft tube. On the other hand, it is very desirable to close the opening into the œsophagus, for, although the stitches always give way at the end of three or four days, the surrounding tissues are by this time sufficiently recovered to render the risk of spreading septic inflammation much less probable. If the pouch is of long standing, and if it is of large size, a soft tube should be passed into the stomach and retained as long as is necessary for feeding. If the patient cannot or will not permit this, or vomits the tube, it must be passed over a guide every time food is taken, otherwise almost all the food will pass out through the wound in the neck. If this cannot be done, a tube should be introduced into the stomach through the wound in the neck, and retained there until healing is nearly accomplished."

[1] *Brit. Med. Journ.*, July 11, 1903.

CHAPTER XXXII

OPERATIONS ON THE SPINAL ACCESSORY, UPPER CERVICAL NERVES, AND SYMPATHETIC

PARTIAL NEURECTOMY, OR NERVE-STRETCHING

Indications. In cases of spasmodic torticollis in which: (1) All previous palliative treatment has failed, *e.g.* large doses of conium, massage, galvanism of the affected side, and faradisation of the opposite muscles. (2) The spasms so severe and constant as to interfere with the patient's taking food or enjoying sleep and to cause real suffering. (3) The only muscles affected are the sterno-mastoid, or the sterno-mastoid and trapezius.

Anatomy of the Spinal Accessory Nerve. The relations of this nerve are of very great importance, as it is frequently exposed and may easily be accidentally divided in the removal of tuberculous glands and other deep-seated growths in the neck. The spinal or external part of this nerve, having left the skull by the jugular foramen, is directed backwards in front of, or behind, the internal jugular vein, and appears below the digastric and the occipital artery (Fig. 161). In this part of its course it passes in front of and then turns backwards below the transverse process of the atlas: This is the surest anatomical guide to the position of the nerve. It then descends obliquely outwards to the sterno-mastoid muscle, and disappears under this at a distance of two inches from the apex of the mastoid process. Having usually perforated the muscle, the nerve passes across the posterior triangle, to end in the deep surface of the trapezius. While passing through or under the sterno-mastoid the nerve communicates with branches from the second cervical. Having emerged from the muscle, it communicates with the second and third nerves, and is often in intimate connection with the great auricular and small occipital. When under the trapezius, it is joined by branches of the third and fourth cervical.

Operations for Partial Neurectomy. The nerve may be found by two different incisions.

A. Along the anterior border of the sterno-mastoid, so as to come upon this nerve before it perforates this muscle.

B. Along the posterior border of the muscle; the surgeon finding the nerve as it emerges here to cross the posterior triangle to gain the trapezius, and following it up to a point above its branches to the sterno-mastoid, so as to paralyse this muscle also. The first of these operations is much preferable, and for these reasons:

(1) Though the nerve lies more deeply at the anterior than at the posterior border of the muscle, it is here a single nerve, and not likely to be confounded with other nerves, *e.g.* branches of the second and third cervical which also emerge at the posterior border to supply the skin. Furthermore, in this latter position the spinal accessory is often found

in close connection with the small occipital and great auricular, as these two nerves appear at the posterior border and curve upwards.

(2) By finding the nerve at the anterior border of the muscle, paralysis of the sterno-mastoid is better ensured. When the nerve is found at the posterior border and followed up into the muscle before division, there is always an uncertainty as to whether some branch to the muscle may not have come off above the point at which the surgeon has divided the nerve. And though the nerve is more superficial in the posterior triangle, it is difficult to make certain whether it is the spinal accessory or one of the superficial cervical nerves which emerge close to it from behind the muscle.

(3) The transverse process of the atlas is a sure guide to the nerve in this situation.

A. Operation in front of the Sterno-mastoid. The parts having been shaved and sterilised, and the head suitably raised and turned to the opposite side, the surgeon makes a free incision along the anterior border of the sterno-mastoid for three inches, commencing at the apex of the mastoid process and ending about two inches below the angle of the jaw. Skin, fasciæ, and platysma being divided, the anterior border of the sterno-mastoid is clearly defined, and drawn strongly backwards so as to put the nerve on the stretch. In doing this the posterior and lower part of the parotid may have to be drawn forward if this gland overlap the muscle. The wound being then thoroughly dried, the operator searches for the nerve with a director in the fatty connective tissue which lies between the muscle and the carotid sheath. If, in doing this, he keep for his landmark the angle of the jaw, he is almost certain to be on a level with the point where the nerve enters the muscle. If this landmark fail him, he should define the lower border of the digastric, and, tracing upwards the posterior belly of this muscle, feel for the transverse process of the atlas, between the front of which process and the posterior belly of the digastric the nerve emerges to pass backwards to the sterno-mastoid. The small branch from the occipital artery which accompanies the nerve will give no trouble; and if in the deeper parts of the wound only a director or a blunt dissector be used, neither the occipital artery nor the internal jugular vein will be injured. A full inch of the nerve should be removed.

B. Operation below or at the Posterior Border of the Sterno-mastoid. To find the nerve in this situation an incision should be made two inches long, along the posterior border of the sterno-mastoid, the centre of the incision corresponding to about the centre of this border of the muscle. The fascia being slit up to the same extent, the trapezial branch of the nerve is sought for as it emerges from the sterno-mastoid to cross the posterior triangle. It will be found a little above the centre of the wound, and should be traced through the muscle till the common trunk is discovered above its division into branches for the trapezius and sterno-mastoid. Half an inch of the nerve should then be cut out.

Mr. Jacobson has operated on the following three cases:

In the first, in 1878, the nerve was found in the posterior triangle, and after tracing it upwards a portion of the common trunk was removed in the substance of the sterno-mastoid. In the second case, in 1894, the nerve was found at the anterior border of the muscle, the angle of the jaw being taken as a guide. Both patients were middle-aged women, the subjects of severe spasmodic torticollis. In each case some of the deep cervical muscles supplied by the upper cervical nerves were affected, and in neither was the result satisfactory. In the first no permanent benefit can

be said to have resulted. In the second the relief was considerable, and the patient has hitherto declined further operation in the form of division of the posterior branches of the cervical nerves. Atrophy of the sterno-mastoids followed in each case.

In the third case, as both sterno-mastoids were affected, excision of part of each spinal accessory was performed above the sterno-mastoid. While the muscle on the left side remained paralysed, the right contracted afterwards as vigorously as before. There was no doubt whatever that the nerve had been found and part removed, for it was absolutely quiescent for three weeks after the operation. Whether the return to activity was due to reunion taking place, or to the additional nerve-supply from the second cervical, must remain doubtful. The same result has occurred to Mr. Harsant, surgeon to the Bristol Royal Infirmary.[1] This case, of twenty years' duration, was rendered further unfavourable by the number of muscles involved. Thus, when the head was fixed by the sterno-mastoids and trapezii in rigid spasm, the platysma, occipito-frontalis, and orbicularis palpebrarum were also in violent action, the arms were rigid, and the abdominal recti were powerfully contracted. Though on each side three-quarters of an inch of the spinal accessories were removed, it is stated that some weeks later "there was no actual paralysis of either sterno-mastoid or trapezius, which all appeared to contract violently at times."

There is no comparison between the two methods, that in which the nerve is found at the anterior border of the muscle being infinitely easier and more satisfactory.

A very interesting contribution to the literature of this subject is a paper by Mr. Ballance.[2]

His patient, a woman of 48, was a good instance of the distress and misery due to spasmodic torticollis. Division of the right spinal accessory in the anterior triangle gave most decided relief. At the end of four months, when the history ceases, the patient is reported to have been "much better and stouter. The face is happy and tranquil. There is neither headache nor pain, and sleep and appetite are good. The control of the movements of the head is perfect as long as she is not excited, and so long as the head is not raised so that the eyes are directed much above the horizontal plane in which they lie. . . . The right sterno-mastoid and trapezius are atrophied."

Division of the spinal accessory deserves a further trial, even if the relief given be not permanent. No serious loss of function occurs after division of the nerve. Though there is some dropping of the shoulder and atrophy of the trapezius the arm can still be raised and the head rotated.

The chief fear is that other muscles are or will become involved, as in the cases previously described. Thus, Mr. Ballance writes of his patient: "Since the operation, it has been certain that some of the muscles supplied by the upper spinal nerves are liable to spasm. It would be strange if it were not so, considering the intimate connections between the second, third, and fourth spinal nerves and the spinal accessory, in the sterno-mastoid, trapezius, and posterior triangle, together with the fact that some of the fibres of the spinal accessory are connected with the same cells, or with cells in the immediate neighbourhood of those from which arise the motor rootlets of the cervical spinal nerves."

The following conclusions may be drawn with regard to the operative treatment of spasmodic torticollis: (1) Palliative treatment will be of little permanent value, and the earlier surgery is resorted to the better the outlook. (2) The most common combination of spasm is that involving the sterno-mastoid on one side and the posterior rotators on the other, the

[1] *Bristol Med.-Chir. Journ.*, 1896.

[2] *St. Thomas's Hospital Reports*, vol. xiv. p. 95. Other successful cases will be found recorded by Prof. Annandale (*Lancet*, 1897, vol. i. p. 555) and by Mr. Southam, *ibid.*, 1881, vol. ii. p. 369).

head being held in the position of sterno-mastoid spasm with the addition of retraction through the greater power of the posterior rotatory.[1]

(3) Operation on the spinal accessory may afford relief, even if other muscles than the sterno-mastoid are affected. On the other hand, the affection previously limited to the sterno-mastoid may spread to other muscles in spite of this operation.[2] (4) No fear of disabling paralysis need deter us from recommending operation, as the head can be held erect even after the most extensive resection.[2] (5) It is clear from Mr. Harsant's cases as well as the others already mentioned that, after undoubted resection of portion of the spinal accessory, spasmodic action of the sterno-mastoid may still persist. (6) The need of resorting to surgery early in these cases has already been pointed out. The disease will certainly spread from one muscle to another, from one group to another, the abnormal condition of one nerve-centre extending to other closely adjacent centres. Further, it is here as in traumatic epilepsy of any duration (p. 273); over-excitability of one or more nerve-centres becomes, if left too long, a permanently established condition, and with it over-activity of the muscles which are physiologically associated with those nerve-centres.

Treatment of Congenital Torticollis. Here the essential condition is a contraction of the sterno-mastoid, though in old-standing and advanced cases there will be also a secondary contraction of certain of the deep muscles of the neck. In early or slight cases treatment by manipulation or by mechanical means should be tried, and if there is any suspicion of congenital syphilis anti-syphilitic treatment should also be carried out. If these are not successful, or if the deformity is too advanced for them to offer any prospect of success, operative treatment is indicated. Either of the following operations may be employed:

(*a*) *Subcutaneous division of the Sterno-mastoid.* The muscle should be divided about an inch above the clavicle. The skin of the neck having been carefully sterilised, a sharp pointed tenotomy knife is introduced, from the outside if the right muscle is contracted and from the inside in the case of the left. The external jugular vein must be carefully avoided and the knife pushed deep to the muscle, which is now made tense by an assistant rotating the head. The knife is now turned so that the cutting edge is directed towards the skin, and the muscle is divided by a series of sawing movements.

(*b*) *Division of the Sterno-Mastoid through an Open Incision.* A transverse incision is made through the skin and fasciæ a short distance above the clavicle. The margins of the sterno-mastoid having been defined a director is passed beneath it and the muscle is completely cut across. Any further contracted bands of fascia are now felt for by the finger and are then divided. All vessels are then secured and the wound is closed.

The two Operations compared. The great advantage of the first method is the absence of any noticeable scar. Its chief disadvantage is that the whole of the contracted structures may not be divided. Thus contracted bands of fascia may very easily escape, and it is quite possible that the muscle may be transfixed by the knife so that its deeper fibres escape division. Another disadvantage is that the external jugular may be cut, or even the important structures beneath the sterno-mastoid may be damaged.

The great advantage of the open operation is that all contracted structures may be identified and then thoroughly divided. Vessels can be avoided, and any abnormal vein can be secured before being cut across. The only objection is the scar, but if primary union be secured, this should not be unsightly. On the whole, then, the open operation is to be recommended.

After-Treatment. After the operation the head should be fixed by a plaster of Paris case or other apparatus in a position of slight over-correction. This must be worn for three weeks; after this time the patient should wear a poroplastic collar, which, fitting comfortably over the shoulders and the upper part of the thorax, supports the head in the correct position. This apparatus, which should be removed daily for massage and manipulations, must be worn for some months.

[1] Dr. Maurice H. Richardson and Dr. G. L. Walton, *Amer. Journ. Med. Sci.*, 1895. No. cix, p. 27.

[2] *Ibid.*

Resection of some of the Branches of the Upper Cervical Nerves. In those cases of spasmodic torticollis where, after resection of part of one

FIG. 283. A, A, Trapezius. B, B, Sterno-mastoid. C, C, Splenius. D, D, L. anguli scapulæ. E, Complexus. F, Rhomboideus minor. *a*, *a*, Occipital arteries. *b*, Transverse or superficial cervical. *c*, Superficial cervical. *d*, *d*, Branches of deep cervical. *e*, Cutaneous branch of posterior auricular. 1, 1, Great occipital nerve. 2, Third cervical nerve. 3, Fourth cervical nerve. 4, Fifth cervical nerve. 5, 5, Small occipital nerve. (Godlee.)

spinal accessory, mischief still persists in muscles of the opposite side, this step has been practised by Mr. Noble Smith,[1] and by Prof. Keen,[2] and Prof. Krause for occipital neuralgia.[3]

[1] *Brit. Med. Journ.*, 1891, vol. i, p. 753.
[2] *Journ. Nerv. and Ment. Dis.*, December 1889.
[3] Von Bergmann's *Syst. Prac. Surg.*, American translation, vol. i, p. 579.

The following are the chief steps in the operation detailed by this authority :

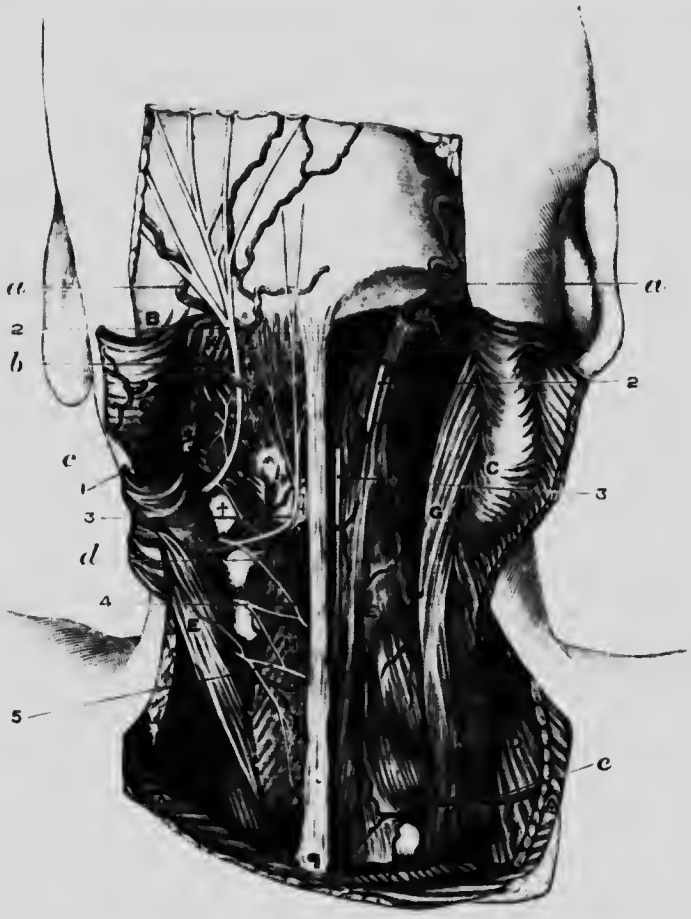


Fig. 284. A, A, Trapezius. B, Sterno-mastoid. C, C, Splenius. D, D, L, anguli scapulæ. E, E, Complexus. F, Rhomboideus minor. G, Trachelo-mastoid and transversalis cervicis. H, Semispinalis. I, Rectus C, posticus major. J, Rectus C, posticus minor. K, Obliquus superior. L, Obliquus inferior. *a, a*, Occipital artery. *b*, Princeps cervicis. *c*, Vertebral. *d*, Deep cervical. *e*, Superficial cervical. 1, Suboccipital nerve. 2, 2, Great occipital. 3, 3, Third cervical. 4, Fourth cervical. 5, Fifth cervical. * Transverse process of atlas. † Articular process of axis. ‡ Spinous process of axis. ¶ Sp. æ of seventh cervical. (Godlee.)

The incision through the thick skin begins at the occiput near the middle line and 3 cm. below the external occipital protuberance. Carried outwards and slightly downwards to a point 2 cm. from the tip of the mastoid, it now runs obliquely downwards and forwards to the posterior edge of the sterno-mastoid, and ends a little below the level of the hyoid bone. The greater part of the incision runs within the limits

of the hairy scalp. The great occipital nerve is found by dissecting the upper lip of the wound upwards. It comes through the upper lateral margin of the thin trapezius to enter the dense fatty tissue of this region along a horizontal line 2 cm. below the external occipital protuberance, and at a varying distance from the middle line. The trapezius must be divided or displaced inwards according to its development, the splenius and semispinalis also cut through transversely as far as is necessary to give access to the deeper parts. The nerve is followed to where it turns round, the inferior oblique where it is resected. Prof. Krause considers the existence of the third occipital constant. It lies along the inner side of the great occipital. It must be followed back through the semispinalis, over and below the inferior oblique to its exit between the second and third vertebræ. The small occipital and great auricular will be exposed by the above incision where they appear at the posterior edge of the sterno-mastoid, at about the level of the hyoid bone. In following them backwards towards the spinal column the sterno-mastoid is to be displaced forwards and the splenius and other muscles backwards. Care must be taken of the spinal accessory, which frequently communicates with the superficial cervical nerves. The most troublesome bleeding will be met with in the deeper part of the wound, and is only to be controlled by compression. Thiersch's method of avulsion (p. 364) is not to be employed here owing to the proximity of a very important part of the spinal cord, and the fact that the phrenic may arise in part from the third nerve. An electric head light will be found helpful in dealing with the deeper part of the wound. The divided muscles should be united by buried sutures. The wound should be drained. Figs. 283 and 284 illustrate the anatomy of this intricate region.

RESECTION OF THE CERVICAL SYMPATHETIC FOR EXOPHTHALMIC GOITRE, ETC.

Owing to the uncertainty of the results and the dangers accompanying partial thyroidectomy in exophthalmic goitre (p. 615), some surgeons in recent years, relying on the suggestion, originally put forward by Trousseau, that the three cardinal phenomena of the disease are due to some disturbance of the cervical sympathetic, have practised removal of these ganglia. This method of treatment does not appear to be based on sound foundations, or to be followed by good results with sufficient constancy to justify our resorting to it. Thus, even if morbid changes in the ganglia were constantly present in this disease (a postulate which cannot be conceded) any attempt to explain the three cardinal symptoms of exophthalmic goitre is unsatisfactory. Thus, while the exophthalmos and the goitre may be explained by paralysis, the third chief feature, the excited heart's action, means irritation, not paralysis, of the above ganglia. It must be remembered that the removal of the sympathetic chain, always a difficult operation, is rendered more so by the presence of the goitre, and the points which have been fully alluded to above, viz. the poor vitality of the patient, the risks of the anæsthetic, the dangers of thyroidism, have to be faced here also.

With regard to the results of this mode of treatment of exophthalmic goitre, they do not seem to be any more constantly beneficial than those following partial thyroidectomy, and this is especially the case with reference to those nervous symptoms which are so frequent and distressing a feature in this disease. Of this operation Mr. Berry [1] says, after considering published results: "These results do not seem to me very encouraging. I have never performed the operation myself, nor do I feel at all inclined to recommend it."

Jaboulay, who first gave prominence to it,[2] gives in the second paper eleven cases, and speaks of the operation as especially preferable to partial thyroidectomy in those cases in which the goitre is not a prominent feature. For Jaboulay's later results see Jaboulay and Chalier.[3]

[1] *Loc. supra cit.* [2] *Lyon Méd.*, February 7, 1897; *Presse Méd.*, February 12, 1898.
[3] *Lyon Méd.*, 1911, vol. cvi. p. 501.

B. Farquhar Curtis, of New York, discusses the various operations for exophthalmic goitre,[1] with special reference to the merits of thyroidectomy and sympathectomy. Having met with three deaths in eleven cases of thyroidectomy from acute thyroidism alone, without wound complications, and attracted by the results claimed by Jonnesco for complete bilateral removal of the cervical sympathetic, Dr. Curtis operated in seven cases, but, as there were two deaths from acute thyroidism, and one probably due to the anæsthetic, his results have not been better. While it is allowed that it was early to judge of final results, it is claimed that "three cases were cured, one improved, none unimproved." Three cases died. *Operation.* The following points are emphasised. The incision should be along the anterior border of the sterno-mastoid, the large vessels exposed and, with the goitre, displaced to the inner side, the sympathetic trunk exposed in the middle of the wound, and traced to the upper ganglion. The latter is isolated by forcible retraction of the upper angle of the wound in a good light, the nerve clamped just above the ganglion, and this body twisted out. The nerve is then followed down, and the second and third ganglia isolated and removed. The inferior thyroid artery, which may have nerve filaments in front of and behind it, may need ligature.

The second ganglion is often small or fused with the third. The third is often fused with the first dorsal, and will have to be separated with scissors or knife after blunt isolation. "I look upon this part of the operation as the most difficult, because of the depth of the ganglion and the proximity of important structures. The recognition of the nerve also presents serious difficulties in some cases. It is very variable in size and appearance. In any case it should be a cardinal rule not to inflict any damage upon a structure supposed to be the nerve until it has been proved to be the sympathetic by tracing it to either the upper or lower ganglion."

The bilateral removal of the sympathetic should be done in two stages, with an interval long enough to permit the patient to recover from the effects of the first operation. A trial should be given to local analgesia, but owing to the increased difficulties due to the presence of the goitre, the success of this is doubtful.

The other conditions for which removal of the cervical sympathetic has been chiefly practised are epilepsy and glaucoma.

With regard to epilepsy, Jonnesco claims a certain proportion of cures, but the interval that had elapsed is too short to allow of a judgment of any value as to the final results. According to Braun's more recent experience, the operation is negative. In the case of glaucoma, the results of Jonnesco, who first removed the cervical sympathetic in 1897, are given by Mr. Burghard.[2] Later results will be found much less favourable. Wilder, of Chicago, gives[3] a detailed report of seven cases of removal of the cervical sympathetic still under observation in his own practice, and adds briefly the results of operations by others on fifty-four cases. The results are not very encouraging. In certain of the cases in which improvement at first followed the operation, relapses are reported. The following sequelæ of the operation have been noticed: myosis, ptosis, congestion of conjunctiva, hoarseness or aphonia, dysphagia. Wilder is inclined to advise, "In acute glaucoma, and in the subacute with intermissions, practise first iridectomy, and if it fails, do sympathectomy. In simple glaucoma use myotics five times a day; if they suffice, continue them. If, in spite of their systematic employment, the vision fails, do sympathectomy."

An interesting paper by Mr. Burghard on excision of the superior cervical ganglion will be found in the *British Medical Journal*, vol. ii, 1900, October 20, p. 1175. The operation was performed on three occasions for very different conditions: in the first case, for the relief of subacute glaucoma; in the second, for the removal of an enlarged epitheliomatous gland adherent to the upper ganglion; and in the third, for a variety of false neuroma which had attacked the ganglion. Here the middle ganglion was removed as well. The operation was successful in the second and third cases, in the first no benefit followed.

Operations on the Brachial Plexus These have been chiefly performed in cases of laceration of the plexus, for compression by scars, exostoses, &c., and lastly in that form of birth-paralysis in which the muscles chiefly affected are the deltoid, biceps, and brachialis anticus. Surgery is not likely to be successful in curing a case

[1] *Trans. Amer. Surg. Assoc.*, 1903, p. 303.
[2] *Loc. infra cit.*
[3] *Journ. Amer. Med. Assoc.*, February 2, 1904.

of the first description where several of the lower cervical nerves have given way at the level of their spinal attachments. Mr. Thorburn [1] relates in detail a case of operation, performed about seven months after the injury, resulting in recovery of sensation and certain movements of the shoulder to an imperfect degree. As is so frequently the case in hospital practice, the patient took no pains to contribute her share of the after-treatment. Compression cases are, of course, more favourable. Dr. R. Kennedy, of Glasgow,[2] records a case of practically complete recovery after operation on a scar involving the plexus. He also deals here with the subject of birth-paralysis alluded to above. Three cases of operation for this condition are given. In one, in which sufficient time had elapsed, the result was most satisfactory, flexion of the forearm and abduction of the shoulder being regained.

Mr. Tubby [3] has proved that in some of these cases of paralysis of the upper root of the brachial plexus dating to birth, muscle-grafting may be employed with benefit. To remedy the inability to flex the elbow, the triceps is exposed by a long incision at the back of the arm much as for the musculospiral nerve (p. 185), and brought forward below. The nerve having been found and drawn aside, the outer head of the triceps is detached from the tendon above the olecranon and stripped upwards for three or four inches. The biceps is next exposed and cleaned in its lower part. An aperture having been made in this muscle two inches above the elbow, the strip of triceps is drawn through from behind forwards and firmly pleated down (Fig. 18, p. 108). In two cases voluntary flexion of the elbow joint was obtained in four to six weeks.

To obtain abduction at the shoulder joint, part of the pectoralis major and trapezius were detached from the clavicle and united to each other and then attached to the deltoid or humerus. The result may be said to be promising.

[1] *Brit. Med. Journ.*, May 5, 1900.
[2] *Ibid.*, 1903, vol. i, p. 298.
[3] *Ibid.*, vol. ii, p. 975.

CHAPTER XXXIII

LIGATURE OF THE ARTERIES OF THE HEAD AND NECK[1]

LIGATURE OF THE TEMPORAL ARTERY

Indications. These are very few, viz.:

(1) Wounds, *e.g.* stabs and gunshot injuries.

(2) Aneurysm, usually traumatic. These are by no means uncommon and should, as a rule, be treated by excision.

Guide. A line drawn upwards over the root of the zygoma, midway between the condyle of the jaw and the tragus.

Relations. Given off behind the jaw, this vessel passes up, midway above the two points, over the zygoma, and at a point 1½ or 2 inches higher up it divides into its anterior and posterior branches. Lying at first in the parotid gland, it is covered a little higher up by a dense fascia passing from the parotid to the ear, by the attrahens aurem, often a lymphatic gland, and one or two veins which lie superficial but close to it. Some branches of the facial nerve cross it, while the auriculo-temporal nerve accompanies it closely. Higher up the artery and its branches are subcutaneous.

Operation. The parts having been shaved and sterilised, the head fitly supported and turned to the opposite side, an incision about one inch long is made in the line of the artery so as to expose it just above the zygoma. The dense subcutaneous tissue and the strong parotid fascia being clearly divided, the artery must be accurately defined, and the vein being drawn to one side, usually backwards, the ligature should be passed from behind forwards, care being taken to include only the artery.

Arteriotomy. A few words may be said here about this obsolete operation. The surgeon having defined the anterior division of the temporal, steadies the vessel by placing his finger just beyond the point which he intends to open, and then with a small sharp scalpel lays open the vessel till it is about half cut through. The blood required having been removed, he divides the vessel completely, so as to allow the ends to retract, applies a pad of sterilised gauze, and retains this in position with the twisted or knotted bandage for the head. The pad should not be removed for four or five days.

LIGATURE OF THE FACIAL ARTERY

Indications. These are much the same as, but still fewer than, those for ligature of the temporal artery.[2] Ligature of the artery is often required in the course of operation in the submaxillary region, *e.g.* removal of malignant glands. The vessel's course is divided into a cervical and a facial part.

[1] Ligature of the thyroid arteries has already been considered (p. 630).

[2] The reader is advised to take every opportunity afforded upon the dead body to tie these and other arteries, though apparently so small and unimportant, as only by such practice can dexterity be really acquired.

Cervical Part. The vessel is reached by an incision similar to that for the external carotid (p. 693) or the lingual (p. 674). In either of these cases it would be found just below the posterior belly of the digastric and the stylo-hyoid, these muscles being drawn upwards to enable the surgeon to ligature the vessel just before it enters the submaxillary gland.

Relations in the Neck. The facial artery is given off just above or in connection with the lingual, about an inch above the bifurcation of the common carotid. It passes upwards and inwards to the lower jaw, being covered by skin, fascia and platysma, the digastric and stylo-hyoid, and embedded in the submaxillary gland, to which structure the vein lies superficial. The tortuous outline of the vessel is well known. The vein, running a straighter course, lies posterior to the artery.

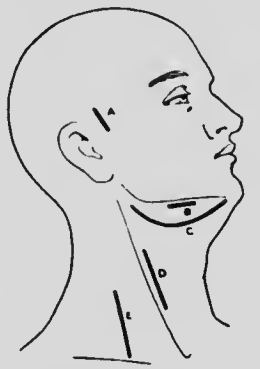


FIG. 285. A, Incision for ligature of the superficial temporal. B, Incision for ligature of the facial. C, Incision for ligature of the lingual. D, Incision for ligature of the common carotid. E, Incision for ligature of the vertebral or the inferior thyroid.

Facial Part. The artery is readily secured by a small horizontal incision just below the jaw in front of the masseter muscle, the anterior border of which should be first defined, this being easily done on the living subject by telling the patient to throw it into action. The incision should be made carefully, so as to avoid any branches of the facial nerve which may lie in the way. The artery will now be felt when rolled upon the bone by a finger. The ligature should be passed from behind forwards so as to avoid the adjacent vein.

LIGATURE OF THE OCCIPITAL ARTERY

Indications. (1) Stabs. (2) Gunshot wounds. (3) In the treatment of arterial varix, cirsoid aneurysm, or aneurysm by anastomosis on the head (p. 690). (4) For hæmorrhage from an abscess in the neck. Sir W. Mitchell Banks [1] published a most instructive case:

A weakly man, aged 32, had had a suppurating gland incised three weeks before admission. Poultices were applied, and a week after, during a violent attack of coughing, blood burst from the wound "like a tap being turned on." Three times afterwards hæmorrhage ensued, pressure being applied in vain. On admission he was in the last stage of exhaustion. The right side of the neck from ear to clavicle was occupied by a great fluctuating swelling. In front of the sterno-mastoid, about half way down, was the original incision, from which a little sanious discharge was issuing. Behind the muscle a piece of skin about an inch square was actually sloughing from the subjacent pressure. Under ether, and in a good light, the original incision was enlarged upwards and downwards, and a quantity of putrid broken-down clot turned out. Then a similar incision was made behind the sterno-mastoid through the sloughing skin. Everything being mopped and cleaned up, blood was found to be trickling down from somewhere very high up. To get at it, the sterno-mastoid and skin over it were cut clean across, thus uniting the two vertical incisions by a transverse one. The muscle was dissected upwards, exposing the sheath of the carotid vessels, but still the blood always kept running from some deep-seated point high up. At last this was reached, just in front of the transverse process of the atlas. From it arterial blood issued, and an aneurysm-needle was thrust through the tissues on each side of it and ligatures applied, which at once checked all further bleeding. The vessel was the occipital artery not far from its

[1] *Clinical Notes upon Two Years Work at the Liverpool Royal Infirmary*, p. 161.

origin. Into it the abscess had made its way. The patient was very near to death's door, but ultimately recovered.

Relations. A posterior branch of the external carotid, the occipital comes off opposite to or a little above the facial just below the digastric. It at first ascends, having the hypoglossal nerve hooking round it, under the digastric, stylo-hyoid, and parotid, and crossing the internal carotid, internal jugular, vagus, and spinal accessory. Having reached the interval between the transverse process of the atlas and the mastoid process, it now, in the second part of its course, turns horizontally backwards, grooving the mastoid portion of the temporal bone, covered by the sterno-mastoid, splenius, digastric, and trachelo-mastoid, and lying on the complexus and superior oblique. In the third part of its course it runs vertically upwards, piercing the trapezius, and ascending tortuously in the scalp.

Operations. (1) If the artery require securing low down, this may be effected much as in tying the external carotid, an incision being made along the anterior border of the sterno-mastoid, the deep fascia opened, and the digastric and hypoglossal nerve exposed.

(2) To tie the artery behind the mastoid process, *e.g.* when it has been wounded by a stab in the neck, the following steps should be taken: The parts being sterilised and the head at first being placed in much the same position as for ligature of the carotids, an incision is made from the tip of the mastoid process rather obliquely upwards, so as to lie over a point midway between the mastoid and the external occipital protuberance. The tough skin and fascia being incised, the sterno-mastoid, in part at least, with its strong aponeurosis, and next the splenius capitis, must be divided, together with any fibres of the trachelo-mastoid that are in the way. The wound being somewhat relaxed by turning the head over to this side, retractors deeply inserted, and an electric lamp used if needful, the artery will be found deep down between the mastoid process and the transverse process of the atlas. In separating it from its vein, one or more veins varying in size may be met with, forming communications between the occipital and mastoid veins, and thus with the lateral sinus. The wound should therefore be kept rigidly aseptic.

LIGATURE OF THE LINGUAL ARTERY (Fig. 286)

Indications. (1) Before the removal of the tongue. This subject has been considered at p. 535. (2) After removal of the tongue, to arrest hæmorrhage. (3) In cases of tongue cancer not admitting of operation, in the hope of checking the rate of growth, diminishing the fœtor, profuse salivation, &c. This step is uncertain as to the amount of good which it effects, and any good that it may do will not be long-lived. (4) In cases of macroglossia this operation may be tried before removing a wedge-shaped piece of the tongue; it would require to be performed on both sides, and would be attended with considerable difficulty in a child. It might do too much.

Relations. The lingual artery arises about a quarter of an inch above the superior thyroid, often in common with the facial, and at a point opposite to the great cornu of the hyoid bone. It first ascends to a point rather above the level of the hyoid bone, then descends somewhat and runs just above the great cornu, and finally, ascending to the under surface of the tongue, it runs forwards with a tortuous course to the tip as the ranine.

For practical purposes the relations of the artery may be subdivided into *three parts*—the *first*, before it gets under the hyoglossus; the *second*, while it lies beneath this muscle; and the *third*, beyond this muscle.

In the first, it runs very deeply, though only covered by the skin, platysma, and fascia, facial, lingual, and some pharyngeal veins; it lies upon the middle constrictor and the external laryngeal nerve.

In the second part of its course the artery again lies upon the middle constrictor, and is now covered by the hyoglossus, hypoglossal, part

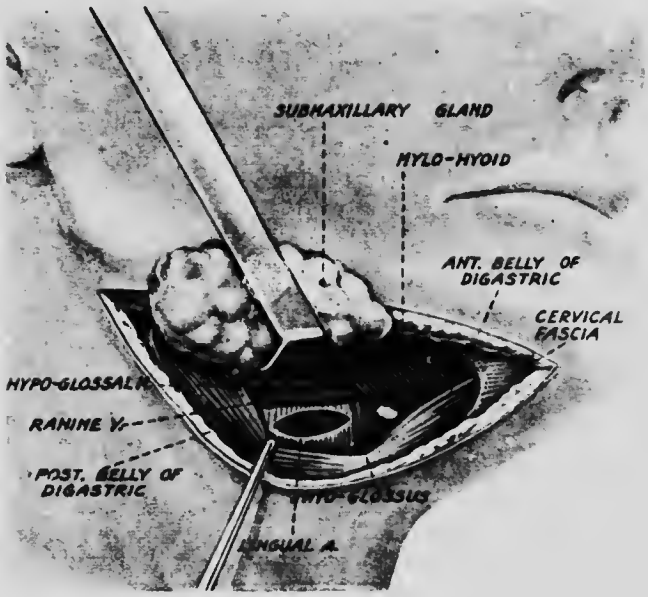


Fig. 286. Ligature of the lingual artery.

of the mylo-hyoid, and the lower border of the submaxillary gland. From this part come off the four branches of the artery—the hyoid at the outer or posterior edge of the hyoglossus, the dorsalis linguæ under this muscle, and the sublingual and ranine at its anterior border, thus allowing room for placing a ligature.

The third part lies in the mouth and runs along the under surface of the tongue up to the point of the frenum. It is only covered by mucous membrane. A vein runs with it, and a large branch of the gustatory nerve.

Operations. (i) *Ligature under the Hyoglossus.* (ii) *Ligature of the First Part of the Artery.*

(i) The vessel is usually tied while *under the hyoglossus muscle*, owing to the useful guide which the great cornu of the hyoid bone forms, and this is the operation which will be described here (Fig. 286). If tied as a preliminary to removal of the tongue (p. 535), the ligature may be applied close to its origin by an incision similar to that for the external carotid (p. 693), so as to make sure of getting behind the dorsalis linguæ. The parts being sterilised, the head suitably supported and turned to the opposite side, and the lower jaw firmly closed, the surgeon, standing or

seated on the same side, steadies the tissues between his left finger and thumb, and makes a curved incision with its centre just above the great cornu of the hyoid bone (a point previously carefully noted), and reaching, *e.g.* on the left side, from just below and to the left of the symphysis downwards, backwards, and then upwards towards the angle of the jaw, ending just anteriorly to the line of the facial artery.

The incision divides skin, superficial fascia, and platysma; the deep fascia is then opened, and any branches of the anterior jugular, facial, or communicating branch with the temporo-maxillary vein are secured carefully so that the wound may be kept as dry as possible. The lower border of the submaxillary gland, which probably projects into the wound, is turned upwards[1] and the hypoglossal nerve sought for, which lies deeper, and is a good guide to the hyoglossus. Lower down in the neck is the glistening tendon of the digastric attached to the hyoid bone. The hyoglossus being defined, the hyoid bone is carefully steadied by the finger-nail or tenaculum, a director passed under the hyoglossus, and this muscle divided cautiously. In doing this the lingual vein must be carefully looked for either on the muscle or beneath it, with the artery. The artery having been found under the muscle just above the hyoid bone, it should be traced backwards, so as to apply, if possible, the ligature behind the origin of the dorsalis linguæ.

All oozing must be checked before the wound is closed.

Guides and Aids to finding the Artery. (1) A sufficiently free incision. (2) Carefully defining the hypoglossal nerve, and remembering the relative position of the submaxillary gland, the digastric tendon, and the great cornu of the hyoid bone. (3) Keeping the wound bloodless. (4) Incising the hyoglossus between the great cornu of the hyoid and where the hypoglossal nerve crosses it.

Difficulties. (1) Matting of the parts from old cellulitis. (2) Presence of large veins. (3) Depth of the wound, and oozing low down from the severed hyoglossus. (4) In one case Dr. Shepherd[2] found the digastric so extensively tied down to the hyoid bone by the deep cervical fascia as to require separation. (5) The position and condition of the lingual vein alike are at times perplexing. Usually two small venæ comites accompany the artery, while the main vein lies on the hyoglossus; occasionally it lies under it, with its artery. Billroth,[3] who has tied the lingual artery twenty-seven times, tied the vein for the artery in one case, as was verified at the necropsy. "Every surgeon knows the difficulty of tying the lingual artery in old people; the vessel lies so deep that it is very difficult to distinguish it from the thick-coated distended veins, especially when, owing to heart disease—as in this case—the veins pulsate. Never previously had I met with a lingual vein of such thickness." (6) Abnormal position of the lingual artery itself. This is rare, but the artery may lie higher than usual; it may pierce the hyoglossus: occasionally one lingual is minute or absent. (7) The submaxillary gland may be unusually large and occupy much of the space between the jaw and the hyoid bone.

(ii) If the vessel cannot be found beneath the hyoglossus, or if the condition of the soft parts is such, owing to cellulitis matting or enlargement

[1] The submaxillary gland should be gently handled, and not cut into. Otherwise in the one case troublesome swelling, in the other temporary weeping of saliva, or even a fistula, will be the result.

[2] *Ann. of Surg.*, vol. 5, No 11, p. 359.

[3] *Clinical Surgery*, p. 113.

of glands, as to prevent any attempt being made here, the surgeon must cut down upon the *first part* either by an incision similar to the above but less curved, and running from the centre of the hyoid bone just above the great cornu to the anterior border of the sterno-mastoid, or by one similar to that used for ligature of the external carotid, with its centre opposite to the hyoid bone.

The difficulties are not great. It is only necessary to remember that: (1) The artery itself is not constant in position here, varieties occurring frequently in the height at which it comes off from the external carotid, whether above, or in common with the facial. (2) Large veins, *e.g.* the lingual and facial, will certainly be present.

LIGATURE OF THE COMMON CAROTID (Figs. 285, 287)

Indications. (1) *In Wounds of the Trunk itself.* Owing to the rapidly fatal issue of such injuries, the surgeon is not often called upon to meet them. Cases indicating ligature for wounds of the trunk may be grouped as follows: (*a*) for immediate hæmorrhage; (*b*) for secondary hæmorrhage; (*c*) for gunshot injuries.

(*a*) *For Immediate Hæmorrhage.* Ligature of the common trunk is here rarely called for, as above stated. In civil practice such cases may occasionally occur in cut-throat. If the surgeon arrive in time, he should arrest the hæmorrhage, while waiting for assistance, by thrusting one or more fingers into the wound, and making pressure on the bleeding-point, remembering that but slight force is required if the pressure is on the right spot. If the patient has to be removed any distance, finger pressure must be kept up, or the wound plugged with a sterilised sponge or aseptic gauze, and the head kept rigidly still. Pressure with a finger or with a sponge on a bobbin should be kept up on the bleeding-point while the wound is enlarged, and the opening in the carotid secured by ligature placed above and below it.

(*b*) *For Secondary Hæmorrhage.* A remarkable instance of punctured wound of the common carotid in which the vessel was tied for secondary hæmorrhage, in the pre-Listerian era, is thus recorded by Mr. Durham[1]:

A child, aged 9, was wounded with glass, owing to an explosion of hydrogen gas. When admitted into Guy's Hospital, under the care of Mr. Hilton, the child was cold and blanched, but the bleeding, which had been profuse, had entirely ceased. There was a wound about an inch long "in the left carotid region." On the eighth day after the accident hæmorrhage recurred, and the common carotid tied. Nine days later slight bleeding took place, but was arrested by plugging the wound with a sponge. Repeated epistaxis occurred, which weakened the child perceptibly. The sloughs became very offensive, but there was no further bleeding from the wound for eighteen days, when a considerable quantity was lost.

At the necropsy the common carotid was found to have been traversed by a sharp-pointed fragment. Behind the wounded vessel was an abscess implicating the sympathetic. Mr. Durham thought that if a ligature had been applied on the distal as well as on the proximal side the child's life would have been saved.

Another case of secondary hæmorrhage has been recorded by Mr. Rivington.[2] It is an excellent instance of the way in which the carotid may, at any time, be wounded from within, and not from outside, by a foreign body penetrating the pharynx.

A boy, aged 9, six days after swallowing a small plaice-bone, was admitted to the London Hospital with stiffness and tenderness of the neck, a small tender lump

[1] *System of Surgery*, vol. i, p. 739.
[2] *Trans. Med.-Chir. Soc.*, vol. lxix, p. 63.

on the left side[1] opposite to the cricoid cartilage, profuse salivation and inability to swallow solid food. On the ninth and eleventh day hæmorrhage took place, on the latter occasion to the amount of half a pint. The following account of the operation by which the injured vessel was found and secured will be most instructive to every operating surgeon, owing to the difficulties which presented themselves. An incision was made along the edge of the sterno-mastoid for several inches. The muscle was found glued to the subjacent parts by recent adhesions. Above the anterior belly of the omo-hyoid was a dark patch about the size of a fourpenny piece, caused by extravasated blood looming through the fascia. The fascia over

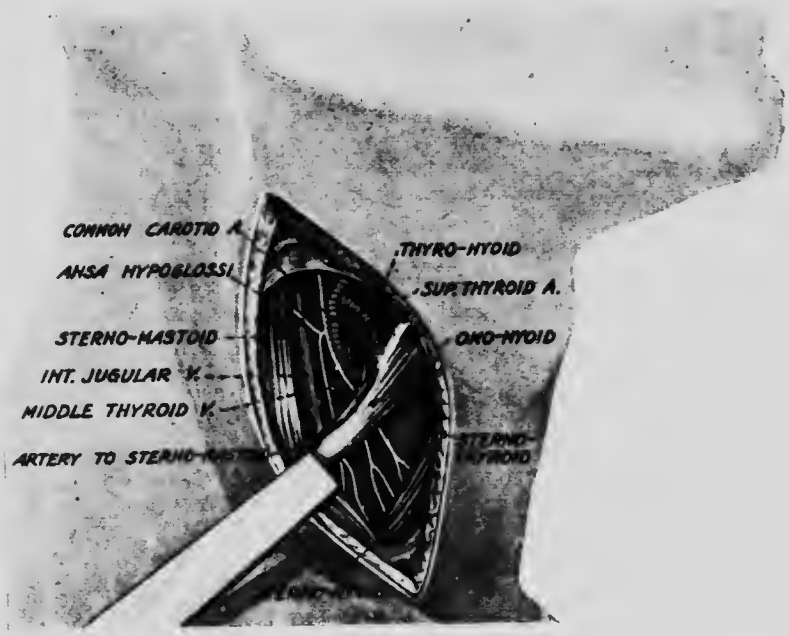


FIG. 287. Surgical anatomy of the common carotid.

the large vessels being divided, a probe was passed down into a cavity containing clot hollowed out behind the vessels and on the inner side. Owing to the uniform discoloration of artery, vein, nerves, fascia, and areolar tissue by the extravasated blood, the structures met with being all dark and equally stained, could scarcely be recognised. The descendens hypoglossi could not be seen, nor the vagus distinguished, though carefully looked for. More clots being turned out from the cavity, in one of these the fish-bone was found. A gush of blood which took place, evidently from the distal end, was arrested partly by pressure and partly by pulling forward the vessels with a blunt hook. The wounded vessel being found, a ligature was passed closely, as it was thought, around it, both above and below the seat of injury. Owing to the danger of subjecting the patient to a further loss of blood, there was no time to make a prolonged dissection, and it was thought prudent to divide the artery at the seat of the wound to make sure that no branch was given off between the ligatures. No evidence of ill effects from the divided vagus, save perhaps slight cough and difficulty in swallowing, had been noticed during life. The patient died ten days after the operation, and at the necropsy it was found that the vagus had been divided. Two gangrenous abscesses in the left half of the brain, which were probably already in progress prior to the operation, were the cause of death.

[1] The left common carotid is more exposed to danger in these cases from the passing of the œsophagus somewhat to this side.

(c) *Division of the Common Carotid* by gunshot injuries is usually fatal at once.

(2) *In Aneurysm of the Carotid.*. When an undoubted aneurysm of this vessel exists, and is increasing in spite of pressure,[1] or where this cannot be made use of, the artery should be tied, on the cardiac side of the aneurysm if possible, or, failing this, distally.

The "old" operation for aneurysm is described at p. 195. Matas's operation is described at p. 53.

Dr. Mendes, of Bahia, advocates [2] extirpation of ordinary aneurysm of the common carotid, and records two cases in which this step was successful. In neither case is the report as full and precise as is usually the case with French surgeons.

The patients were 62 and 64. In the first the history was one of sixteen months. The aneurysm was as large as a mandarin, its upper limit apparently blending with the parotid. An incision having been made from the lobule of the ear to just above the clavicle, a preliminary ligature was placed around the lower part of the artery. The vagus was separated with difficulty from the sac. In the attempt to get above the upper extremity of the sac, which reached as high as the mastoid and appeared to enter the skull, a tear was made in the sac leading to profuse haemorrhage, stopped at once by tightening the preliminary ligature. The account of the steps taken at this critical stage is brief and very obscure. A ligature was thrown round the upper part of the sac, and this was cut through two centimetres below the ligature. The cut end was then closed by sutures. The sac must either have collapsed, or forcipressure must have been employed. The rest of the sac and the vessel down to the first ligature were then, presumably, removed. But no details are given on this point, nor whether the internal carotid was involved. The patient recovered and was well fourteen months later.

In the second case, which was of eleven months duration, the swelling, the size of a fist, occupied the upper two-thirds of the carotid region. The common carotid was tied low down and divided between the ligature and a pair of forceps. A tear made in the internal jugular vein during the separation of the sac was sutured. Great difficulty was met with in getting above the upper end of the sac, which was intimately blended with the parotid. It is to be gathered that a ligature was finally placed above the sac, which reached, in this case also, as high as the mastoid. Here, again, no details are given where they are most needed. The patient recovered.

(3) *In Aneurysm of the Innominate or Aortic Arch.* The question of the advisability of ligaturing the carotid, either together with the subclavian or alone, especially in the case of the left common carotid, is considered in the treatment of thoracic aneurysm (p. 723).

(4) *In Orbital Aneurysm*, where the symptoms are becoming aggravated, or where pressure has failed, or where it cannot be endured, even intermittently, for a few minutes only at a time, and where galvanopuncture and injection of coagulating fluids are set aside owing to their uncertainty and riskiness. It would probably be well to tie and resect any especially enlarged veins at the inner angle of the orbit at the same time (*vide infra*).

Of fifty-three cases,[3] viz. twenty-one idiopathic and thirty-two

[1] This may be applied to the artery, or the sac, or both. In the former case the artery should be compressed above the transverse process of the sixth cervical vertebra, to avoid making pressure on the vertebral at the same time. If pain, vertigo, sickness, &c., prevent a fair trial of digital pressure, an anæsthetic may be tried, but as Mr. Barwell points out (*Encycl. of Surg.*, vol. iii. p. 498), there may be much difficulty in deciding how far the syncope, &c., which may be present, are due to the anæsthetic or to the pressure. Another means of keeping up pressure on the common carotid is that suggested by Ronge, in which the sterno-mastoid being relaxed, the surgeon insinuates his fingers behind one border and his thumb behind the other border of the muscle, and thus compresses the artery between them.

[2] *Rev. de Chir.*, April 1905.

[3] Rivington, *Dict. of Surg.*, vol. ii. p. 131.

traumatic, in which the common carotid was tied, thirteen of the former were cured and seventeen of the latter. The above writer, speaking of this mode of treatment, says it is "at present the most successful and satisfactory means of treating orbital aneurysm. It should not be practised on patients advanced in years, or on those with heart disease, or with evident atheromatous degeneration of the arteries." The latter statistics of Bodon, quoted by Dr. Murray,[1] confirm the success of ligature of the common carotid in this disease if the arteries are healthy. He collected in 1899 fifty-eight cases of traumatic exophthalmos treated by ligature of the common carotid. Twenty-six were cured, twenty improved, six were not improved, and six died chiefly from infective causes and haemorrhage, conditions less likely to occur at the present time. Bodon also collected six cases in which both common carotids were tied without any deaths, and, with one exception, with cure or improvement.

Dr. W. F. Murray reports a case with many points of interest.[2] Thus, while the blow had been on the left side of the head, it is probable that both internal carotids had been ruptured, as the exophthalmos, &c., were marked on both sides. The left common carotid was tied three months after the injury, a step followed by great relief on both sides. A year and a half later the exophthalmos had reappeared, being most marked on the left side; the subconjunctival veins were engorged, and the supra-orbital vein was much enlarged. Pulsation had returned in the external carotid and superior thyroid arteries. Dr. Murray considered that this indicated complete return of the collateral circulation and increase in the pressure in the cavernous sinuses, and that it would have been wiser to tie the internal carotid. As in two cases of reappearance of the trouble resection of the branches of the veins at the inner angle of the orbit has been most successful, this step was advised, but declined by the patient.

(5) *In Aneurysms of the External or Internal Carotid.* These are very rare. Two cases of aneurysm of the former vessel have been published in recent years:

Sir H. Morris[3] recorded one in which, after failure of ligature of the common carotid, the old operation of incising the sac was performed, and ligatures placed on the facial and lingual arteries, and upon the main trunk of the external carotid above the sac, with ultimate recovery.

The second case was published by Mr. Heath[4] in order to prove that ligature of the common carotid alone is sufficient to cure some cases of aneurysm of the external carotid.

The occurrence of aneurysm here in a woman, aged 23, was accounted for by the state of the cardiac valves and the liability for embolism to occur in consequence of detachment of a vegetation. There was a smooth, round, pulsating swelling just below the right mastoid process, reaching down to about the level of the upper border of the thyroid cartilage. It had the size and shape of half a small orange. The right tonsil was somewhat pushed inwards, the right temporal pulse was markedly weaker than the left, and the tongue deviated much to the right, the right half being a good deal wasted. The common carotid was tied and the wound healed; pulsation in the aneurysm had stopped on the tenth day, and on the eighteenth the sac was smaller and quite hard. All seemed to be doing well till the thirty-third day after the operation, when loss of speech occurred somewhat suddenly, followed by right hemiplegia, and death on the thirty-fifth day, this being brought about by cerebral embolism taking place through the left carotid, the aneurysm being solidified throughout.

Aneurysm of the internal carotid is equally rare.

[1] *Loc. infra cit.*
[2] *Ann. of Surg.*, March 1904.
[3] *Med.-Chir. Trans.*, vol. lxiv. p. 1.
[4] *Ibid.*, vol. lxxxiii. p. 69.

The following is a brief abstract of such a case[1] in which the common and external carotids were tied, together with the superior thyroids, successfully.

The internal trunk was affected with atheroma to such an extent that the ligature could not be applied to this vessel. The operation was performed July 24, 1883. The tumour rapidly diminished in size, the patient leaving the hospital on the twenty-ninth day after the operation. She was living and well four years after the above date.

(6) *In Arterio-venous Aneurysms.* This matter has recently received additional attention from the origin of these aneurysms in wounds by small bullets of high velocity. The experience of Mr. T. H. Makins, C.B., on this subject has already been given (p. 189). In the Journal of the Royal Army Medical Corps, June 1905, this authority gives the further history of five cases of arterio-venous aneurysm of the neck, and draws the following conclusions: (*a*) A special difficulty met with in the neck is the exact localisation of the point of communication. Thus in the cases detailed in the above paper there was a doubt in one whether the common carotid or the inferior thyroid was the artery implicated; in another whether one or two of the carotids were invaded; in two others the localisation to either the innominate, carotid, or subclavian had to be considered; and in the fifth case time alone allowed the carotid to be definitely fixed upon as the wounded trunk. (*b*) In considering a local operation, the risk to the cerebral circulation of simultaneous ligature of both common carotid artery and internal jugular vein has to be considered. (*c*) The extreme severity of the operation itself, as judged by recorded cases, seems to render the local incision of the aneurysm inadvisable, except under circumstances of extreme urgency. (*d*) Mr. Makins' "own view, therefore, is in favour of allowing time for the consolidation and contraction of the sac, and then the application of a proximal ligature when practicable, in all cases involving the great vessels of the neck." It is pointed out by Mr. Makins that the five cases illustrate the tendency to spontaneous cure exhibited by aneurysms resulting from wounds of healthy vessels. In the two in which a proximal ligature was applied to the common carotid, seven and six weeks respectively after the injury, recovery was ultimately so complete that both the officers returned to active service.

The following case is quoted from the Report on Surgical Cases noted in the South African War, edited by Surg.-Gen. Stephenson:

P. 239. Case 99. Wounded at Paardeberg. Entrance (Mauser) to right of pomum Adami; exit ant. margin of left trapezius, and two inches below angle of jaw. Some haemorrhage, which ceased without operation. Wound healed, leaving symptoms of an arterio-venous aneurysm at the point of bifurcation of common carotid. Swelling, thrill, and pulsation over an area an inch and a half in diameter, and loud machinery murmur audible to patient when lying on injured side; left eyeball appeared prominent; voice weak and husky, with some cough, giddiness; pulse 100 and irregular and somewhat irritable. It was thought that the lesion might be on the internal carotid, and on the sixty-second day an attempt was made to place a ligature below it, but the sac of the aneurysm was found extended over the point of bifurcation. "The vein vibrated visibly, quivering in exact consonance with the palpable thrill." The ligature was placed on the main trunk beneath the omo-hyoid. Patient made a good recovery, and pulsation ceased but thrill persisted; six months later sac small; pulse 110–120; thrill slight; voice strong and good. "Aneurysm is either at bifurcation of common, or an immediate commencement of internal, carotid. Ligature of external carotid will probably cure it" (Mr. Makins).

[1] Dr. Wyeth, *Ann. of Surg.*, August 1887, p. 114.

(7) *Ie Hæmorrhage caused by Ulceration of the Throat after Scarlet Fever.* This is a rare but most dangerous complication of ulceration of the throat, and is usually brought about either by sloughing of the soft parts, or, as in the case mentioned below, by the opening of an artery or vein into an abscess cavity.

Dr. Mahomed communicated a case to the Clinical Society[1] in which this complication occurred in a patient aged 21. Secondary sore throat, after an ordinary convalescence, was noticed on the fifty-fourth day, with much swelling on the left side of the neck, followed by severe bleeding (to forty ounces) from the mouth on the fifty-eighth day. The left common carotid was tied by Mr. Pepper on the fifty-ninth day. Five and a half ounces of pus were brought up soon after the operation, and the swelling of the neck and pharynx subsided, a good recovery ultimately taking place.

The common carotid was selected for ligature in preference to the external, since it allowed the operation to be performed quite clear of the infiltrated tissues, and thus conferred a greater immunity from secondary hæmorrhage. Moreover, had the original bleeding come from the ascending pharyngeal, ligature of the external carotid might have failed to arrest it, as the place of origin of the former vessel is variable.

The next groups of cases, 8 to 11, may call for ligature of the external carotid rather than of the common trunk. With reference to them it must be remembered that ligature of the common carotid must be resorted to, not, as has too often been the case, on account of the greater facility with which this vessel can be tied, but only when the state of the patient or the condition of the parts either primarily, from an anatomical point of view, or, later on, after secondary hæmorrhage, does not admit of tying the external carotid itself.[2]

(8) *In Incised or Punctured Wounds near the Angle of the Jaw.* In these cases, as in those below, a correct diagnosis as to the vessel or vessels injured is by no means easy when a sharp weapon has passed obliquely and deeply behind the angle of the jaw. By such a wound either the external or the internal carotid or some branches of the former may be laid open. A careful dissection can alone clear up the source of the bleeding, and, whenever it is possible, this should be resorted to; where the circumstances do not admit of this, the surgeon, relying upon the extreme rarity of injury to the internal carotid from its protected position,[3] will be abundantly justified in tying the external carotid. Ligature of the common trunk is less reliable, though, if resorted to on account of its simplicity, it may be defended by cases like those briefly alluded to by Mr. Le Gros Clark,[4] in which he successfully tied the common carotid for profuse arterial hæmorrhage due to stabs near the angle of the jaw.

"The injury was inflicted in the same way, and with the same form of instrument, in both instances—a pointed table-knife was plunged downwards and inwards behind the angle of the jaw. The bleeding was, in each case, controlled only by direct pressure with the fingers in the wound; and whilst this pressure was maintained I tied the artery. Not an untoward symptom accompanied or followed either of these operations."

[1] *Trans.*, vol. xvi, p. 21.

[2] In some of these cases the hæmorrhage may be arrested, and the dangers of tying the common carotid avoided, by the temporary closure of this vessel by a loop of stout catgut applied as at p. 385.

[3] Mr. Cripps (*Med.-Chir. Trans.*, vol. lxi, p. 235) shows that out of eighteen cases in which the bleeding vessel was identified, the internal carotid was found only to have been wounded twice alone, and once in conjunction with the external.

[4] *Lect. on Surg.-Diagnosis, Shock, and Visceral Lesions*, p. 222.

(9) *In punctured wounds through the mouth.* Here, too, the common carotid has been tied in some cases successfully, while in others this step has been followed by repeated hæmorrhages and death.

The following case may be quoted as an instance of the former result :

A child fell while carrying the sharp end of a parasol in his mouth, the point being thrust forcibly to the back of the fauces and very nearly coming through the skin at the side of the neck. Considerable hæmorrhage occurred at once, and also about a week later. Ten days later a gush of arterial blood followed on coughing. The common carotid artery was tied, and the case ended successfully.

(10) *In Hæmorrhage from Carcinoma of the Mouth*, e.g. *Tongue or Fauces.* This subject is alluded to at p. 672. It would be better surgery to tie the lingual in the case of tongue cancer, or, if the growth be farther back, to deal with the external carotid (p. 688) and ascending pharyngeal, and, only if this be found impossible, to ligature the common trunk.

(11) *In Hæmorrhage after Removal or Incision of Tonsils* (p. 477), *or from an Abscess about a Tonsil.* These cases are infrequent, but when they do occur, are, in a large proportion of instances, most dangerous. The possible sources of the hæmorrhage are very numerous, viz. : (1) one of the tonsillar arteries ; (2) the tonsillar venous plexus ; (3) the ascending pharyngeal ; (4) the internal carotid. Hæmorrhage from the last two is much more likely to occur in suppuration in or around the tonsil than in wounds inflicted during operation on it.

The following is a good instance [1] of a tonsillar abscess proving fatal from hæmorrhage :

A man, aged 39, was admitted with severe tonsillar abscess, which soon burst with the escape of a little blood. About sixteen ounces were lost on the third day, bleeding again recurring on the fourth and fifth. The left common carotid was now tied ; thirty hours afterwards twenty-two ounces were lost, and the patient died. There was an abscess cavity around the left tonsil which communicated with the left internal carotid.

Mr. Morrant Baker has recorded a case of suppuration around the tonsil dating to an injury.

Here the vessel injured was the ascending pharyngeal, but too short a time elapsed between the ligature of the common carotid and the death of the patient to say whether the operation would have been successful.

A man, aged 23, was admitted with symptoms of acute tonsillitis, the parts being tense, elastic, and prominent at one spot. A puncture was only followed by the escape of blood. The patient now gave a history of having fallen two days before when drunk and having grazed his throat with a clay pipe ; this had been followed by very little bleeding. The temperature went up to 105°, and arterial hæmorrhage occurred on the third day after admission. A probe passed through the puncture showed that a considerable cavity existed ; this was plugged with lint soaked in tr. ferri perchlor. The next day hæmorrhage recurred to the amount of half a pint ; when ether was given the bleeding again came on, nearly suffocating the patient. On exploring the cavity with a finger-tip, a bit of clay pipe was withdrawn ; the cavity was again plugged and the common carotid tied. The patient died without rallying three hours later. A wound was found in the ascending pharyngeal artery.

Given a case of hæmorrhage from the tonsil (whether from a wound or an abscess) which resists other treatment,[2] including well-applied pressure kept up with a padded stick inside the mouth and a finger behind the angle of the jaw, and the use of one or two sutures (p. 477), the surgeon should tie the external carotid as low down as possible, placing a ligature on the

[1] Mr. Pitts, *St. Thomas's Hospital Reports*, vol. xii, p. 131.

[2] Every care should be taken throughout to keep the wound in the tonsil as aseptic as possible.

ascending pharyngeal as well, if this vessel can be identified. If the bleeding is from one of the tonsillar vessels it would be thus arrested; only if these steps fail should the common trunk be tied.

(12) *In Hæmorrhage after Operations on the Neck or Jaw. In Hæmorrhage secondary to Gunshot Injuries.* In both these cases the parts may be so altered that it is quite impossible to find the bleeding-point, and the soft parts may be so damaged, matted together, &c., that the surgeon may be driven to tie the common carotid, and to trust to this and to

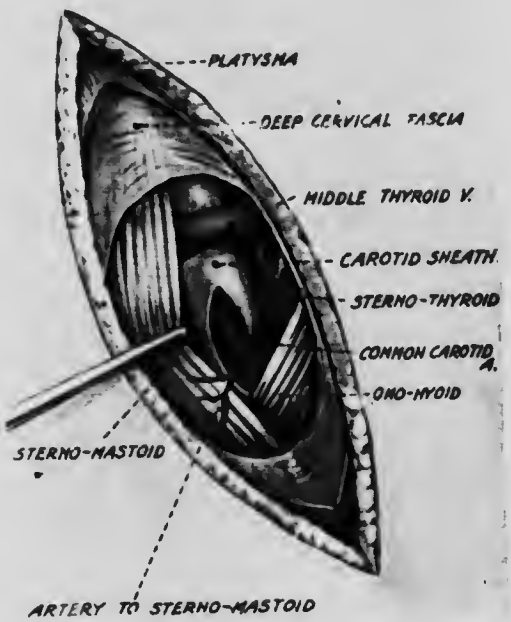


FIG. 288. Ligature of the common carotid.

plugging the wound, rendered as aseptic as possible, with scops of sterilised gauze, and firm pressure over all.

(13) *To arrest the Growth of Aneurysm by Anastomosis on the Side of Face, Head, and Neck.* The treatment of this condition is discussed at p. 690. It is shown there that ligature of the external carotid cannot usually be looked upon as sufficient without other measures, owing to the free anastomosis between the branches of the opposite vessels. Still less is ligature of the common carotid likely to be successful, and this step should only be resorted to when ligature of the external carotid is impossible from the disease extending too low down; when from its creeping towards the orbit, or to the back of the upper jaw, it is probable that there is a free anastomosis between the branches of the external and internal carotid through the ophthalmic; or when the ascending pharyngeal is sure to be involved, but this branch cannot be separately ligatured.

(14) *To arrest the Progress of Malignant Growths which cannot be operated on, or which are recurrent, and which derive their Blood-supply from the Internal as well as the External Carotid.* This operation, first performed by Mott, has been tried in cases of malignant disease of

the antrum, nose, &c., where the growth cannot otherwise be attacked, and is increasing very rapidly, causing frequent bleeding, intense pain, and threatening to interfere with deglutition and respiration. The results, however, have not been encouraging.

Line. From the sterno-clavicular articulation to a point midway between the angle of the jaw and the mastoid process.

Guide. The above line and the inner edge of the sterno-mastoid.

Relations. The common carotids, as far as their relations in the neck go, extend from the sterno-clavicular articulation to the upper border of the thyroid cartilage, along a line from the above joint to a point midway between the jaw and the mastoid process.

In Front

Skin; fasciæ; platysma; superficial branches of transverse cervical nerve, and anterior jugular.

Sterno-mastoid; sterno-thyroid; sterno-hyoid; omo-hyoid; sterno-mastoid artery.

Superior and middle thyroid veins, and often a communicating branch between anterior jugular and facial veins, along the anterior border of sterno-mastoid.

Descendens hypoglossi, usually on the sheath, sometimes within it.

Anterior jugular vein (below).

Sheath.

Outside		*Inside*
Internal jugular (closer on left side).	Common carotid	Pharynx. Larynx. Trachea. Thyroid gland and vessels. Recurrent laryngeal.

Behind

Rectus capitis anticus major.
Longus colli; scalenus anticus.
Inferior thyroid artery and recurrent laryngeal.
Vagus.
Sympathetic.
Sheath.

Operation. Two sites are usually described, according as the vessel is tied above or below the omo-hyoid.

A. *Above the Omo-Hyoid* (Fig. 288). Also known as "the seat of election," owing to the greater facility with which this operation is usually performed.

The parts being sterilised, the shoulders are sufficiently raised, and the chin at first drawn a little upwards, while the head is turned to the opposite side,[1] so as to define the anterior border of the sterno-mastoid.[2]

[1] Turning the head strongly to the opposite side should be avoided as it brings the muscle over the artery. Mr. Barwell (*Encycl. Surg.*, vol. iii. p. 498) gives the following practical hint: "In certain aneurysmal cases (aortic and innominate) the anæsthetised patient cannot breathe while his head is thrown back; the anæsthetist is obliged to insist on bending it forward, and the operator has to get at the vessel under very trying circumstances, since in that posture it lies much deeper, and the ramus of the jaw is terribly in the way."

[2] Not always easy on the dead subject, or when the parts are infiltrated.

The surgeon, standing usually on the same side, makes an incision about three inches long, with its centre opposite to the cricoid cartilage, in the line of artery, through the skin, platysma, and fasciæ, exposing the anterior border of the sterno-mastoid. Any superficial veins are now drawn aside, or tied, before division, with double ligatures. The deep fascia at the anterior border of the sterno-mastoid is now divided, and the cellular tissue beneath opened up, usually bringing into view the upper border of the omo-hyoid, which, if in the way, is drawn down with a blunt hook, or divided. The edge of the sterno-mastoid is now drawn outwards, and the pulsations of the artery felt for just above the omo-hyoid.[1] In clearing the tissues which remain over the vessel, troublesome hæmorrhage may arise from the superior and middle thyroid veins, especially if the respiration be embarrassed; more rarely the sterno-mastoid artery is cut, and requires a ligature. The sheath is next exposed, and opened well to the inner side, avoiding the descendens hypoglossi, which usually lies to the front and outer side of the sheath. Other difficulties which may now be met with are an enlarged thyroid lobe overhanging the artery or overlapping of it by the internal jugular when much distended. The coats of this vessel are so thin that, if it be much swollen, it is easily punctured, the result being that the wound is flooded with blood. It is best avoided by opening the sheath well to the inner side, but, if it still give trouble, it should be drawn aside with a blunt hook, or pressure should be made on it by an assistant, in the upper angle of the wound. If it should be opened, firm pressure should be made on this spot with a sterilised swab, and the artery tied at a fresh place above or below. As soon as the ligature is tightened the hæmorrhage will cease, and firmly applied pressure outside the wound for forty-eight hours will suffice to prevent any recurrence. If, after wounding the vein, attempts be continued to tie the artery at the same place, the wound in the vein is almost certain to be made larger. Other methods are to take up the wound in the vein with a tenaculum and secure the opening (if small) with a purse-string or other sutures of fine sterilised catgut or silk. If this fail, or in the case of a larger wound in the vessel, this should be secured between double ligatures. *See* also "Treatment of Injuries of the Vessels," p. 57.

The sheath having been opened well to the inner side with a careful nick of the knife, the artery is now cautiously and sufficiently cleaned, the inner edge of the sheath being held with forceps while this side of the vessel is cleaned, and then the outer in the same way, and, finally, the posterior aspect, the point of Watson Cheyne's director being kept most scrupulously in contact with the vessel here.[2] The needle is then passed from without inwards, being kept most carefully close to the artery, especially behind, so as to avoid including the vagus.

In this, as in every other artery whose relations are important, the fewer of these relations that the surgeon sees the more masterly and successful will his operation be.

In a deeply lying artery, in addition to relaxing the parts by flexing forward the head and depressing the chin, the sterno-mastoid must be drawn outwards and the larynx inwards with retractors, while the omo-

[1] If the bifurcation be at low one, that vessel is chosen which, on compression, is found to be connected with the disease or injury.

[2] Opening the sheath on the inner side and cleaning the vessel properly are the two best safeguards against accidents. For a hint which may be helpful in recognising the artery on the dead subject, a footnote (p. 687) may be referred to.

hyoid is drawn downwards with a blunt hook or divided. The pulsation of the artery is then felt for, or, where this is feeble or absent, the rolling of the artery as a flat cord under the finger is made out.

B. *Ligature below the Omo-hyoid.* Here the artery lies much deeper, and has the recurrent laryngeal nerves behind it; on the left side, the internal jugular vein lies very close to the artery; on the right, there is a distinct interval between the two vessels.

The patient's head and the operator being in the same position as at p. 684, an incision three inches long is made in the line of the artery, from below the cricoid cartilage to just above the sterno-clavicular joint, exposing, as before, the anterior edge of the sterno-mastoid. This is drawn outwards and, if needful, divided or detached below by making a short incision outwards along the clavicle. In this case the anterior jugular vein must be carefully looked for as it passes outwards in the root of the neck under the sterno-mastoid. The depressors of the hyoid bone next come into view; of these the sterno-hyoid, overlying the broader sterno-thyroid, is certain to be seen. If the omo-hyoid is coming up at this level, it lies external to the others. In such it is to be drawn out while the other two are pulled inwards, any of the three being divided, on a director, if needful. At this stage one or more of the inferior thyroid veins may come into view, much swollen. The pulsation of the artery being felt for, or the flattened artery felt slipping beneath the finger when pressed upon, the sheath is to be opened well to the inner side, retractors being usually required at this stage. Care must be taken of the internal jugular, especially on the left side, as, if distended, it may conceal the artery.

When the carotid is sufficiently cleaned, the needle is passed from without inwards, avoiding the recurrent laryngeal nerve behind by keeping very close to the artery.

Temporary Ligature of the Carotid. Mr. Rivington and Sir F. Treves [1] have drawn attention to this method, believing that the ligature of main arteries is resorted to too often, as there is sufficient evidence to show that in most cases it is only temporary arrest of the current that is required.

This method should certainly receive a further trial, on account of the risks of cerebral mischief after ligature of the carotid, and also because, as Sir F. Treves says, pressure upon the carotid cannot be successfully maintained for a serviceable length of time.

The artery being exposed in the ordinary way, a thick piece of soft catgut is passed round it and tied in a very loose loop. By pulling on the loop, the blood-current is at once arrested, and restored when the tension is relaxed.[2]

The following are abstracts given by Sir Frederick:

(1) *Probable Wound of Superior Thyroid Artery.* A young man was admitted with a deep, profusely bleeding wound about the level of the great cornu of the hyoid. A fragment of glass driven in by a bursting soda-water bottle had been removed. The patient was blanched and almost insensible. It being "obviously useless to attempt to find the bleeding-point while blood was welling up from so deep a wound," a temporary ligature was placed round the common carotid. Traction on this arrested all bleeding, and was maintained for half an hour. On relaxing the catgut no haemorrhage occurred. The loop was left in situ for four days, and then removed. The bleeding was supposed to come from the superior thyroid.

(2) *Haemorrhage from Internal Carotid.* A child, aged 3, had profuse haemorrhage from the right ear, and vomited blood. This recurred, and the right common carotid was ligatured, when the bleeding ceased. The next day haemorrhage recurred, blood having evidently been brought round by the left carotid. As there

[1] *Lancet*, January 21, 1888, p. 111.

[2] Crile's artery clamps may be employed for this purpose

is no case on record[1] of recovery after ligature of both common carotids when the interval between the occlusion of the two vessels was less than some weeks. Sir F. Treves simply placed a loop of catgut round the left carotid, and had traction on it. The child never bled again, but sank exhausted six days after the second operation.

(3) *Hæmorrhage probably from External Carotid, after Impalement with a Spike.* A man, aged 41, fell twenty-six feet upon a railing-spike, which, entering just in front of the left ear, passed through the upper jaws, and entered the mouth through the hard palate on the right side. After removal of the spike, blood welled up freely from the wounds and nose. Traction made on a catgut loop passed round the left common carotid arrested this. A weak pulse could be felt in the temporal on the fourth day, and on the seventh the loop was removed. The case did well. It is not stated how long traction was maintained.

(4) *Hæmorrhage during an Operation.* In this case the loop was placed around the artery prior to removing a large malignant tumour of the neck. Very free bleeding occurred during the operation, but was always checked by traction on the loop. Without this the operation would have been very difficult.

Dr. G. Crile, of Cleveland, U.S.A., recognising, as we all do, the limit of safe range in the severer operation on the head and neck due to hæmorrhage, the immediate blood loss, later infective pneumonia, and the fact that, while permanent closure of the external carotids is permissible, that of the common is attended with much risk, has devised experimentally and carried out successfully the *temporary closure of the carotids by special clamps*.[2]

The technique is as follows: In cases where the trunks of the vagi or their superior laryngeal branches are likely to be interfered with,[3] one-hundredth of a grain of atropine should be injected twenty minutes previous to making the incision, in order to prevent possible inhibitory action upon the heart. The artery is closed by small clamps with blades protected by india-rubber and capable of delicate and accurate closure by a screw. Surgeons of this country will at once recognise their close similarity to Mr. Makins' intestinal clamps. In operations in which blood may enter the air passages, Trendelenberg's position should be employed. This partially makes up for the lowered cerebral blood-pressure which results from closure of the carotid, while, from cases published, it does not appear to increase the venous and capillary hæmorrhage to any material degree. In applying the clamps the walls need only to be approximated, not compressed. This is effected by the delicate control of the screw, and by keeping the blades exactly parallel with each other. Dr. Crile's experiments on nineteen dogs showed that a clamp properly adjusted could be left in position, in the absence of infection, from twenty-four to forty-eight hours, without serious injury to the artery. The release of the clamp should be made slowly, the field of the operation being carefully inspected

[1] Dr. Simpson, Surg.-Capt. Ind. Med. Service, records the following very interesting case, which has an important bearing on the above statement: Case of Resection of the Right Upper Jaw for Sarcoma, with Ligature of both Common Carotids. The patient was a Telugu lad, about 18 years of age, admitted into the Madras General Hospital while Dr. Simpson was acting as surgeon. Prior to the resection the right common carotid was tied with the view of diminishing the hæmorrhage at the operation. One week elapsed between the ligature of the artery and the removal of the jaw. During that interval Dr. Simpson and Dr. Smyth came to the conclusion that there would be no immediate danger in occluding the other common carotid, if need arose. Dr. Simpson began the operation (on the eighth day after ligature of the right carotid) by exposing the left common carotid at the level of the cricoid and passing a piece of elastic tubing round it. This was tightened gently, and produced no effect upon the patient, who was well under the influence of chloroform. With the assistance of Dr. Smyth, Dr. Simpson removed the jaw, this being done almost bloodlessly. On relaxation of the tubing, sharp hæmorrhage ensued. In preference to attempting to arrest this, and thus causing much delay—a matter of great importance—a ligature was substituted for the tubing, and the artery was tied. The patient made an uninterrupted recovery, and six months later was known to be in good health. There seemed danger at first of sloughing along the lines of separation of the jaw, and irrigation was constantly employed for the first two or three days. The case will be found published in the *Trans. South Ind. Branch Brit. Med. Assoc.*, vol. v, No. 3.

[2] *Ann. of Surg.*, vol. xxxv, 1902, p. 441.

[3] In two cases where, in spite of injection of a hundredth of a grain of atropine, manipulation of the vagus caused the pulse to fall from about 90 to 56, the application of 2 per cent. solution of cocaine to the nerve led to a prompt return of the pulse to its previous rate.

for any vessels which may have been overlooked. When the Trendelenberg position has been employed it is safer to restore the patient to the horizontal position before releasing the carotid. Sixteen cases are given which in severity were well calculated to test Dr. Crile's method. They include cases of removal of epithelioma of the tongue, floor of mouth and glands, growths of the parotid, removal of upper jaw, congenital growths, nævoid, and other of neck and orbit. Both common carotids were closed in ten cases. There were no deaths attributable to the method. The ages of the patients varied from 7 months to 69 years.

In every case the circulation was resumed at once on the release of the clamps. There were no appreciable effects on the vessel walls, and no later cerebral effects. Less anæsthetic was necessary with closed arteries, especially in the cases in which the common carotids were closed. In the latter case there may be embarrassed breathing, especially later. Wholly or partially releasing one or both carotids gave material and immediate assistance. The time occupied was much diminished, as the field of operation was quite bloodless. The amount of blood lost was strikingly less, as was also the difficulty in keeping blood from the respiratory tract. The application of the clamp is easily accomplished, the incision being prolonged if needful for removal of glands, &c.

Difficulties and possible Mistakes during Ligature of the Common Carotid. (1) Altered condition of the soft parts, *e.g.* matted and œdematous, from the close contiguity of an aneurysm, from a previous trial of pressure; or loaded with blood or inflammatory products, as in the case of a wound. (2) Presence of an aneurysm encroaching upon the incision. (3) Not hitting the edge of the sterno-mastoid. This muscle may be drawn over the artery if the chin be too much forced to the opposite side. The chin should be kept about midway between the acromion and the episternal notch on the opposite side (Barwell). (4) Great enlargement of the superior and middle thyroid veins.[1] (5) An enlarged and overlapping thyroid gland. (6) A large internal jugular overlapping the artery. (7) Opening the sheath towards its outer side, and so running down upon, and perhaps injuring, the vein.[2] (8) Including one of the nerves[3] in relation with the artery, *e.g.* the descendens hypoglossi, the vagus, or the sympathetic (p. 675).

Causes of Failure and Death after Ligature of the Common Carotid. (1) *Cerebral complications*, *e.g.* impaired nutrition and softening. Sir J. E. Erichsen thinks that "cerebral symptoms" (he does not say whether he means fatal ones or not) are liable to occur in twenty-five per cent. of ligatures of the common carotid. They may come on almost at once, or some days after the operation. The same surgeon divides them into

[1] Mr. Barwell (*Internat. Encycl. Surg.*, vol. iii. p. 490) says that the superior thyroid vein, very full and turgid, sometimes runs in front of, more often behind, the carotid. "I suppose it is the effect of the anæsthetic which causes this to swell to the size of a cedar pencil."

[2] On the dead body, especially, there is a risk of mistaking the flaccid jugular for fascia, on opening it, unless the sheath has been opened over its front and inner part as should always be the practice. Another hint may be useful. In a body injected with formalin, owing to the clotting of the blood in the vein, this vessel may appear thick, and give the impression of an injected artery. The latter will be known by its white colour and empty condition.

[3] "The descendens hypoglossi lies usually on the outer part of the sheath, and will rarely be endangered if that structure is opened as above described; but it is well to see that it is out of the line taken by the director; if its absence there be verified, it need not be hunted up elsewhere. The pneumogastric lies in the interval between the artery and vein in the back part of, but not loose in, the sheath; each of the vessels, as well as the nerve, has a compartment, strongly walled to itself; while the sympathetic, behind the sheath, is also separated by a thick fascia from the vessels. If these anatomical positions be maintained, both nerves are saved. Young operators are sometimes made anxious and embarrassed by unnecessary cautions, yet sometimes the parts do not quite maintain their proper positions. Hence it is well, before tightening the ligature, to see that it includes the artery only" (Barwell, *loc. supra cit.*).

two sets: (*a*) the early ones, resulting from the too small supply of arterial blood, viz. syncope, twitchings, giddiness, impaired sight, and hemiplegia; (*b*) after the above have been present for a few days, and softening has taken place, convulsions and death ensue. It would be, perhaps, worth while, in view of the above mortality, to try pressure before resorting to the ligature, in order that the opposite vessels may become enlarged. Pressure could only be kept up, without an anæsthetic, for a few minutes at a time, and care would have to be taken not to apply it at the intended site of ligature. The temporary ligature and Dr. Crile's method (pp. 685, 686) also deserve trial. (2) *Infective complications.* (3) *Recurrent pulsation.* In most cases this is due to blood finding its way round from the opposite side. The pressure, however, in cases of aneurysm, having been relieved, coagulation, as a rule, takes place, though slowly. In a smaller number of cases the recurrence of the pulsation has been of a more permanent kind, from the ligature becoming loosened or dissolved, especially when catgut has been used. (4) *Suppuration of the sac.* Sir J. E. Erichsen states that this is not very uncommon. "In the majority of cases the patient eventually does well." (5) *Hæmorrhage.* This has never been a common complication, owing to the absence of branches. It may take place from the site of ligature [1] or from a suppurating sac. It should be still more rarely met with in the future, owing to the modern treatment of the wounds. (6) *Low forms of lung inflammation.* The above authority states that these are not uncommon. He attributes them to diminished freedom of the respiratory movements owing to the disturbed circulation in the brain and medulla.

LIGATURE OF THE EXTERNAL CAROTID (Fig. 289)

This operation has not received the attention which it deserves, having been too often set aside for the easier operation of ligature of the common trunk.[2]

Mr. Cripps,[3] discussing the ligature of the external carotid in the treatment of hæmorrhage from punctured wounds of the throat and neck, states that the objections raised to the above operation are:

(1) The fear of secondary hæmorrhage from the seat of ligature due to the close proximity of its larger branches.

(2) The futility of the operation should the wounded vessel be the internal carotid.

Mr. Cripps answers this objection by comparing the rareness of a wound of the internal carotid with one of the external or its branches.

He points out that of eighteen cases in which the bleeding vessel was identified, the internal one was wounded twice alone, and once in conjunction with the external.[4]

[1] This danger would seem to increase the lower down the ligature is placed. Mr. Barwell says that the only fatal case of secondary hæmorrhage he has had in this operation followed the ligature of a carotid with catgut close above the sterno-clavicular joint. It is not stated whether the wound was aseptic throughout or not.

[2] See a paper on Ligature of the External Carotid reporting seven cases by Dr. Fisk (*Ann. of Surg.*, 1909, vol. xlix, p. 767).

[3] *Med.-Chir. Trans.*, vol. lxi, p. 234.

[4] Mr. Cripps' list is interesting to the surgeon. In the first ten it is to be presumed that ligature of the external carotid would have been the wiser course. In two, the bleeding came from the external carotid; in one, the lingual; in one, the facial; in one, a tonsillar branch; in one, a branch in the parotid gland; in two, the internal maxillary; in one, the inferior dental; in one, the middle meningeal; in one, the verte-

(3) The external carotid is less easy to ligature than the common.

This objection will not weigh with a surgeon who knows his anatomy, who is in the habit of operating, and who begins by exposing the vessel at the bifurcation of the common trunk.

The *advantages* of the operation are :

(1) That the circulation through the brain is not in the least interfered with. Consequently one large element of danger is avoided (p. 687).

(2) The incision made over the external carotid can also expose the bifurcation and the internal carotid, and may thus lead to a direct exposure of the wounded vessel.

Indications. (i) *Wounds of the Trunk and of its Branches.* This subject has already been alluded to. While it cannot be denied that the easier operation of ligature of the common trunk has answered in some of these cases, it has also certainly failed repeatedly. Considering the rarity of wounds of the internal carotid, the surgeon will do more wisely, in the case of a wound over the carotid area, to expose and tie the external carotid, low down in any case of doubt, so that the trunk and the internal carotid may be exposed as well, if needful.

Mr. Rivington recorded [1] an interesting case of a wound of the external carotid by a stab in the parotid region giving rise to recurrent attacks of hæmarrhage, and treated successfully by temporary [2] ligature of the common carotid and ligature of the external carotid at the seat of injury.

A man, aged 31, was admitted into the London Hospital with three wounds, one severing the lobule of the left ear and passing into the parotid gland below the zygoma, a second behind the ear, and a third over the mastoid process. Hæmorrhage occurring about a week later was stopped by pressure. Erysipelas followed, and an abscess was opened in front of the ear. About three weeks after the accident hæmorrhage again occurred, being brought on by a fit of coughing, blood running out from all the incisions. Though it was again arrested by pressure, Mr. Rivington judged, from the size of the stream and the force of the jet, that the injured vessel must have been the external carotid in the parotid gland.

On account of the difficulty of securing the artery at the seat of injury, and the amount of blood which would be lost before this could be accomplished, and not being able to rely upon pressure on the common carotid during the operation, Mr. Rivington cut down first on the common trunk at its bifurcation and placed a temporary ligature round it,[3] tying this lightly so as to stop the current of blood, but not to divide the inner and middle coats.

The openings in the parotid region being explored and clots turned out, a little below the angle of the jaw was found a hole from which some blood issued in a feeble stream. The external carotid was ligatured above and below this spot. The ligature in the main trunk was then untied, and left in situ for use if needed. All bleeding had ceased, and there was no recurrence. The patient made a good recovery, some weakness of the face muscles having almost disappeared when he left the hospital.

Mr. Rivington drew attention to the advantage of the temporary ligature on the main trunk, rendered very evident by the fact that immediately before the operation, when the sponge was removed, arterial blood spurted out in a lively jet, whilst after the ligature a languid stream only issued from the distal side of the hole in the external carotid.

bral ; in two, the internal carotid ; in one, the external also was wounded ; in one, the source was close to the bifurcation ; in two, the common carotid, at the point of bifurcation, was wounded ; in one, the ascending pharyngeal.

[1] *Clin. Soc. Trans.*, vol. xvii. p. 79.

[2] Some cases in which Sir F. Treves at a later date made use of this step are given at p. 685.

[3] It remained uncertain whether this temporary ligature was placed on the external or the common carotid.

He further pointed out that the employment of temporary ligatures, either lightly tied or left in situ for use in case of need, is capable of wider application in the treatment both of hæmorrhage and of aneurysms.

(ii) *Aneurysm by Anastomosis of Scalp and Side of Head and Neck.* Here the ligature of the external carotid is made use of as an adjunct to local treatment, or where this has failed. If the growth is not too large, it should be excised with aseptic precautions, tying each vessel as it is cut. The operation may be rendered partly evascular by the use of sterilised india-rubber tubing passed round the back of the head and the lower jaw, with pledgets of gauze over the main vessels, *e.g.* temporal or external carotid, posterior auricular, and occipital.[1] Where the above is not applicable, the external carotid may be tied preliminary to removing the tumour. When this is being effected, any skin that is not too much involved should be preserved. If this is impossible, the growth must be taken away, with the skin over it, the vessels being secured as cut. Every care must be taken to keep the wound sterile, and thus promote rapid granulation-healing, completed by Thiersch's skin-grafting (p. 43).

As these cases are most obstinate, attention will be drawn to other cases, proving that ligature of the external carotid (even if performed on both sides) is not likely to be successful without local treatment as well, viz. either underrunning the vessels with pins, or excision. They are recorded by Dr. Bryant, of New York[2]:

> The patient, aged 24, had a well-defined pulsating tumour at the site of a healed scalp-wound in front of the left ear. The trunk and branches of the temporal and the occipital were concerned in the growth. As this was rapidly increasing, the left external carotid was tied with catgut about half an inch above its origin. Tying the lingual artery also provided a branchless portion of the external carotid about an inch in extent. The ascending pharyngeal was sought for, but not found. All pulsation was at once checked, and the growth was also reduced to about one-third of its previous size. The operation was antiseptic throughout, and when the dressings were changed for the first time in ten days, a slight return of pulsation was noticed in the tumour. A month after the operation, pulsation, thrill, and bruit were nearly as strong as before, and it was decided to attack the tumour itself in preference to tying the occipital and temporal branches, or the right external carotid. The arterial circulation was admirably controlled by surrounding the head with two strong rubber bands, beneath which compresses were placed at the points where arteries passed to supply the scalp.
>
> Dr. Bryant found on record eight other cases of ligature of the external carotid for the cure of aneurysmal tumours of the head, face, and parotid gland, in two of which both the vessels were tied simultaneously. This latter procedure is not reported to have been successful in either case. Of a total of nine cases, only one, a traumatic aneurysm of the parotid, was cured by ligature alone.

Thus it would appear that local remedies, viz. excision and underrunning, aided by ligature of the chief feeding arteries, are most likely to be successful in this disease, which so often baffles treatment. Ligature of the external carotid, on one or both sides, will fail, owing to the free collateral circulation, if tried by itself, even in recent traumatic cases without much general dilatation of the vessels. If used at all, it should be as an adjunct and a preliminary step to diminish the vascularity of the tumour before this is dealt with locally by the methods above indicated.

(iii) *Aneurysm of the External Carotid.* The treatment of this rare condition has been already discussed at p. 678.

[1] Makka's clamps (*see* p. 255) would be of service here.

[2] *Ann. of Surg.*, August 1887, p. 116.

(iv) (*a*) As a preparatory step to extirpating malignant growths of the upper jaw, pharynx, &c., or (*b*) as a palliative step where the above extirpation cannot be attempted.

(*a*) As a *preparatory step* to extirpating malignant growths. The external carotid may be tied before attempting to remove growths of the parotid, tonsil, upper jaw, angle of lower jaw, palate, or pterygoid region. The risk of secondary hæmorrhage is alluded to at p. 555.

A case has been alluded to at p. 528, in which this step was carried out—one of a sarcoma of the palate and pterygoid region. The first patient is alive and well five years after the operation.

(*b*) As a *palliative step* where removal of such growths as those alluded to above is impossible. On this point reference should be made to the remarks already made at p. 544.

The following cases[1] are of interest as bearing on this matter. In each of these cases repeated operations had been performed for removal of malignant diseases involving the lower jaw, floor of the mouth, and more or less of the tongue. Rapid recurrence had taken place in each case until, the use of the knife no longer appearing feasible, the only course seemed to be starvation of the growth. Accordingly this was attempted by simultaneous ligatures of both the external carotids, by incisions in the usual place, the enlarged lymphatic glands found being removed. When the carotids were reached, most unusual anomalies were found. The right common carotid bifurcated beneath the posterior belly of the digastric, which was divided to admit of passing the ligature. On the left the bifurcation was behind the hypoglossal nerve, which was drawn down, and the ligature then passed just below the digastric. The lingual and facial branches were not seen on the right side; but this caused no apprehension, as the facial was said to have been tied some months before, during removal of the diseased submaxillary gland on that side. On the left side the branches of the external carotid were normal. The malignant growth diminished in size rapidly, the discharge became scanty, thin, and watery, and the ability to speak and swallow improved quickly. On the fifth day a portion of the growth on the right side sloughed out, leaving an aperture bounded by sloughy tissue, at the bottom of which could be seen necrosed bone in the lower jaw. Nine days after the operation profuse hæmorrhage took place, with a fatal result. This hæmorrhage was caused by sloughing of some of the diseased starved tissue, into which the trunk common to the facial and lingual passed.

In the second case no hæmorrhage or sloughing followed on ligature of the external carotids. For two months the state of the patient was much improved, the growth showed but little tendency to increase, and the pain and dysphagia did not return. Then profound cancerous cachexia set in, with emaciation and loss of strength, beyond which there was no note.

Excision of the External Carotid. This method has been introduced in America to meet the objections which may accompany mere ligature of the artery, viz. secondary hæmorrhage, if the wound unavoidably becomes septic, and, in the case of growths, the reactivity which sets in when the collateral circulation is restored. The following account is taken from Dr. Coley's article on "Cancer":[2] "R. H. M. Dawbarn, of New York, has originated a method of dealing with inoperable malignant tumours in regions deriving their blood-supply from the external carotid arteries, which he designates as 'excision of the external carotid arteries.' Attempts to starve malignant tumours by cutting off the arterial supply had previously been made, but never systematically. Four years ago J. D. Bryant, of New York, reported before the New York Medical Society a case of inoperable naso-pharyngeal sarcoma which apparently disappeared after ligature of both external carotid arteries, the patient remaining well nearly ten years afterwards. Bryant tried the method on a number of other similar cases, but the results were always confined to temporary shrinkage of the tumour. Dawbarn, reasoning from these results that the first case was successful because there happened to be present poor anastomotic connections, and that the other cases were improved at first, but later became worse as soon as anastomosis developed, conceived the idea of excising the carotids.

[1] Dr. Bryant, *Ann. of Surg.*, August 1887, p. 121.

[2] *Twentieth Century Practice of Medicine*, vol. xvii, p. 405.

"The technique of the operation is as follows: Ligature the external carotid just above its origin. Cut just above and seize the upper cut end with stout artery-forceps. These hold the vessel as a handle throughout. Working upwards, tie off between two ligatures and divide each branch as reached. When the artery at length disappears into the substance of the parotid gland, use gentle traction on the artery downwards while stretching with a dressing-forceps a passage up into the gland. Avoid the knife here, to threaten facial paralysis as little as may be. At length one is able to slip a single ligature about the two terminal branches just above their origin—the internal maxillary and temporal—and to divide the end of the external carotid."

Dr. Dawbarn has recently modified his technique.[1] After the different branches of the external carotid have been found and tied, they are cut, and the distal portions injected with a mixture of white paraffin and gelatin, introduced at a temperature of about 120° F. The two trunks are dealt with at an interval of about fourteen days. The result of his experience is as follows: "For sarcomas the result is particularly favourable. Cases are now on record in which three, four, five, six, and even seven years after the tying of the external carotid, there has been no recurrence of sarcomatous tumours which were growing rapidly before the operation, but which dwindled immediately afterwards, and have never again resumed their malignant activity. In one very severe case of sarcoma of the base of the skull, in which the tumour was very large and had yielded somewhat to the injection of Coley's toxin, but had afterwards resumed its growth, the tying of the external carotids led to the gradual disappearance of the tumour; and it has not recurred. Unfortunately this is not so true for the carcinomas. Improvement follows the cutting off of the blood-supply to malignant growths of this kind, but the relief is not permanent. In a few instances there was marked diminution in the size of the tumour, followed by the relief of symptoms for from a few months to a year. Recurrence, however, has inevitably taken place in all true carcinomas, though usually the patient has suffered very much less before the fatal termination than would have been the case had the carotid not been tied. In every instance the tumour has shrivelled, and great temporary benefit has been derived from the operation."

(v) *Hæmorrhage from Middle Meningeal Artery after Trephining.* This matter has been considered at p. 266, and more fully in *Guy's Hospital Reports*, vol. xliii, where it is shown that severe hæmorrhage is not uncommon after a wounded middle meningeal has been exposed by trephining, but that the bleeding will usually yield to measures short of ligature of the external carotid.

Guide. The anterior border of the sterno-mastoid above the hyoid bone.

Relations. The external carotid extends from the upper border of the thyroid cartilage to a point midway between the external auditory meatus and the condyle of the jaw; beyond this point it is continued on as the temporal, having just before given off the internal maxillary. In the first part of its course the external is somewhat nearer the middle line than the internal carotid, and is more superficial than this throughout.

In Front

Skin; fasciæ; platysma; nerves from transverse cervical and facial; superficial veins.
Lingual and facial veins.
Digastric and stylo-hyoid.
Parotid; facial nerve; temporo-maxillary and other veins.
Hypoglossal nerve.

[1] *Intern. Clinics*, 1905, vol. i. p. 112.

Inside	O	*Outside*
Pharynx. Hyoid bone. Ramus of jaw. Parotid.	External carotid.	Parotid. Temporo-maxillary vein when this descends to join the internal jugular.

Behind

Parotid gland.
Superior laryngeal.
Glosso-pharyngeal.
Stylo-glossus and stylo-pharyngeus.

The veins in relation with the external carotid vary a good deal. But, in addition to the lingual and facial crossing it, a number of veins joining the external and anterior to the internal jugular may form a kind of plexus round the artery, and the temporo-maxillary may descend outside the artery to join the internal instead of the external jugular.

Branches [1]

ANTERIOR	POSTERIOR	ASCENDING	TERMINAL
Superior thyroid. Lingual. Facial.	Auricular. Occipital.	Ascending pharyngeal.	Temporal. Internal maxillary.

Operation. This is performed at two spots :

(*a*) *Below the Digastric* (Fig. 289).

(*b*) *Above this muscle*, behind the ramus of the jaw.

(*a*) *Below the Digastric.* This is the operation more frequently performed in order to cut off the blood-supply through all the branches of the artery. Though these are so numerous, and vary somewhat, there is usually a spot, from one half to three-quarters of an inch, between the superior thyroid and the lingual, on which a ligature may be safely placed, especially if the superior thyroid and linguals be ligatured as well.

To meet the difficulties which may be encountered, and to expose the desired vessel quickly, the bifurcation of the common trunk must first be found, and the artery which gives off branches traced upwards.

The position of the patient's head and that of the surgeon being the same as at p. 683, an incision three inches long is made in the line of the artery, from the angle of the jaw to the upper border of the thyroid cartilage, about a quarter of an inch in front of the anterior border of the sterno-mastoid. This incision should divide skin, fasciæ, and platysma ; any superficial veins being secured, the cellular tissue in front of the muscle is opened up, and the bifurcation of the common carotid and the posterior belly of the digastric or the hypoglossal identified as guides to the vessel. In doing this the sterno-mastoid should be drawn outwards, any large veins, *e.g.* facial or lingual, pulled aside with a strabismus-hook or secured with double chromic-gut ligatures before division. The muscle or the nerve being defined, the pulsation of the artery is felt for below them, and the vessel carefully cleaned just above the thyroid cartilage. The

[1] While this is a common arrangement, it is by no means the only one. Very frequently one trunk gives off two or three arteries. Sometimes all the branches, save the two terminal, arise very close together, the external carotid constituting then an arterial axis. It is the presence of these branches which enables the surgeon to decide whether he is dealing with the external or internal carotid.

use of the steel director or knife should be most cautious on the outer side of the artery, where lie, below, the internal jugular and the internal carotid. At the same time the presence of the descendens hypoglossi on the artery is to be remembered, and that of the superior-laryngeal nerve running obliquely downwards and inwards behind the vessel. The needle

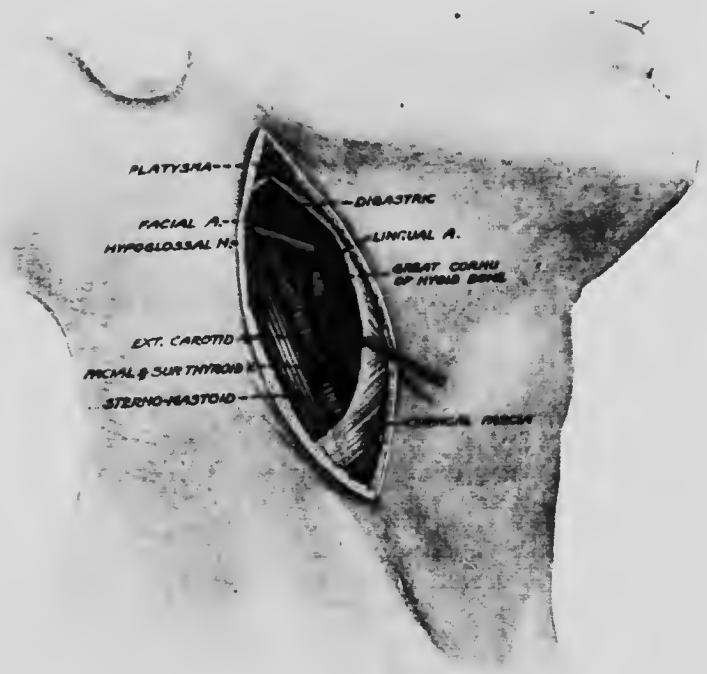


FIG. 289. Surgical anatomy of the external carotid artery.

should be passed from without. The superior thyroid, facial, and lingual should be ligatured at the same time, and the ascending pharyngeal if it can be found.

(*b*) *Above the Digastric, behind the Ramus of the Jaw.* This operation has the disadvantage of probably entailing the division of important branches of the facial nerve.

The head and shoulders being duly raised and supported, the surgeon makes an incision downwards from the tragus of the ear, just behind the ramus of the jaw, dividing the skin and fasciæ. The sterno-mastoid must now be drawn outwards, and the digastric and stylo-hyoid downwards, and it will probably be needful to divide these latter muscles partially in order

to secure the artery before it enters the parotid gland, this structure being drawn upwards and forwards.

The needle may be passed from either side, as is most convenient to the surgeon.

Several veins communicating between the facial and the external jugular will probably cross the line of incision, and must be dealt with.

LIGATURE OF THE INTERNAL CAROTID

Indications. These are extremely few.

(1) *Wounds, usually Stabs.* The following striking case is quoted by Dr. Liddel,[1] and reflects the greatest credit on the medical men concerned:

On July 31, 1869, a man was wounded in the neck, at the angle of the lower jaw, by a knife, which penetrated several inches, opening the internal carotid. Alarmed by the tremendous jets of arterial blood, Dr. Denning, in whose drug store the stabbing occurred, at once compressed the carotids. Happening to be close at hand, Dr. A. T. Lee promptly cut down upon the artery by the usual incision, exposed it by careful dissection, found the bleeding-point, and applied a ligature on the cardiac side of it. Haemorrhage now occurring from the upper end, was arrested by a ligature on the distal side of the wound. The patient was pulseless, and death was considered imminent, but under energetic stimulation with whisky and ammonia, the circulation was soon restored, and the patient made a good recovery, being in active work nine years later.

(2) *Aneurysm.*[2] In the non-traumatic and sacculated variety, which is extremely rare, the decision as to treatment, if pressure have failed, must lie between the Hunterian operation of ligaturing the common carotid or, if the artery be sound, and if there be room above as well as below the aneurysm, of placing ligatures above and below the sac, and opening this to turn out the clots. But one or both of the above conditions may very likely be absent.

If the aneurysm be traumatic, resulting from a stab or gunshot injury in the neck, or if, in spite of other treatment, it be steadily increasing, the only operation likely to avail is the old one.

The following case is an excellent example of the difficulties which may be met with in these cases, and how they should be dealt with:

Dr. Prewitt, of St. Louis,[3] has recorded the following most interesting case of traumatic aneurysm: A negress, aged 17, was shot with a revolver bullet, which entered the cheek over the malar bone and passed backwards. Profuse haemorrhage took place at once from the wound of entrance, there being none of exit. This was controlled by pressure. A swelling quickly appeared between the ramus of the jaw and the mastoid process, which three months later was found to project into the pharyngeal cavity, crowding the tonsil over the middle line and resting against the uvula.[4] Externally the swelling reached from the temporal bone to the

[1] *Intern. Encycl. of Surg.*, vol. iii. p. 111; *Amer. Journ. Med. Sci.*, January 1879, pp. 124, 143.

[2] Aneurysm of the internal carotid here refers to the cervical part of the artery. The treatment of orbital aneurysm, which often depends on arterio-venous communication (traumatic or idiopathic) between the internal carotid and the cavernous sinus, has already been considered at p. 677. Matas's operation of endoaneurysmorraphy might also be employed here.

[3] *Trans. Amer. Surg. Assoc.*, vol. iv. p. 233.

[4] With reference to this tendency of internal carotid aneurysm to project inwards Dr. Prewitt thus quotes from Prof. Agnew (*Surgery*, vol. i. p. 594): "The deep situation of the artery, covered as it is externally by the stylo-hyoid, stylo-pharyngeus, and styloglossus muscles, and by dense aponeurotic structures which extend down to the styloid process, prevents any very marked prominence of such a tumour on the surface of the neck, and, as the artery is separated from the pharynx only by the mucous membrane

hyoid. Expansile pulsation, well-marked bruit, and thrill were present. Sense of taste was lost in the right side of the tongue, which was atrophied, and, when protruded, inclined to the right. Pressure on the common carotid arrested pulsation in the tumour, and caused some decrease in size. There was no perceptible difference in the right and left temporal pulses; the pupils were equal. There was persistent headache, and sometimes roaring in the right ear. Difficulty in swallowing had existed from the first. The general condition was unsatisfactory.

It was decided to tie the common carotid at once, but though the pulsation and thrill in the sac seemed arrested at first, they returned in a few minutes. It was then decided, as a forlorn hope (because the diagnosis had placed the opening of the sac close to the carotid foramen), to extend the incision upwards in front of the tragus to determine the feasibility of laying open the sac and tying the vessel upon the distal side of it.

A cautious dissection at the back and upper part of the sac showed that this filled all the space between the mastoid process behind and the condyle and ramus of the jaw in front, the sac seeming also to blend with the skull or to be closely adherent to it. A little reflection made it apparent that there was no portion of the artery between the carotid foramen and the sac to be tied. The wound was washed out, drained, and closed. On the evening of the eighth day, there having been pyrexia and free suppuration of the wound in the interval, haemorrhage took place from the sac. The wound was enlarged, and search made with the finger for the orifice of the artery or the carotid foramen. The search being fruitless, and it seeming certain that laying open of the sac or removal of the finger would be followed by speedily fatal haemorrhage, the sac was packed. Haemorrhage did not recur, but the patient died exhausted twenty-five days after the first operation.

The necropsy was conducted under great difficulty, but it was thought that it was made out that the opening in the artery was close to the carotid foramen. Death seemed largely due to infective causes, *e.g.* thrombosis of the inferior petrosal and lateral sinuses.

(3) At p. 678 another indication is given, viz. some cases of traumatic exophthalmos, in which ligature of the internal carotid is to be preferred to that of the common trunk.

Line and Guide. These are practically the same as those given for the common carotid. The internal carotid lies at first outside and rather behind the external carotid. Soon after its commencement it becomes too deeply placed to admit of ligature.

RELATIONS IN THE NECK

In Front

Skin; fasciae; platysma.
Sterno-mastoid; stylo-glossus; stylo-pharyngeus.
Glosso-pharyngeal nerve.
Hypoglossal nerve.
Parotid gland.
Occipital artery.

Outside	O	*Inside*
Internal jugular Vagus.	Internal carotid. Artery.	Pharynx. Ascending pharyngeal. Tonsil.

Behind

Rectus capitus anticus major.
Superior laryngeal nerve.

and the constrictor muscle, its extension inwards becomes an anatomical necessity. Indeed, in this peculiarity lies the chief difference between aneurysm of the internal carotid and aneurysm situated at the division of the common trunk."

Operation. This is much the same as that for ligature of the external carotid. The artery can be tied in its first and more superficial part. It here lies outside and rather behind the external carotid. The bifurcation of the common trunk should first be found, and the internal carotid carefully traced upwards being identified by the absence of branches.

Thus the incision should be made along the anterior border of the sterno-mastoid, and not just in front of it, the centre of the incision lying about half an inch above the upper border of the thyroid cartilage. The sterno-mastoid being defined, and the cellular tissue opened up in front of it, the same superficial structures will be met with as in the external carotid (p. 692). When the carotids are found, the external should be drawn inwards, and the digastric upwards. The needle should be passed from without inwards, avoiding the internal jugular and the vagus.

LIGATURE OF THE VERTEBRAL ARTERY

Indications. (1) Wounds and (2) Traumatic Aneurysm may be considered together.

There is liable to be much obscurity as to whether it is the vertebral or some other artery (*e.g.* inferior thyroid, ascending cervical, common carotid, or, if high, the occipital, which is affected; and, when it is decided that it is the vertebral artery, it is by no means easy to carry out satisfactory treatment. The best course is to enlarge the wound, and to decide, with the finger, the relation of the wounded vessel and of the haemorrhage to the transverse processes of the vertebrae. The direction of the wound and the effect of pressure below and above the level at which the vertebral ceases to be compressible, *i.e.* above the "carotid tubercle" (*vide infra*), will also be helpful.

If the wound be low down, there are about two inches of the artery available for ligature, and this should be placed above and below the wound. But if, as is more frequent, the wound is higher up in the neck, it will be almost impossible, even after exposing and clipping away the anterior roots of the transverse process, to find and secure the artery, and the best course will be carefully to plug the wound, a method successfully employed by Prof. Kocher.[1]

Aneurysms of the vertebral are always traumatic. There are about twenty-four[2] cases on record of aneurysms and wounds of this vessel. The situation varies much. Usually it is high up near the mastoid process.[3]

The difficulty of diagnosis of wounds of the vertebral and other arteries, and their results, has already been alluded to. Mr. Holmes[4] states that there are eleven cases in which the carotid has been tied for wound or aneurysm of the vertebral, of course with no advantage. This mistake seems to have arisen from forgetfulness of the fact that, while

[1] Langenbeck's *Arch. f. Klin. Chir.*, Bd. xii. S. 867. A full abstract of the paper given in the *Syd. Soc. Retr.*, 1871–1872. p. 202.

[2] Barbieri, of Milan, quoted by Kocher (*loc. supra cit.*), has collected sixteen; Filz (Langenbeck's *Arch. f. Klin. Chir.*, Bd. ix) has gathered together four. Then there are Kocher's, one by Lueke in the same *Arch.*, Bd. viii. S. 78, and the American case given below.

[3] In nine, according to Kocher, the wound was at or above the second cervical vertebra; in two "at the upper part of the neck"; in six it was below the second cervical vertebra. In four of the latter it was in the neighbourhood of the external carotid artery and its branches: in one the wound was at the angle of the jaw.

[4] *Lancet*, July 26, 1873.

pressure on the common carotid below the transverse process of the sixth cervical vertebra will check all pulsation in the carotid, the branches of the carotid, and aneurysms situated on them, it will also check pulsation in a vertebral aneurysm. Mr. Holmes points out that the above "carotid tubercle" is higher up than is usually supposed, being situated two or three inches above the clavicle; and he lays down the rule that when a traumatic aneurysm is situated in the course of the vertebral, and its pulsations are commanded, however completely, by pressure on the common carotid low in the neck, it ought not to be treated as being carotid, or as affecting a branch of the carotid, until it is clearly proved that its pulsations are stopped by pressure applied above the level at which the vertebral ceases to be compressible, *i.e.* above Chassaignac's carotid tubercle. Ligature of the vertebral artery in the first few inches of its course being so very rarely available, compression of the artery low down, with the aid of an anæsthetic, if needful, and with the additional help of direct pressure or cold on the aneurysm above, should be made use of.

Dr. Weir[1] records a case of a man stabbed on the right side of the neck, about three-quarters of an inch below the ear, just in front of the sterno-mastoid. A traumatic aneurysm, believed to be of the vertebral, slowly developed. Digital pressure over the carotid tubercle was made use of, and in three hours the tumour was cured.

If pressure fails, and if a vertebral aneurysm increases in size, the surgeon must decide to face the risks of opening the swelling and efficiently plugging it. The gauze should be carried into the aneurysm, the wound being opened sufficiently freely to allow the surgeon to see what he is about, and the head should afterwards be kept rigidly still.[2]

(3) The vertebral has been tied on several occasions in ligature of the innominate artery, either at the same time, to prevent secondary hæmorrhage, or later on, to arrest this when it has occurred at the seat of ligature owing to the reflux of blood from the subclavian (p. 719). More than once the vertebral has been wounded during ligature of the first part of the subclavian.

Relations. The vertebral artery, the largest and usually the first branch of the subclavian, arises from the upper and back part of the artery, and ascends at first a little outwards and backwards to reach the foramen in the transverse process of the sixth (sometimes the fifth or the seventh) cervical vertebra. Traversing these foramina, it passes through that of the axis; it then bends outwards and upwards to reach that of the atlas, and, passing backwards, lies in a deep groove on the posterior arch of the atlas behind the articular process, beneath the suboccipital nerve. In this position it lies in the suboccipital triangle. Finally, it pierces the posterior occipito-atloid ligament and dura mater, and, running upwards and forwards through the foramen magnum, winds round to the front of the medulla to join its fellow and form the basilar at the lower border of the pons Varolii.

Behind

Cervical nerves (in vertebral canal).
Sympathetic plexus.

[1] *New York Archives of Medicine*, 1884.

[2] In one case related by Kocher the nerves lying behind the artery were injured, and in another dangerous inflammation of the spinal meninges took place.

Outside	O	*Inside*
Scalenus anticus and phrenic nerve.	Vertebral artery.	Longus colli.

In front

Internal jugular.
Inferior thyroid.
Thoracic duct (left side) crossing from within outwards.
Vertebral vein (often plexiform).
Sympathetic plexus.

Operation. The head having been suitably raised and turned slightly over to the opposite side, an incision, three inches long, is made along the outer border of the sterno-mastoid, extending to the clavicle. In deepening this incision the external jugular must be looked out for, running parallel here with the outer border of the muscle. When the deep fascia is divided, the sterno-mastoid, together with the vein, is to be drawn inwards, the incision being prolonged along the clavicle, and some of the clavicular fibres detached from the bone if needful. The surgeon then, working with the narrow point of a steel director, carefully opens up the deep connective tissue, and endeavours to define the interval between the scalenus anticus and the longus colli muscles. As the outer border of the former muscle corresponds with that of the sterno-mastoid, this muscle must be well retracted inwards. In defining the vertebral artery as it lies between the scalenus and longus colli the presence of the phrenic nerve lying on the scalenus, the pleura internally, the internal jugular, inferior thyroid, and the vertebral veins over the vessel, with the thoracic duct crossing it, on the left side, from within outwards, must all be borne in mind, these structures being drawn to either side, as is convenient, with small retractors. The depth of the wound and venous hæmorrhage are difficulties at this stage. The needle is then passed from without inwards. Owing to the deep position of the artery, a good light is essential, and the head must be manipulated so as to relax the deep parts as required. The anterior transverse tubercle on the sixth cervical vertebra is a good guide in cases of difficulty; below it, the pulsation of the artery should be felt. In cleaning the artery previous to passing the ligature the fibres of the sympathetic must be disturbed as little as possible.

Temporary paralysis from interference with these fibres is almost certain, and immediate contraction of the corresponding pupil is of very frequent occurrence, and may be regarded as a pretty certain indication that the vessel has been secured. If the vertebral vein is wounded and cannot be secured separately, ligatures should be placed on artery and vein together, above and below the wound in the latter.

LIGATURE OF THE SUBCLAVIAN IN ITS SECOND AND THIRD PARTS (Figs. 290, 291)

Line. From the curved and short course of this vessel no definite line can be given.

Guide. The chief point to remember is the outer margin of the sterno-mastoid, as this corresponds to the outer border of the scalenus anticus, which has to be defined and then traced down to the scalene tubercle on

the first rib, the part of the artery to be tied lying on the upper surface of this bone, outside and behind the muscle and tubercle.

Relations (third part):

In Front

Skin; fasciæ; platysma; branches of cervical plexus.
Venous plexus, viz. external jugular; suprascapular; posterior scapular; transverse cervical; branch from cephalic.
Transverse cervical and suprascapular arteries.
Cellular tissue and fat.
Nerve to subclavian.
Subclavian vein (below).

Above
Omo-hyoid.
Cords of brachial plexus.

Subclavian artery (third part).

Behind
First rib.

Relations (second part):

In Front

Skin; fasciæ; platysma.
Sterno-mastoid.
Scalenus anticus.
Phrenic nerve.

Above
Cords of brachial plexus.

Subclavian artery (second part).

Below
Pl[illegible]

Behind
Scalenus medius.

Collateral Circulation. *When a ligature is applied to the Third or Second Part.* Three main sets of vessels are here employed, viz:

Above		*Below*
The suprascapular, The posterior scapular.	with	The acromio-thoracic, the infra-scapular, subscapular, and dorsalis scapulæ.
The superior intercostal, The aortic intercostals, The internal mammary,	with	The long thoracic and the scapular arteries.
Numerous plexiform vessels passing through the axilla from branches of the subclavian.	with	Branches of the axillary.

When a ligature is applied to the First Part. The collateral circulation may be carried on by the superior anastomosing with the inferior thyroid, one vertebral with its fellow, the internal mammary and superior intercostal with the long thoracic and the scapular arteries, and the princeps cervicis with the profunda cervicis.[1]

Indications. (i) In some cases of axillary aneurysm,[2] *i.e.* those in which, owing to the pain, the irritability of the patient, the depth of the artery, or the rapid increase of the aneurysm, pressure is not available.

[1] Smith and Walsham, p. 38.
[2] Some of these cases will be suitable for Matas's operation (*see* p. 53).

The high mortality met with in past days is due chiefly to three causes, viz. (1) Inflammatory changes within the chest; (2) suppuration of the sac; (3) hæmorrhage.

(ii) Cases of subclavian and subclavio-axillary aneurysm not amenable to other treatment; or where the aneurysm, especially if subclavio-axillary, is small in size (not larger than a hen's egg), with a history of a few months' duration, and distinctly traumatic in origin.

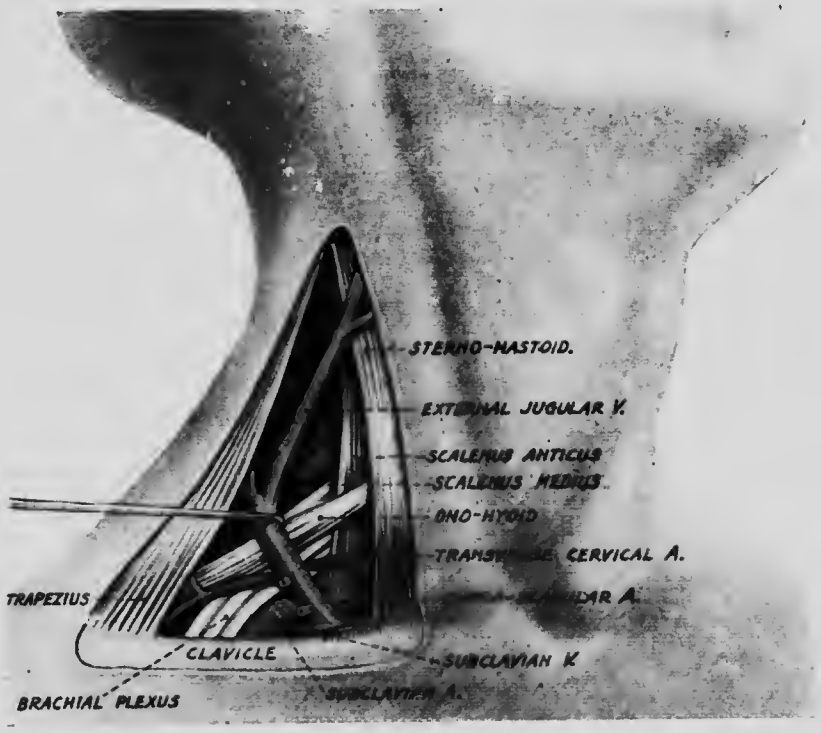


FIG. 290. Surgical anatomy of third part of the subclavian artery.

Mr. Poland,[1] in his report on subclavian aneurysm, gives nine cases of recovery and twelve cases ending fatally after ligature of the second or third portions of the subclavian for subclavian or subclavio-axillary aneurysm. With regard to the nine successful cases, Mr. Poland raises a very important question: Was the aneurysm developed in a healthy artery? If so, the success is explained. In three the aneurysm was entirely local, independent of general arterial disease; in two this was doubtful; in four the origin was spontaneous. Whether general atheroma existed here must remain uncertain, as the patients recovered, and the artery, where tied, was healthy. "We can only say this: that subclavian aneurysm in its early stage, occurring in persons of the early or middle period of life, without any indication of disease of the heart or large vessels, may and does recover, and that a cure may be effected by means of a ligature of the third or second portion of the artery notwithstanding the disease is one of spontaneous origin, and therefore presumed to be indicative of arterial disease."

Dr. Taylor, of Dublin, has related[2] a very instructive case of traumatic aneurysm of the left subclavian, due to fracture of the clavicle, most successfully treated under circumstances of great difficulty.

[1] *Guy's Hospital Reports*, 1871. [2] *Ann. of Surg.*, November 1903

The man, æt. 62, had fractured his clavicle in the usual way, and tried to work the day after. There was much swelling from the first, and the X-rays showed a spicule of bone passing down towards the vessel. Two weeks after the injury a large swelling, with all the evidence of an aneurysm, was present. A fortnight later an attempt was made to tie the first part of the subclavian after removal of the inner third of the clavicle. Owing to the difficulties met with which led to injury of the vertebral artery, it was determined to remove the centre of the clavicle, expose and control the artery, empty the sac, and apply double ligatures. The subclavian being controlled by pressure and the sac emptied, an opening was found in it of the size of a knitting-needle. Forceps were now placed on the proximal and distal sides of the sac, and allowed to remain on for twelve days, a plug of gauze being introduced between them. The wound granulated satisfactorily and the patient made a good recovery, though the return of power in the limb was very slow.

(iii) As a distal operation, together with ligature of the common carotid for some cases of aneurysm of the innominate and aorta (*see* p 723).

(iv) Preparatory to such operations as interscapulo-thoracic amputation (p. 235).

(v) For wounds of the subclavian itself, *e.g.* stabs. This is very rarely called for.

Operation for Ligature of the Third or Second Portion of the Subclavian (Fig. 291). These two will be considered together, as one operation is but an extension of the other.

The patient having been turned over on to the sound side, propped up with pillows at the edge of the table, the head drawn over to the opposite side, the shoulder on the side of the aneurysm is depressed as strongly as possible, so as to open out the posterior triangle. The surgeon then, standing in front of the shoulder, draws the skin down over the clavicle with his left hand, and makes an incision, three inches long, over this bone, between the sterno-mastoid and trapezius, dividing skin, fasciæ, and platysma.

The soft parts being now allowed to glide up, the incision should lie half an inch above the clavicle, the external jugular vein thus escaping injury; for, as this vein perforates the deep fascia just above the clavicle, it cannot be drawn down with the skin, superficial fascia, and platysma. If more room be required owing to the elevation of the clavicle or the presence of an aneurysm, the above muscles must be divided, and a longitudinal incision made upwards, at right angles to the inner end of the first, and a triangular flap raised outwards and upwards.

When the superficial parts have been sufficiently incised, the deep fascia is carefully opened at the inner end of the incision and laid open on a director, and the areolar tissue beneath, which varies much in density and in the amount of fat it contains, divided cautiously in a direction aiming for the outer edge of the scalenus anticus, which corresponds to the outer margin of the clavicular part of the sterno-mastoid. As soon as the deep fascia is divided, the presence of the following complications must be remembered and provided for. The soft tissues may be much matted, œdematous, and altered owing to previous use of pressure, or inflammation set up around a rapidly growing aneurysm. The venous plexus formed by the external jugular receiving the suprascapular and transverse cervical veins, and, often, the posterior scapular and a branch over the clavicle from the cephalic as well, may be much engorged. Any one or more of these veins which are in the way should be drawn aside or divided between fine catgut ligatures. It cannot be insisted upon too

strongly that a bloodless wound will best enable the surgeon to reach this often most difficult artery, and a bloodless wound is best secured by tying beforehand every vein which cannot be drawn out of the way, and by using a fine-pointed steel director as much as possible after the deep fascia is opened.

As a rule, the transverse cervical artery is above the incision, and the suprascapular below it, under the clavicle, but occasionally one or both of these may be found lying across the field of operation, and must then be drawn aside. While the veins may be ligatured without hesitation,

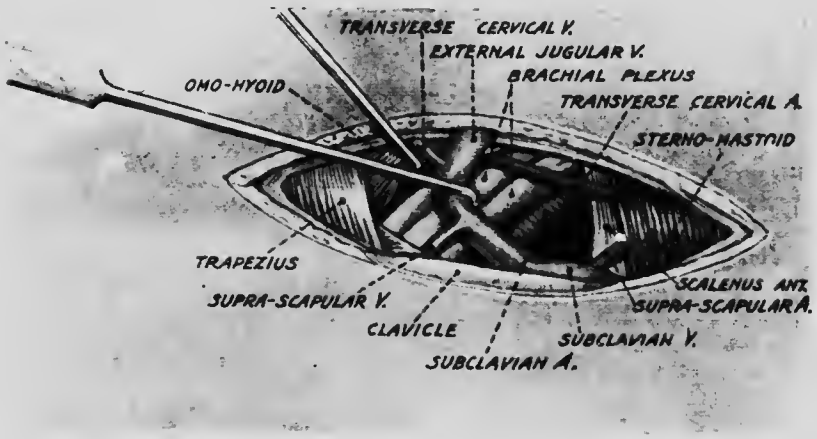


Fig. 291. Ligature of the third part of the subclavian artery.

the arteries must be preserved intact, that the collateral circulation may not be interfered with (p. 700).

The omo-hyoid varies in position, and may be neglected.

By dissecting through the cellular tissue the scalene tubercle on the first rib, immediately above and behind which landmark lies the artery, can be felt. One of the lowest cords of the brachial plexus will now come into view, and is another good guide to the artery.

George Wright, of Manchester,[1] emphasises the value of the lowest nerve cord as a guide in preference to the scalenus anticus and the scalene tubercle. In his case the muscle was not a very good guide, as "the tense fascia reaching from its posterior border to the sheath of the artery obscured the line of the muscle," and as the artery rose fairly high in the neck, the tubercle was not of much value either.

This cord must not be mistaken for the artery, a contingency otherwise not unlikely to happen, as the lowest cord is in close contact with the artery and may receive pulsation from it. A little cleaning will show the fasciculation of the nerve, while the artery is closer to the rib, and is flat, not rounded, when rolled under the finger.[2] By compressing the artery between the needle passed beneath it and his forefinger, and noting

[1] "Case of Ligature of Subclavian Artery for Axillary Aneurysm," *Ann. of Surg.*, 1888, p. 362.

[2] Another difficulty about the pulsation is its variableness. Sometimes it is violent and excited; at others, as in the case of a dilated and diseased artery, or one much handled in the operation, it is almost imperceptible (p. 174).

the result of this pressure on the aneurysm and the pulse below, the surgeon will clear up any doubts as to whether he has the artery or not.[1]

The position of the artery being made sure of, the sheath [2] is opened with the point of the knife, the artery cleaned, and the needle passed from above downwards and from behind forwards. This best avoids the worst risk, *i.e.* of including a nerve cord. The needle should be kept most carefully close to the vessel, and not dipped suddenly or used with any force; otherwise the pleura or subclavian vein may be injured.[3] The artery, before the ligature is tightened, will be inspected with some anxiety as to its condition—whether normal in size and structure, or dilated, thickened or thinned.[4] If much alteration be found, the surgeon should carefully divide the outer half of the scalenus anticus on a director with a blunt-pointed scissors, keeping the wound absolutely dry so as to watch for the phrenic nerve, which, if seen, should be drawn inwards.

If the artery be found diseased here also, the surgeon should use one of the ligatures described at pp. 713, 715, and endeavour so to adjust the tightening of the ligature as not to divide both the internal and middle coats.

In cases where the wound is a very deep one, care must be taken, while making the second knot, that the first does not slip. The ligature having been tightened and cut short, drainage is provided, if needful, and the wound carefully closed and dressed. The limb is then bandaged with cotton-wool and kept somewhat supported, and the temperature maintained with hot bottles if needful.

The Chief Points in the After-treatment are: (i) keeping the wound rigidly aseptic, (ii) arresting hæmorrhage, (iii) meeting suppuration of the sac, (iv) combating the stiffness and weakness of the limb which sometimes follow on ligature of the main trunk.

(i) This need not be further alluded to in a work like this, but it cannot be too strongly insisted upon that, if the high mortality (pp. 701, 707) which has hitherto attended this operation is to be reduced, it is mainly to keeping the wound aseptic throughout, and thus to early primary union, that we must look.

(ii) The risk of hæmorrhage is so great that the surgeon should always endeavour to prevent it by trying to obtain early and firm closure of the wound, as just indicated, and by keeping the patient absolutely quiet till all is soundly healed. When once hæmorrhage occurs, the outlook is very grave. The treatment must vary according to the size of the wound which remains. If there be only a sinus, firm pressure must be made over

[1] In the dead subject the artery may be distinguished from the nerve trunk by the fact that the former flattens when pressed between the aneurysm needle and the finger, while the latter feels like a solid rounded cord.

[2] A process of deep cervical fascia which the vessel brings out from between the scaleni, and one which varies much in density.

[3] The surgeon should be provided with needles of different curves and a silver probe with a large eye. As pointed out by Sir W. Fergusson (*Surgery*, p. 607), with his attention to details in operations, the eye of the needle should always be close to the point, that the ligature may be at once seized with forceps as soon as it appears under the vessel, the difficulties at this stage of the operation being not only the surrounding parts of importance, but also the fact that in this case the handle cannot be depressed so freely as in operation on most other arteries, and thus it is difficult to make the point rise above the vessel.

[4] In a case of Liston's the vessel was dilated, thick, and soft, "aptly enough compared to the finger of a buckskin glove." The patient, aged 43, died of hæmorrhage on the fourteenth day. In a patient of M. Jobert's (Poland, *loc. supra cit.*, p. 110) "the vessel was found enormously large, equal to the size of an aorta; pulsation being very marked."

the dressings by well-adjusted bandaging, aided by a heavy bag of shot,[1] and most absolute quiet. If the wound be larger, and perhaps septic and sloughy, an anæsthetic should be given, and, any clots having been removed, it must be rendered aseptic, and plugged with strips of sterilised gauze, the part placed within the wound having been wrung out of solution of formalin (1 in 500 or 750), or turpentine, and pressure applied as above. The patient should be kept as quiet as possible with morphia; the diet should be restricted and given at regular intervals, and without stimulants unless absolutely required.

The cases collected by Mr. Poland[2] show that while hæmorrhage may occur as early as the eighth day it may be deferred till the twentieth day in either case. In neither of these two latter cases had the wound healed; in the first the patient had been allowed to get up; in the second pyæmia was present.

The above and the following remarks apply chiefly, of course, to the days when ligature of arteries for aneurysm was much more common, before the period of aseptic surgery and the employment of sterile ligatures.

The same writer[3] thus sums up the sources of hæmorrhage:

(*a*) From the sac, either primary from puncture during the operation, or secondary from ulceration or rupture at an early period, or later after inflammation and suppuration and giving way of the sac.

(*b*) From the ligatured part, in consequence of non-obliteration of the artery when the ligature is becoming detached, the hæmorrhage being generally from the peripheral end of the artery tied. It may be due also to an unsound state of the coats of the artery, such as dilated, thinned coats or atheromatous degeneration.

It is worth remembering that this hæmorrhage is, in exceptional cases, recovered from.

(iii) Suppuration of the sac. The frequency of this untoward accident has been already alluded to (p. 701). It is due to the close proximity of the ligature to the sac, without any intervening branch, whereby the necessary coagulum is but ill formed and loose, acting as a foreign body, and liable to set up irritation, inflammation, and its consequences.

Every endeavour should be made to prevent its occurrence by forbidding all handling of the aneurysm.

If evidence of it occur, and the swelling, which has at first diminished in size, again about the second or third week steadily increasing in size, become tense and painful, but without pulsation, it must be opened by a sufficiently free incision, carefully emptied of pus and clots, drained, and well-adjusted pressure applied. If the wound be not healed, and particularly if it is infected, hæmorrhage is extremely likely to occur after opening the sac—an ominous complication, which can only be met by plugging with aseptic gauze and using firm pressure (*vide supra*).

(iv) Atrophy, stiffness, and weakness of the limb. These must be met by warmth, use of electricity, and above all, by perseveringly used massage.

The condition which is so common in the lower extremity after an analogous operation (*see* Ligature of External Iliac), in which the limb long remains in a state not far removed from gangrene, is much less common in the upper extremity.

[1] In a large hospital, where relays of assistants are available, digital pressure may be made use of.

[2] *Loc. supra cit.*, pp. 116, 117.

[3] *Loc. supra cit.*, p. 125.

Difficulties and Accidents which may be met with, and Points to avoid, during the Operation.

(1) Sterno-mastoid and trapezius almost meeting.

(2) A full short neck with much fat above and beneath the deep fascia.

(3) Clavicle much pushed up. This may be due to the patient having carried his shoulder raised to relieve the painful pressure on the nerves, or to the presence of an aneurysm.

(4) The artery may be displaced.

This deviation from its usual course may be acquired, as in a case of Warren's[1] where the left subclavian was raised and displaced by a curvature of the spine in a woman, aged 30, the subject of an aneurysm (attributed to strain) about the size of a pigeon's egg, just above the scapular end of the clavicle. Ligature was performed by an incision made obliquely from the outer edge of the sterno-mastoid towards the acromio-clavicular joint, the pulsation of the artery being the guide. Congenital deviations which have been met with are the artery perforating the scalenus anticus, or lying in front of it, or, as usual, behind this muscle, but now closely accompanied by its veins.

(5) The soft parts infiltrated, or œdematous, or matted together owing to the presence and irritation of an aneurysm, aided, perhaps, by previous attempts at cure by pressure.

(6) Great engorgement of the veins met with here, due to the presence of an aneurysm, and increased by the anæsthetic.

(7) An aneurysmal sac very prominent and liable to be punctured in the operation.

(8) Wound of the suprascapular artery necessitating ligature of this branch. As a rule this artery lies too low down to be injured a complication to be extremely deprecated, as it is one of the chief channels by which the collateral circulation is established (p. 700). In about one out of every three cases the posterior scapular will be found to arise from the third part of the subclavian as a separate branch. Erichsen[2] advised, if this condition were met with, that the ligature should be applied, as far as possible, "to the proximal side of the branch. If necessity obliges the ligature to be applied close to the branch, it is perhaps safer to tie this also, as the anastomosis of vessels in this region is so abundant that the risk of gangrene from the obliteration of a single branch would be very small."

Any artery crossing the subclavian should be, normally, the transverse cervical. This or any other vessel which may be an artery should be drawn aside.

(9) Pulsation in the artery weak or deficient, or, on the other hand, excited and tumultuous (p. 703).

(10) Including a cord of the brachial plexus (p. 703).

(11) Injuring the pleura. This has happened on several occasions during the passage of the needle round the artery, owing to the close proximity of the serous membrane to the vessel, and the difficulty in passing the needle, especially when the clavicle is much raised, rendering it impossible to pass the needle from below, and thus away from the pleura.

Erichsen[3] considered the inflammation of the contents of the thorax to be the most frequent cause of death, proving fatal in one out of every 2·5 cases. This is not pyæmic, but arises from causes essentially connected either with the operation or with the aneurysm itself.

[1] Poland, *loc. supra cit.*, p. 77.

[2] *Surgery*, vol. ii. p. 208.

[3] *Loc. supra cit.*, vol. ii. p. 212.

"These are referable to three heads. (1) Septic inflammation of the deep areolar tissue at the root of the neck may extend to the anterior mediastinum, the pleura, and pericardium. . . . (2) The sac may, by its pressure inwards, encroach upon, and give rise to inflammation of, that portion of the pleura which corresponds to its posterior aspect. (3) Division of the phrenic nerve would necessarily, by interfering with the respiratory movements, induce a tendency to congestion and inflammation of the lungs; and although such an accident must be a very rare one in cases of ligature of the subclavian for axillary aneurysm, yet it undoubtedly has occurred, as I have myself witnessed in one case."

(12) Injuring the nerve to the subclavius, or including it in the ligature. This nerve, derived from the junction of the fifth and sixth cervical, usually gives a filament to the phrenic. If, as occasionally happens, this filament is replaced by a nerve constituting an important part of the origin of the phrenic, injury to it will be followed by urgent and possibly fatal dyspnœa.

(13) Injury to the subclavian vein. This is rare, as the vein lies below and well away from the artery. But if ligature were called for in a case in which the vein accompanied the artery between the scaleni, this deviation would prove embarrassing.

Mention has been made at p. 704 of division of the scalenus anticus if the surgeon does not find the part of the artery beyond this muscle healthy. It is not needful to speak at length and separately of this step, as it is a mere extension of the operation for ligature of the third part, the muscle also being only divided in part. Mr. Poland [1] points out that, of eight cases in which the scalenus was partially divided, five recovered, and that of these five recoveries the operation was on the left side. These cases thus fully prove that a ligature may be placed on the second part of the artery without fear of want of thrombus formation or of injury to important parts.[2]

LIGATURE OF THE FIRST PART OF THE SUBCLAVIAN [3]

As this operation has been performed by surgeons of the highest eminence, and as it affords good practice on the dead subject, it will be given here. How far the improvements of modern surgery, aided by recently introduced ligatures and removal of the inner part of the clavicle, will ever render this a successful operation, and meet that secondary hæmorrhage which has proved so fatal from the distal side of the ligature, owing to the facility with which the numerous collaterals bring in blood to this spot, remains to be seen.

Relations. These, owing to the great depth of the artery on the left side, must be given separately.

[1] *Loc. supra cit.*, p. 128.

[2] As shown by Mr. Poland, the remarks of Porter on the numerous and great perils of this operation are scarcely borne out, viz. the phrenic on the scalenus anticus; the thoracic duct lying, on the left side, at the inner edge of the muscle; the three large branches usually given off by the subclavian while between the scaleni; and the close proximity of the first dorsal nerve behind the artery.

[3] These remarks refer chiefly to the right subclavian. A ligature has certainly once been placed on the first part of the vessel on the left side, Dr. Rodgers, of New York, being the operator, and losing his patient from hæmorrhage on the fourteenth day. Sir J. E. Erichsen (*loc. supra cit.*) states that Sir A. Cooper failed in an attempt to secure the vessel, and that he is said to have wounded the thoracic duct.

In Front

Skin: fasciæ.
Sterno-mastoid; sterno-hyoid; sterno-thyroid.
Internal jugular and (often) vertebral vein.
Vagus; phrenic; cardiac nerves.

O

Right subclavian (first part).

Behind

Recurrent laryngeal; sympathetic.
Longus colli; pleura (and beneath).

In Front

Sterno-mastoid; sterno-hyoid; sterno-thyroid.
Pleura; lung.
Vagus; phrenic; cardiac nerve
Internal jugular; innominate [illegible].
Common carotid.

Outside		*Inside*
Pleura.	O Left subclavian (first part).	Trachea. Œsophagus; thoracic duct.

Behind

Sympathetic.
Œsophagus; thoracic duct.
Longus colli.

Operation. This resembles ligature of the innominate. The following account is taken from Mr. Barwell [1]:

A triangular flap having been turned upwards and outwards, and both heads of the sterno-mastoid divided, the anterior and, if needful, the external jugular veins are secured with double chromic-gut ligatures and divided. The fascia over the sterno-hyoid being exposed, "the director, after a little opening in the aponeurosis has been made, can be insinuated behind that muscle, which also must be severed. It is well now to look and feel for the carotid artery before going on to divide the sterno-thyroid, whose outer edge covers that vessel, and never, as far as my experience of the dead subject goes, conceals the subclavian." [2] The finger of the operator, after division of the sterno-hyoid, readily detects the longitudinal course and pulsation of the carotid, and may with ease push the edge of the sterno-thyroid from off its sheath inward, in which position the muscle should be held with a blunt hook. When the sheath of the vessel is thus brought into view, the operator should look for the large veins that always, but more especially if there have been dyspnœa, overlie it. Choosing a vacant spot, he merely nicks the loose structure in which they lie, and then pushes them up and down, tearing the cellular tissue a little, till the dense fibrous sheath is bared sufficiently first to have a small opening made in it, and then to be slit up. This should be done on the front and inner aspect. Now, at this part, the vein diverges a little from the artery, so as to leave a triangular interval, through which the vagus runs. A blunt hook is placed over

[1] *Intern. Encycl. Surg.*, vol. iii. p. 513.

[2] "The mere division of the muscle is in itself unimportant, but there lies behind it a plexus of large veins, passing from the thyroid body to the internal jugular, generally distended by the dyspnœa, accompanying aneurysm at the root of the neck. Their division causes profuse bleeding, and subsequent difficulty in recognising the deeper parts."

this, and it is to be drawn with the jugular vein gently outward. The next point is to find the subclavian. To do this the operator must remember that the usual description and delineation of the innominate bifurcation is incorrect. It is generally depicted as if the two branches rose side by side and almost at right angles to each other. In reality, the subclavian springs behind the carotid, and the angle between the two vessels is very acute. Therefore, to detect the subclavian, the operator must place his finger at the back and outer part of the carotid when, passing it down, he comes, generally a few lines above the clavicle, to the slightly divergent pulsating line of the subclavian, which lies deeper than the carotid by the whole diameter of that vessel.

In selecting the spot for placing the ligature, it is well not to put it quite close to the bifurcation, but also not too near the scaleni, lest the recurrent laryngeal or the phrenic should be injured. The vagus and the jugular vein should be kept, not too forcibly, outwards, and the needle should be passed from below, while with his left forefinger the surgeon gently presses the pleura downwards and outwards. Some obstruction behind the artery will very likely be encountered, but it is better gently and patiently to overcome this, and never on any account to attempt to pass the needle the other way; for if this be attempted the instrument is certain to penetrate the pleura. Having now passed and tied the ligature, the surgeon should consider the advisability of also securing the vertebral. It lies in the groove between the longus colli and scalenus, so that the jugular vein must now be held inwards; the dissection already made will have so nearly exposed the artery that a few touches with a director will lay it sufficiently bare to allow the passage of the needle. The position of the phrenic nerve on the anterior scalenus, outside and a good deal in front of the vessel, guards it against much risk of injury, but still it must be carefully avoided. The operator must not mistake the inferior thyroid (which is, however, much smaller, and usually at this part external) for the vertebral[1] itself.

As a c. Stonham's case of ligature of the first part of the left subclavian for aneurysm of the first and second parts of this vessel[2] is one of the few cases in which this operation has been completed and ended successfully, the following details are given. They emphasise in the strongest way the need of removing the inner part of the clavicle in these cases (p. 717). The patient being in the usual position, with shoulders raised, "a vertical incision about six inches long was made parallel to the sternal head of the sterno-mastoid, the centre being over the sterno-clavicular joint. In its lower half the incision was carried right down to the sternum; a second incision was then made along the inner half of the clavicle, the knife being here also carried down to the bone. The inner part of the clavicle, for about an inch and a half isolated subperiosteally while the deeper parts were protected, was removed. The floor of the wound was now seen to consist of a portion of the clavicular periosteum, a layer of the deep cervical fascia, and muscular tissue. By means of two pairs of dissecting-forceps the outer edge of the muscular layer was clearly defined, the muscles being the sterno-hyoid and sterno-thyroid; these were drawn inwards. Further blunt dissection revealed the carotid running vertically upwards along the inner border of the wound, which was now becoming very deep. On the outer side and below was the dome of the pleura, covered by the junction of the subclavian and internal jugular and a short piece of the left innominate vein. These veins were drawn carefully downwards and outwards, when, deeply behind them, about two-thirds of an inch of the subclavian artery was revealed, surrounded by a little loose fat. The thoracic duct was not seen, nor any veins or nerves other than those mentioned." The artery was now tied with little difficulty by means of a ligature of salicylic-acid floss

[1] In certain cases the aneurysmal sac overlying the vertebral artery renders it inaccessible.

[2] *Lancet*, August 2, 1902.

it passed from within outwards by means of a curved aneurysm needle. The ligature was tied with a surgeon's knot, only sufficient force being used to occlude the vessel.

Within two months of this skilfully performed operation the aneurysm was again enlarged and pulsating. By means of an incision similar and a little external to the first, a triangular flap was turned outwards and upwards. The two heads of the clavicular head of the sterno-mastoid were drawn outwards and the internal jugular vein exposed. Blunt dissection external to the vein exposed the anterior scalenus and phrenic nerve. The jugular vein was drawn inwards, and the muscles outwards. The transverse process of the sixth cervical vertebra was exposed. A vessel of no great size was now defined in the position of the vertebral artery, and was ligatured with silk; the ligature, fortunately left long, dividing the vessel, which was secured with difficulty, and tied at both ends. No other vessel could be found in this situation, though the foramen through the transverse process could be clearly defined. A second vessel, the inferior thyroid artery, was also tied." As ligature of these two vessels did not arrest, though it materially diminished, the pulsation in the sac, a distal ligature was applied to the third part of the axillary just above the subscapular branch. Complete arrest of pulsation followed. The aneurysm was eventually completely cured. Mr. Corbain saw his patient nearly three years later, when he could [illegible] and was doing light work as a carpenter.

Ligature of the Internal Mammary Artery. The internal mammary artery, a branch of the first part of the subclavian, runs downwards [illegible] outer side of the external border of the sternum. Behind [illegible] while in front of it are the cartilages of the upper six [illegible] and below, the triangularis sterni. It thus crosses the [illegible] costal spaces about half an inch from the sternum. The vessel may [illegible] secured for hæmorrhage after a stab, or it may be injured during [illegible] resection of the sternum or ribs. It is occasionally set as an operative surgical test. A transverse incision is made, about two inches in length, with the centre just external to the margin of the sternum, in the line of the [illegible] intercostal space. The anterior intercostal membrane, the internal intercostal muscle, and the layer of fascia on the deep aspect of this are divided, and the vessel accompanied by its companion veins will then be found resting upon the pleura. Care must be taken not to damage the latter structure.

LIGATURE OF THE INNOMINATE

There have certainly been over twenty cases [illegible] about five have the patients survived.

One of these is the [illegible] shown on the part of Dr. [illegible] New Orleans,[1] which occurred before the days of [illegible] cond, under the care of Sir W. Mitchell Banks [illegible] ned. A third successful case of ligature of the [illegible] has published by Dr. Lewtas, of the India Medical Service. The [illegible] an aneurysm here was a traumatic one [illegible] only [illegible] ruration, the artery was healthy, and the patient [illegible] 20.

A month before his admission a piece [illegible] h of a bursting gun had lodged above the right clavicle. A swelling [illegible] of a fœtal head occupied the lower part of the posterior triangle, [illegible] nonch and not pulsating. From a partially healed wound brownish [illegible] en oozing for three days. As the

[1] *Surg. Soc. Rep.*, 1865-6, p. 316.
[2] *Brit. Med. Journ.*, 1889, vol. ii. p. 312.

[illegible] removal of the foreign body, and as the case seemed to be [illegible] upon, the opening was enlarged sufficiently to admit the [illegible] fragment of steel, weighing three drachms, removed with [illegible] followed by an alarming rush of blood so precipitate as to [illegible] discovery of the bleeding point. Fortunately the finger detected [illegible] in the subclavian below the scalenus anticus and by pressure an [illegible] of the hæmorrhage. The patient's condition being desperate, [illegible] was determined to tie the innominate and carotid. This was done by an incision [illegible] sternal head of the sterno-mastoid, dividing the sterno-hyoid and sterno-thyroid muscles. Two ligatures were secured with [illegible] ligatures. A drainage tube was carried into the cellular cavity of the mediastinum, some of the sutures [illegible] and the wound closed. The patient made a rapid recovery.

Mr. Clippinger briefly mentions a case in which he successfully tied the innominate for a large subclavian aneurism. A vertical incision was employed, and silk was used for the ligature. The case was seen at St. Bartholomew's Hospital in 1892, and the patient was quite well, no trace of the aneurism remaining.

Another brilliantly successful case, one most encouraging to the surgeon, was under the care of Mr. [illegible] Edmunds, who supplied the following notes.

"Mr. McCann, aged 54, was admitted [illegible] for a subclavio-axillary aneurism. The most prominent part of the tumour was above the clavicle. The supraclavicular swelling extended towards under the trapezius [illegible] swelling at the border of the sternum. It was just possible to limit the finger between the tumour and the clavicle, so that the artery would be subclavian in its second part, and [illegible] to ligature the first part of the subclavian, and at the [illegible] to secure the innominate. On November 5 a vertical incision [illegible] sternal muscle between the two heads of the sterno-mastoid muscle and [illegible] the first part of the subclavian was identified. On an [illegible], a short sharp gush of blood occurred, which stopped on withdrawing the finger. A further dissection of the artery was made, but again, on passing the finger, the hæmorrhage was repeated with greater force. Pressure of the finger stopped it at once, and, though the pressure was removed, the hæmorrhage was not repeated. As apparently some large branch of the thyroid axis was injured it was decided to ligature the innominate. The sternal head of the sterno-mastoid was, therefore divided, and an incision made in the median line. Thus, there were two vertical incisions joined by a transverse one along the inner third of the clavicle. The sterno-hyoid and thyroid were divided, and subsequently sutured with catgut. The common carotid was easily reached, and surrounded with [illegible] tape. Slight traction was then made upon this: the beginning of the innominate was identified, and then the innominate brought into view. This was secured by a silk ligature, and the wound closed. The muscles were sutured with chromic gut. The ligature was of stout floss silk. After a few days two openings appeared, one over the inner end of the clavicle and one in the first vertical incision. Through both of these several pieces of catgut came away, and one piece of silk. The man made otherwise an uninterrupted recovery, the pain gradually disappeared, and the aneurism became quite hard. When seen in June 1895 the usefulness of the right hand and arm was gradually returning: the aneurism was hard, but still pulsatile. There was no pulsation in the brachial or radial. The carotid could be felt above the ligature."

Dr. H[illegible] published a carefully reported case of ligature of the innominate for aneurism of the right subclavian and axillary. A fatal result in this case did not occur from cardiac collapse (the heart being dilated and hypertrophied) three months after the operation, the wound having healed in seventeen days it must be considered a successful one.

[1] *Lancet*, 1893, p. 243.
[2] *Boston Med. and Surg. Journ.*, August 8, 1895.

The following points are of much interest: (1) The inner end of the clavicle, the sterno-clavicular joint, and the right half of the notch of the sternum for about an inch, were removed (p. 717). (2) The fusiform aneurysm of the subclavian and carotid extended on to the innominate itself, sufficient space being left to place a ligature between this fusiform extension and the aorta. Two ligatures of flat-braided silk were used.[1] The first was placed three-quarters of an inch from the aorta. Both were tied in "square knots." Fully three minutes were taken in tying the first ligature, this being gradually tightened until the circulation was completely cut off. The second ligature was placed, in the same manner, half an inch higher up. As each ligature was tightened the coats were felt to give way. At the necropsy the innominate showed an extreme degree of endarteritis. The artery was occluded by the upper ligature; by the lower one it was severed, consecutive healing along the line of severance having taken place. Continuity of the lumen of the artery had followed here, and the ligature was found within the vessel, probably covered by a thin layer of the intima. While the fusiform aneurysm had shrunk, very little clot had formed at the site of the ligature. For this reason Mr. Burrell, in another case of fusiform aneurysm in this situation, would tie the carotid, if possible the subclavian in its first part, and, if practicable, the vertebral. It is noteworthy that the operation took an hour and a half, and that though the patient, with general arterio-sclerosis and a dilated and enlarged heart, was under the influence of ether all this time, no ill effect followed.

The extreme danger of the operation is due partly to difficulties which may be met with at the time of its performance—difficulties which have driven most skilful surgeons to abandon the operation—but chiefly to the frequency of secondary hæmorrhage.

Sir W. M. Banks' case terminated in death from hæmorrhage on the thirty-seventh day after ligature of the first part of the subclavian, subsequent to ligature of the innominate. The patient, a man aged 50, had a well-marked aneurysm of the third part of the right subclavian. The common carotid was also tied. Mr. Jacobson's case, fatal on the tenth day from exhaustion brought on by incessant restlessness in an alcoholic patient, with probably some infection of the wound, is described at p. 719.

Two more recent cases, each finally successful after other operations which emphasise the gravity of this condition, must be alluded to. They are recorded by Mr. Sheen, of Cardiff,[2] and Dr. B. F. Curtis.[3] Mr. Sheen's paper contains full references to other cases.

Mr. Sheen's patient was 46. The aneurysm affected the second and third parts of the right subclavian. The innominate was reached by a five-inch median incision, without removal of bone, and the vessel tied with stout floss silk (No. 2 pearl silk) passed double round the artery and tied by Ballance and Edmunds's stay-knot. The carotid was also tied. Pulsation returning in the aneurysm, an unsuccessful attempt was made about six weeks later to again tie the innominate. After another interval of a fortnight, the second part of the subclavian was ligatured with No. 4 Chinese twist tied in a surgical knot. The aneurysm consolidated, and the patient was well eight months after the first operation.

In Dr. Curtis's case a free median incision was made, the manubrium sterni divided in the middle line and transversely above the right second rib. The innominate was tied with a double stout chromic gut ligature, the inner coat not being divided; a single similar ligature was placed a quarter of an inch distally to the first. Pulsation returned four days later. About three months later the carotid and first part of the subclavian were tied; the innominate was impervious, the pulsation in the sac being attributed to some branch of the first part of the subclavian. When last seen, eleven months later, the patient was well and apparently cured of his aneurysm.

Whatever material he employs, the surgeon must have several ligatures reliably sterilised, as their breaking is still an accident to be prepared for.

[1] Two ligatures are considered necessary, "one to act as a breakwater by obstructing the constantly recurring waves of blood coming from the aorta."

[2] *Ann. of Surg.*, July 1903.

[3] *Ibid.*, October 1904.

With regard to the best material for ligature in these cases where the artery is perhaps diseased, where the blood will be driven against it with much force, as it was pointed out in the last edition of this book, Mr. Symonds's and Mr. Coppinger's successful cases with silk have gone far to help on this point. Mr. Sheen's case, successful with a silk ligature, corroborates this view, and gives weight to his remarks: "Too much importance has been attached to the question of the best material for

Fig. 292. Artery ligatured with kangaroo-tendon (X3) without rupture of its coats, to show the folds into which the wall of the artery is thrown by a kangaroo-tendon ligature when the coats are uninjured. Transverse section made immediately above the ligature; there are three main folds, the middle or largest of which is under the knot.

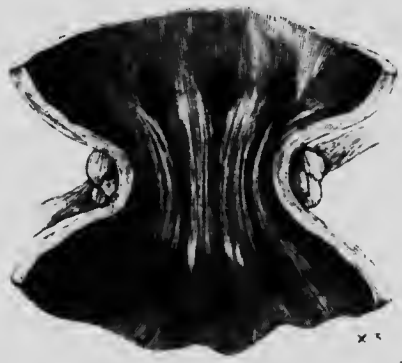


Fig. 293. The same artery opened out by a longitudinal incision passing through the knot and the artery wall beneath it. The arrow in the left figure indicates the line through which this incision was made. The knot is seen cut in two, and the folds of the artery wall are exposed, the largest being divided and the halves turned aside. Each fold has secondary folds, indicated by the longitudinal lines on their surface.

(Ballance and Edmunds.)

ligature, fatal results having been attributed to defects in the ligature, when they have really been due to infection at the site of ligature. Silk, as being strong and certainly sterilisable, is the best material. Whether floss-silk or Chinese twist does not matter." While success has been obtained by a few operators with different ligatures tied in different ways, when we turn to the results of experiment we are struck by the diametrically opposite conclusions at which workers have arrived as to the most useful form of ligature and the best means of tying it.

This, shown by the papers of Mr. Ballance and Mr. Edmunds, "The Ligation of the Larger Arteries in their Continuity: an Experimental Inquiry"[1]; "Ligation of the Great Arteries in Continuity, with Observations on the Nature, Progress and Treatment of Aneurysm" (1891); and Mr. Spencer's "Experiments on Ligation of the Innominate"[2] The first-named writers have arrived at the following conclusions: (1) That the operation of ligature of a large artery in its continuity should be performed without danger to its wall. (2) That the rupture of the coats of an artery during ligation in continuity is a useless and dangerous proceeding: useless, because the surgeon can secure the effectual occlusion of the vessel by a measure at once safer and less severe; and dangerous, on account of the possible occurrence of haemorrhage or secondary aneurysm at the seat of ligature, which could not happen if the wall of the vessel were uninjured by the ligature. (3) That, if the artery be diseased, the advantages attending ligation without rupture of the tunics are much magnified. It sometimes happens that the surgeon, on cutting down upon a large artery, observes a state of atheroma so extensive that he is obliged

[1] *Med.-Chir. Trans.*, 1886, p. 443.

[2] *Brit. Med. Journ.*, 1889, vol. ii. p. 73

to close the wound and ligate a vessel nearer the heart, and thus expose his patient to considerably increased risk. There is no escape from such a dilemma under the system which declares that the arterial coats must be divided; but with a non-irritating aseptic ligature, so applied as not to lessen the power of the arterial wall, but actually to be a source of additional strength to it, the question of ligation is seen under entirely new auspices, and the occlusion of a diseased artery would be undertaken with an assurance of success almost equal to that which obtains when a healthy vessel is in question. (4) That, when the coats of an artery are uninjured by the ligature, the danger of ligation near a large collateral branch is wholly avoided, because (*a*) no danger can accrue from hemorrhage when the wall of the vessel is intact; (*b*) the formation of clot, upon which the safety of the patient so

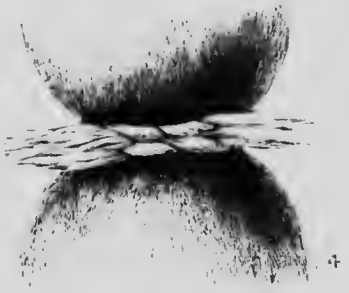


FIG. 294. Floss-silk stay knot (first stage). Represents two floss-silk ligatures side by side (X4). The first half of a reef-knot is tied on each in the same way. The two ends on either side, being treated as one, are drawn up so to occlude the vessel. The hitches are at the bottom of a deep groove, and are seen to fit into one another.

FIG. 295. Floss-silk stay knot (completed). Shows the knot completed by using the two ends on each side as a single cord, and by tying the second hitch as if completing an ordinary reef-knot. The ligatures may also be tied seperately.

(Ballance and Edmunds.)

much depends if the wall of the vessel be damaged, has really nothing to do with the adhesive changes which take place in a ligatured vessel; (*c*) the plastic actions which proceed at the place of ligation are practically alike, whether the tunics be ruptured or not. (5) It would appear that a small round aseptic ligature which will not become absorbed in less than three weeks, and which during that period holds firmly so as to cause a constriction of the arterial wall, and complete, or almost complete, obstruction of the cavity of the vessel, will so influence the nutrition of the part that permanent occlusion will follow. It is pointed out that by the use of two ligatures a greater length of the intima of opposite sides is brought into contact. (6) That it is no more necessary to use a flat tape-shaped ligature (as revived by Mr. Barwell to prevent damage to the arterial coats during ligation) than to rupture the coats of the vessel. The small round ligature is the most easy to manipulate, and it is not difficult to learn to apply it in the manner here indicated. Mr. Sheen is inclined to take the opposite view with regard to the degree of tightness with which the ligature should be tied. "Injury to the inner coats becomes a dangerous factor only when, in addition to such injury, sepsis is present." Mr. Sheen places in order of preference the methods suitable for occlusion of the innominate as follows: (*a*) Two separate ligatures tied with the special object of preventing the first hitch slipping, which is probably, to a large extent, brought about by the force of the blood pumped from the aorta. Two strands are passed beneath the vessel if possible half an inch or more apart. The first turn of a surgical or reef-knot is then made in the proximal ligature and tightened, pulsation ceasing in the vessel beyond and in the aneurysm. This first turn in the proximal ligature is then held tight, and the force of the pumping blood being thus taken off the part of the vessel encircled by the distal ligature, the latter is completely tied by a surgical or reef-knot. Finally the second turn is taken in the proximal ligature and fixes it. (*b*) The "stay-knot." (*c*) A single ligature tied in a surgical knot. Some amount of damage to the inner coats would be particularly essential in the last method.

Mr. Spencer, from his results of ligature of the innominate in monkeys, also advises silk, concluding that the best ligature is one of Chinese twist silk which has been kept in five per cent. carbolic acid, and boiled in that solution before being used. A silk ligature can be thus "rendered more thoroughly aseptic than any other without injuring its strength, and, being aseptic, it will remain quiet in position without relaxing. The ligature should be tied right to divide the internal coats."

The Question of using Drainage. If all oozing can be stopped and the wound be left dry, it should be completely closed. If any oozing were going on it should be drained either by a strip of sterile gauze or by a small drainage-tube.

As to **selection of cases,**[1] the following words of Mr. Holmes should be remembered. The operation "should never be performed, however, unless the artery can clearly be felt healthy behind the sterno-clavicular joint,[3] or the tumour is so plainly limited as to afford a very reasonable hope that it will be found so. In cases of tubular enlargement of a long tract of artery in the neck, it is more than useless to expose an artery which will probably be found so diseased as either to prevent the operator from the attempt to tie it, or to give way and occasion fatal bleeding within a few hours if it be tied."

The following are amongst the *precautions* indicated:

(1) Rigid aseptic precautions persevered with till the wound is soundly closed. (2) Use of a reliable ligature in securing the innominate (probably diseased) viz. one of sterile kangaroo-tail or silk with care, as far as possible, that the knot is not a hard one and does not press strongly on the vessel towards the artery.

(3) Securing the carotid artery at the same time. By this, in Mr. Spencer's words, "a thrombus is then formed in the proximal end of the carotid, which extends to the bifurcation, and thus aids a thrombus in forming in the first part of the subclavian as far as the vertebral; otherwise the blood-flow will pass from the subclavian to the carotid close by the distal side of the ligature of the innominate, and so the operation will lack one of the important characteristics of a Hunterian ligation." (4) Obliterating the cavity and all pockets as thoroughly as possible, after every care has been taken to check all oozing and to leave a dry wound, so as to prevent formation and collection of discharges.

(5) Keeping the patient absolutely at rest till the wound is soundly healed, morphia being used subcutaneously, and any tendency to cough checked at once if possible.

Line and Guide. The vessel, one to two inches long, extends along a line drawn from the middle of the junction of the first with the second bones of the sternum to the right sterno-clavicular joint (Holden). Its point of bifurcation varies somewhat.

Relations:

In Front

Sternum: sterno-hyoid; sterno-thyroid.
Left innominate and right inferior thyroid vein.
Inferior cervical branch of right vagus.

[1] A radiographic examination will afford important evidence of the extent of the aneurysm, especially as to whether the innominate artery and the aorta are involved.

[2] *Syst. of Surg.*, vol. iii, p. 442.

[3] As Mr. Holmes remarks in a footnote, "if the shape of the bones or joints is altered, it is clear that the aneurysm arises in the thorax."

Outside		*Inside*
Right innominate vein.	Innominate artery.	Left carotid.
Right vagus.		
Pleura.		

Behind

Trachea.

Collateral Circulation. This is thus given by Sir W. MacCormac (Ligature of Arteries, p. 75):

Cardiac Side		*Distal Side*
First aortic intercostal.	with	Superior intercostal of subclavian.
Upper aortic intercostals,	with	Thoracic branches of axillary and intercostals of internal mammary.
Phrenic,	with	Musculo-phrenic of internal mammary.
Deep epigastric,	with	Superior epigastric of internal mammary.

Free communication of vertebrals and internal carotids of opposite sides inside the skull. Communication of branches of opposite external carotids in the middle line of the face and neck.

Operation. The patient having been brought into as satisfactory a condition as possible by preparatory treatment, which must include the leaving off for some days all lowering treatment, such as that of Valsalva, the whole area of the operation having been sterilised with scrupulous care, the head, body, and arm are placed as in ligature of the subclavian (p. 702). The surgeon, standing in front, makes an incision along the inner half of the clavicle, and another along the anterior border of the sterno-mastoid and upper part of manubrium, meeting the first at an acute angle, each incision being four inches long. The flap thus marked out having been dissected up, the heads of the sterno-mastoid and the sterno-hyoids and sterno-thyroids are divided. This incision was made use of by Mott when he tied the artery in 1818. The fact that it had been employed in successful cases indicates its adoption to begin with, but the surgeon must always be prepared for the need of removing part of the clavicle and manubrium. The above incision has the serious disadvantage of dividing muscles which retract much and leave a large, gaping, deep wound, the difficulty of draining which has already been alluded to. Where the presence of a large aneurysm with one or more processes to its sac increases enormously the difficulties of this operation and thus calls for free access to the important parts dealt with, this division of muscles will be found needful. Mr. Spencer, from his experiments on monkeys, advises the use of a single median, vertical incision, made as if for a low tracheotomy, retracting the sterno-mastoid, sterno-hyoid, and sterno-thyroid, opening the sheath and tying the carotid, and then following this down as a guide to the innominate. He argues rightly that if the muscles be retracted only, and not divided, when they are released they will come together, so that no cavity will be left in the deeper parts of the wound. Sound as this reasoning is, there is no comparison between ligature of the innominate in monkeys and the same operation under the con-

ditions which usually call for it in man. Every atom of room will be required, not only on account of the importance of the parts dealt with, the great enlargement of the veins, the presence of a dilated subclavian, a process of the aneurysm extending inwards, or a hugely expanded vertebral as in the case mentioned at p. 702, but also because the surgeon may feel bound to give his patient the benefit of a less risky operation, and thus be driven to divide the sterno-mastoid in order to examine the fitness for ligature of the second part of the subclavian.

The muscles may be divided in a case of any real difficulty, at a point an inch and a half above the clavicle. If they are divided just above this bone the ends retract behind it, rendering the introduction of sutures impossible. During these preliminary steps one or two small arteries may be divided and some enlarged veins connected with the inferior thyroids drawn aside or tied with double ligatures; and, in reflecting the above-mentioned flap, the presence of the anterior jugular passing outwards beneath the sterno-mastoid just above the clavicle must be remembered.

The above muscles, when cut, being carefully held out of the way, and a layer of deep cervical fascia varying in strength divided, the pulsation of the carotid is defined, and its sheath opened to the inner side and as low down as possible. Other guides will be found, in the trachea and the subclavian artery, to lead the finger down to the innominate.

The carotid having been traced down, the innominate will be found bifurcating into the carotid and subclavian. It is now that the real difficulties may be met with. (1) Owing to engorgement of the venous circulation, increased by the anæsthetic, the internal jugular and innominate vein may be so much enlarged as to protrude into the wound. (2) An aneurysm may have extended under the artery and flattened it out so as to make it difficult of recognition. (3) The cellular tissue round the vessel and between it and the sternum may be so matted with adhesions as to make it difficult to define the artery and its important relations on the right side, viz. vagus, pleura, and right innominate vein. (4) The artery itself may be greatly diseased and expanded. (5) The bifurcation of the artery may be quite an inch below the joint.

In tracing down the innominate itself, the surgeon must keep his instruments most carefully on the front of the artery. In following the vessel down behind the sternum in order to find a site for his ligature, he will be aided by slightly flexing the head, and if needful by an electric headlight. The cleaning of the artery must be done with the utmost caution, especially on the outer side, owing to the important structures lying there; of these the innominate vein and the vagus may be drawn outside, but it is only by keeping the director or needle-point very close to the artery here that injury to the pleura can be avoided.

If there be doubt as to the position of the artery, pressure with the finger behind the vessel against the sternum will arrest the pulsation in the carotid and the aneurysm. If the bifurcation of the artery lie, as in the case mentioned at p. 719, a full inch below the joint, attempts should be made, by pulling up the carotid protected by a piece of aseptic gauze, to raise the bifurcation sufficiently for the passing of the ligature. The method mentioned at p. 719 is preferable to dragging on the vessel by the ends of a ligature previously tied round the carotid, and left long. If it be impossible thus to raise the bifurcation sufficiently, the inner end of the clavicle must be removed by disarticulating and sawing through the

bone; as much of the manubrium as is needful is also removed, partly by a vertical and a transverse cut just above the second rib with a saw, partly with a chisel. Dr. Burrell (p. 711) considers this step essential.

He quotes Bardenheuer [1] as convinced that ligature of the innominate can only be intelligently carried out by resection of part of the sternum and sterno-clavicular joint.

Mr. Ballance [2] split the manubrium, bisecting it vertically with a saw and chisel, and at the level of the upper border of the second costal cartilages added transverse incisions. Pulling apart the two halves did not afford the desired access, so about half an inch of bone was removed on either side of the vertical incision. After this retraction was very effective. Mr. Ballance considers the above method of splitting the sternum [3] inadvisable in these cases.

The needle should be passed from without inwards and a little from below upwards to avoid the pleura. In this case, as in that of the subclavian and other deeper-seated arteries, the surgeon will do well to provide himself with needles of different curves (of these the late Mr. Durham's needle, in which the curve is twisted laterally at a right angle to the shaft, is a very helpful one), or with a silver probe sufficiently flexible to take any curve, and with a large eye close to the point.

The needle should be loaded with thoroughly sterilised silk, or, if preferred, after the needle has been passed, flat ligatures of reliable and sterilised kangaroo-tail should be secured, and then pulled beneath the vessel. The material and mode of securing the ligatures, the latter still an especially moot point, have been alluded to at p. 713. Care should be taken to keep the ligature flat around the artery while tying it, and the knot as little projecting (especially towards the vessel) as possible.

In addition to the amount of force used, the surgeon will, by watching the aneurysm—all pulsation in which should have ceased—derive some information as to the extent to which he has constricted the vessel. No doubt severing the vessel between two ligatures would ensure more rest of the parts which have to heal, but the size of the vessel, its probable condition, the doubtfulness as to whether its lumen is completely closed, and the difficulty of placing the ligatures sufficiently far apart, forbid the adoption of this step. The ligatures having been tied and cut short, the common carotid should be tied also, about half an inch above its origin. If the thyroidea ima arise from a point at which it is likely to bring in a reflux current which will dangerously disturb the clot, on which so much depends, this vessel should be tied also.[4]

The wound is now carefully cleaned and dried, the severed muscles united with chromic-gut buried sutures, hæmorrhage most scrupulously stopped, drainage employed, if needful, and the wound carefully closed. The limb, previously wrapped in cotton-wool, should be secured to the side and chest, and every attempt made, by elastic bandaging, to keep the dressings firmly in place, and thus promote, from the first, steady adjustment of the parts and sound healing. Morphia should be used as freely as is safe, to diminish, as far as possible, the sensibility of the patient to the irksomeness of his position. The slightest tendency to cough should be treated at once. The absolute need of rest

[1] *Mittheilungen aus dem Kolner Burger-Hospital, Estes Heft.* 1886.

[2] *Lancet*, November 1, 1902.

[3] Milton, *Lancet*, March 27, 1897.

[4] This was the case in Lizars' patient (*Lancet*, 1837, vol. ii, pp. 445, 602; Spencer, *loc. supra cit.*).

and quiet should be enforced upon the patient until the wound is soundly healed. The following case of ligature of the innominate which was under Mr. Jacobson's care will illustrate some of the difficulties which may be expected:

A. H. was sent to Mr. Jacobson by Dr. Lockhart Stephens, of Emsworth, February 1890, with a large subclavio-axillary aneurysm. The man gave his age as 48; he looked ten years older, and was stout and flabby, with chronic bronchitis and emphysema. Occupying all the lower part of the posterior triangle, and to be felt in the axilla and between the heads of the sterno-mastoid, was a large aneurysm, six inches by four inches. There was no evidence that the innominate itself was involved. Patient had first noticed the swelling a year before, when it was about the size of a walnut. He had been doing his work as a gamekeeper, till two weeks before his admission, February 10. Chloroform having been given and the parts cleansed, an incision three inches and a half long was made along the anterior margin of the sterno-mastoid, and another transversely outwards, just above the clavicle, over both heads of the sterno-mastoid to a point over the inner part of the aneurysm. The skin and both heads of the sterno-mastoid were divided together, with the hope of keeping the skin down better when the wound was closed, thus better obliterating the large wound and ensuring earlier healing. The sterno-hyoid and sterno-thyroid being divided, two very large inferior thyroid veins secured, and the internal jugular drawn outwards, the inner part of the carotid sheath was opened and this artery traced down to the innominate. The chief difficulty at this stage was due to what was thought to be a pulsating process of the aneurysm, which extended inwards under the jugular and carotid, but was really a hugely dilated vertebral. The carotid being traced down it was found impossible to pass a ligature below the bifurcation, which lay a full inch lower than the joint. In spite of the assistance given by the late Mr. J. N. Davies-Colley, who drew up the carotid, protecting the vessel with a bit of gauze wrung out of carbolic lotion, it was impossible to get a finger or a director sufficiently deep behind the clavicle to make sure of being below the bifurcation. The inner extremity of the clavicle was accordingly removed. It was now possible to bring just the top of the bifurcation into view. More than this was impossible, and the aneurysm needle was passed by touch round the innominate from without inwards. It was previously loaded with silk, to which a piece of ox-aorta ligature, kindly provided by Mr. Barwell, was knotted. In tying the vessel Mr. Jacobson used force sufficient to close it, but not to injure its coats. Judging from the outside, the walls were well puckered together. Pulsation in the aneurysm ceased at once, and never returned. The carotid was then tied, with a similar ligature, about an inch above its origin, not only to prevent any efflux of blood through it, but also because the vessel was probably weakened by much handling. By the third day the aneurysm began to shrink markedly, but the following night the patient began to be restless and delirious, and this increased and persisted. It was most difficult to keep his right arm still, and before long it was needful to secure him with straps. Morphia, sulphonal, chloral, chloralamide, hydriodate of hyoscyamin, were all tried, with very little result. There was also evidence of broncho-pneumonia at both bases. The restlessness and chattering delirium continued, and, in spite of the abundance of food taken, the strength became exhausted, and the patient sank on the tenth day. At the necropsy the wound was found to be perfectly sweet, without a trace of pus, and levelling up well. A large sacculated aneurysm occupied the second and third parts of the subclavian and the first and second parts of the axillary. In addition to the main sac, which occupied the posterior triangle, a hemispherical dilatation projected into the upper part of the right pleura. Encircling the innominate, just below the bifurcation, which was on a level with the first costo-sternal articulation, were the remains of a ligature, but no knot could be found, and the ligature was movable with the point of a director. Surrounding the bifurcation of the innominate was a small cavity, from which could be squeezed not more than a drachm, if so much, of quite sweet pus-like fluid. The carotid had been tied about a quarter of an inch above the top of the sternum, and here, too, the wall of the vessel was very soft, so that in dissecting it a hole was made in the vessel above the ligature. The knot, however, had held well in position. Running behind the carotid sheath, and given off from the subclavian immediately after its origin, was a long fusiform dilatation, which was probably the vertebral much dilated, as large as the forefinger. A small window being cut in the aneurysm showed that this was filled with a greenish-tinted jelly-like coagulum, not blood-

stained, and traversed in every direction by isinglass-like threads. The only remnant of a cavity was quite at the back part, where a space into which the tip of the finger could be introduced contained a little fluid blood. The inner aspect of the sawn clavicle was smooth, with granulations save just at its upper part. Both bases were the seat of broncho-pneumonia. It is quite possible that this was infective, as no bacteriological examination was made of the very small amount of fluid in the wound, but if so the degree of infection was slight, as the first three days passed without unfavourable symptoms, and the patient survived till the tenth day. It should be noted that the man had chronic bronchitis before the operation. The mediastinal connective tissue was extensively occupied with air; this had not penetrated beneath the pulmonary pleura, nor produced interstitial emphysema. The aortic and mitral valves, the latter especially, were diseased; the aortic arch was the seat of atheroma, dilated uniformly, irregular on the surface and rough internally, but not calcareous. The kidneys showed early interstitial nephritis. There was a small hard mass of clot in the innominate, below the ligature, little in the carotid. The brain was normal.

Causes of Death after the Operation. It may be expected that most of these will, with septic precautions, disappear, viz.:

(1) Infective cellulitis and mediastinitis.
(2) Lung trouble, *e.g.* bronchitis, pleuro-pneumonia.
(3) Cerebral softening.
(4) Pericarditis.

There still remains the terrible complication of secondary hæmorrhage which has occurred, as yet, in almost every instance.

Secondary hæmorrhage may occur up to the sixtieth day. It has already been discussed how far modern surgery is likely to prevent this, and certain precautions have been enumerated at p. 713. The treatment, as shown, is mainly preventive. When once bleeding has occurred, little can be done beyond tying the vertebral and common carotid, if this has not already been performed, plugging the wound with gauze and putting on pressure.

The treatment of recurrent pulsation in the aneurysm by ligature of such vessels as the carotid and subclavian has been illustrated by the cases already given.

SURGICAL INTERFERENCE IN ANEURYSMS OF THE INNOMINATE AND AORTA

While the distressing nature of the cases justifies a resort to surgery when medicine fails, it may be pointed out: (1) That the surgeon is often called in too late in large thoracic aneurysms where treatment of any kind is certain to be unsatisfactory. (2) The fact has been too much lost sight of, that large thoracic aneurysms, with their size, varying degree of saeculation, restricted power of collapse, and important surroundings, are on quite a different footing, for operative interference, from aneurysms of the extremities. Further, the disease here is much less often a local one. (3) That, with regard to the amount of relief which surgery can fairly be expected to give, when the large number of cases, published and unpublished, which have been treated surgically in the last few years are duly weighed, when the difficulties of diagnosis and the risks of operation have been considered, it is clear that permanent cures are extremely few; and that while in some cases decided relief is given, in many published at the time as successes, were the sequel followed up, it would be found that very little real relief had followed, while in not a few, what with the risk of the anæsthetic, the excited circulation, the partial cure of the aneurysm in one direction, and the tendency set up to spread

at another spot, possibly less able to bear the strain [1] and perhaps with more important surroundings, surgery has not only failed to check but has actually hastened the progress of the aneurysm.

The advisability of resorting to surgical means will be considered under the heads of: A. Diagnosis; B. Treatment, the latter including: (1) Ligature, (2) Introduction of Foreign Bodies, (3) Galvano-puncture.

A. Diagnosis between Innominate and Aortic Aneurysms. While a precise diagnosis is usually impossible, no pains should be spared in going into those points which may help in deciding how far the aneurysm is probably limited to the innominate or to the aorta, and, in the case of this vessel, which part of the arch is chiefly encroached upon, for it is only by paying attention to the above points that answers can be given to the two questions which arise, viz. (1) Is any operation justifiable at all? (2) If an operation is justifiable, what is it to be?

Chief Points to pay Attention to in Diagnosis. (1) *The Position of the Aneurysm.* This is obviously only of value in a few cases, when the patient is seen early, or when he can be relied upon for an intelligent history of his case. Mr. Wardrop's rule was, that innominate aneurysm first presents itself to the inner side of the right sterno-mastoid, carotid aneurysm in the interval between the two heads, and a subclavian one to the outer side of the muscle. Mr. Barwell [2] writes of the first of the above thus: "The tumour of an innominate aneurysm generally occupies the episternal notch, but chiefly on the right side, and, even though it may not rise high, takes up the whole breadth of this space. On gently pressing the finger backward and downward, the rounded margin of the sac can be felt. After a little time the sternal end of the clavicle protrudes abnormally, and partakes in the pulsation (communicated), while the sternal and, afterwards, the clavicular portions of the sterno-mastoid are also pushed forward. Not unfrequently the first costal cartilage, outside where it joins the sternum, is also abnormally prominent, and throbs with the beat of the tumour."

(2) *The Pulse.* If a decided diminution be found in the right radial and carotid, the aneurysm is probably of the innominate; but an aneurysm near the root of the innominate will bring about the same result.

(3) *Pressure Symptoms.* These will vary with the position as well as the size of each form of aneurysm. Thus, in innominate aneurysm pressure symptoms will vary according as the sac is high up or low down, and pressing inwards or outwards. As to œdema, the value of this, remains undecided while surgeons hold such opposite views.

(4) *A careful X-ray examination* will throw much light on the position size, and extent of the aneurysm.

The other pressure symptoms, viz. laryngeal or tracheal dyspnœa and irregularity of the pupil, are not really distinctive between innominate and aortic aneurysm.

(5) *Displacement of the Heart downwards.* The more marked this is the greater is the probability that the aneurysm is aortic.

Difficulties and Fallacies in the Diagnosis. (1) The proximity of the heart. "Where there is a bruit, it is extremely difficult to distinguish

[1] The rapid extension of the aneurysm in another direction after its original growth has been checked by operative interference is well shown by a case of Dr. Churton's (*Clin. Soc. Trans.*, vol. xix. p. 261), in which, subsequently to galvano-puncture, the blood-pressure found other weak spots in addition to the original aneurysm, thus bringing about other saccular projections and fatal rupture into the bronchus.

[2] *Intern. Encycl. Surg.*, vol. iii. p. 507.

whether it is limited to the tumour, or is propagated into it from the cardiac valves." (2) "The growth of the aneurysms in the cellular tissue of the mediastinum and root of the neck is so free that instances have been observed of aneurysms of the arch of the aorta causing compression of the subclavian and carotid, without any disease of those vessels; while, on the other hand, if the aneurysm approaches the tubular shape, the pulse may be unaffected in the branches, though the trunk is extensively diseased" (Holmes).

(3) The distribution of the branches of the aorta may be anomalous.[1]

B. **Treatment.** (1) *Ligature.*[2]

Aids in selecting Cases fitted for Operation. Mr. Barwell,[3] writing on innominate aneurysms, has formulated the following aphorisms:

(i) An aneurysm commencing suddenly, especially if traceable to some over-exertion, is more likely to be benefited by operation than one arising gradually and without mechanical causes. (ii) Distinct sacculation is a most desirable condition: fusiform dilatation of the innominate indicates almost certainly a similar condition of the aorta and widespread arterial disease. (iii) If symptoms show the aortic arch to be also affected, the disease should be limited, that is, should not extend along the transverse portion. It should be of the sacculated variety, not a general dilatation of the whole calibre. Absence of any other aneurysm, especially of the rest of the aorta, must be ascertained. (iv) Absence of rasp-sound along the aorta or any other indication of extensive atheroma should be verified. (v) Aortic incompetence, unless very slight, is a decided objection, as is also mitral disease, or considerable hypertrophy of the heart. (vi) The patency of the vessels leading to the brain should be investigated by making a few seconds' pressure on the carotids alternately and then simultaneously. (vii) Absence of visceral disease must be ascertained.

Contra-indications to Operative Interference. Mr. Barwell[4] lays down the following: (1) When tumour symptoms reach widely on both sides of the middle line; (2) when, with paralysis of the left vocal cord, there is obstruction of the right bronchus; (3) when there is evidence of considerable aortic incompetence; (4) when there is mitral disease or considerable cardiac hypertrophy; (5) when there is, in the course of the aorta, the rasping sound of calcification or advanced atheroma, the more particularly if the superficial vessels are rough and rigid; (6) when there is pain about the spine and intercostal nerves; (7) when there is obstruction of the left bronchus only; (8) when there is pressure on the left apex, and expectoration of frothy blood.

Choice of Vessels. *Question of Simultaneous or Consecutive Ligature.* On this subject the following remarks of Mr. Holmes may be quoted:

(1) "One thing, I think, has been fully proved, viz. that the distinction which was so much insisted on between aortic and innominate aneurysm is of less importance in regard to the distal operation than used to be taught, and that a case of innominate aneurysm which otherwise seems appropriate for operation need not be rejected because it is suspected or known that the aorta is also involved. It has also been satisfactorily proved that aneurysms purely aortic have been much benefited by distal operations. It remains to inquire what cases should be selected, and what arteries should be tied in each case."

(2) "To my mind the clearest evidence of benefit has been in the case of ligature of the left carotid in the treatment of aneurysm affecting

[1] Mr. Holmes quotes the following instructive case: In a patient in whom, from other symptoms, there was no difficulty to account for, viz. that while the pulse in the right carotid was unaffected, that in the right wrist was imperceptible. After death the right subclavian was found to be the last branch of the aorta. Passing between the aneurysm and the spine, it had been compressed, while the carotid was unaffected.

[2] Many of the remarks below apply also to the two other methods of surgical interference—introduction of foreign bodies into the sac and galvano-puncture.

[3] *Loc. supra cit.*, p. 520.

[4] *Loc. supra cit.*, p. 528.

the transverse part of the arch." In a case of this kind it was the evident extension of the tumour up the neck and towards the trachea which made Mr. Holmes think that the ligature would prove beneficial; and the result even surpassed his expectations, the patient being alive and in tolerable health five, and probably seven, years after the operation.

(3) With regard to operations on the right side in cases of innominate or mixed innominate and aortic aneurysms, opinions vary as to whether the carotid or subclavian should be tied simultaneously, or whether the carotid should be tied first. Mr. Holmes, who holds this latter view, evidently thinks that ligature of this vessel may be sufficient without any consecutive ligature of the subclavian, unless indications arise, *e.g.* the manifest growth of the subclavian portion of the sac, or the effect of compression of the subclavian in diminishing the size or the pulsation of the tumour.

Mr. Holmes' chief reasons for preferring ligature of the carotid alone as a first step are: (*a*) that while the number of cases of simultaneous ligature is much larger, the most striking instances of success have followed ligature of the right carotid alone; (*b*) in some cases, where ligature of the subclavian has been also resorted to later, the aneurysm was already diminishing and becoming firmer after ligature of the carotid; (*c*) the simultaneous ligature of two such vessels as the carotid and the subclavian may be a very formidable undertaking from the prolonged dissection and difficulties with the anæsthetic; (*d*) as ligature of the left carotid has proved sufficient in aortic aneurysm, a similar step should be tried on the right side in innominate aneurysm.

Facts which show that the resort to Ligature has been justifiable. (1) Solidification and diminution in the size of the swelling. (2) Diminution of pulsation. In one case of Mr. Barwell's,[1] a month after simultaneous ligature of both arteries for innominate aneurysm, the swelling again began to increase, and the solidifying tumour to soften, pulsation also recurring; this went on for about two weeks, when the swelling again solidified and decreased, recovery ultimately taking place. (3) Improvement in dyspnœa, dysphonia, and dysphagia. (4) Regain of power over a limb. (5) Expectoration of mucopurulent discharge, which has been accumulating in the lungs owing to interference with expiration from pressure on the trachea.

One of the most recent reviews of the subject of the treatment of innominate aneurysm by distal ligature of the right subclavian and carotid is a critical one by Jacobsthal.[2] After investigating the results obtained by distal ligature and comparing them with other methods, he shows that the results of this operation do not warrant its performance. The immediate mortality is 55·7 per cent. In Poivet's collection of 91 cases, the cures were put down as 7·4 per cent. Jacobsthal has collected 28 more recent cases in which there were no cures, though improvement was found thirteen times.

(2) **Introduction of Foreign Bodies into the Sac.**[3] A. *Wire, Horsehair, &c.* This method was originally brought before the profession by Mr. Moore,[4] who introduced twenty-six yards of fine iron wire into an

[1] *Med.-Chir. Trans.*, vol. lxviii. p. 130.

[2] *Zeit. f. Chir.*, August 23, 1902.

[3] See a paper by Dr. Wm. C. Lusk (*Ann. of Surg.*, 1913, vol. lvii. p. 285), on Wiring of Thoracic Aneurysms. Also a discussion on the Surgical Treatment of Aneurysm before the Surgical Section, Roy. Soc. Med. (*Proc. Roy. Soc. Med.*, Surg. Sec., June 1912, p. 169).

[4] *Med.-Chir. Trans.*, vol. xlvii. p. 129.

aortic aneurysm. No relief followed, inflammation of the sac set in, and the patient died five days later. Used by itself, this method should be considered obsolete. The theoretical advantages have not been borne out in practice. The chief causes of failure have been the difficulties in introducing a sufficient amount of the filiform material; in the case of wire irritation has often followed, leading in some instances to early rupture of the sac; in that of horsehair and catgut, owing to the readiness with which they bend in the cannula, it is far from easy to get enough into the sac. And even if this were rendered feasible, it is probable that the large amount of foreign material present would interfere with the due contraction of the clot, so essential for the cure of the aneurysm. In some cases, where partial consolidation has been secured, extension has followed in another direction, causing, *e.g.* urgent tracheal dyspnœa. Further, this method is not without its special risks; the foreign material may pass beyond the aneurysm and form emboli.

B. *Needles.* While, for reasons already given, none of the surgical methods employed in thoracic aneurysms can be considered satisfactory, this one, is, perhaps, more deserving of trial.

Sir. W. Macewen, who used this method as long ago as 1875, has published [1] a most interesting paper on the use of pins to secure the formation of thrombi, and so the cure of the aneurysm.

"The instrument employed is a pin of sufficient length to completely transfix the aneurysm and so to permit of manipulation within it. Its calibre ought to be as fine as possible, the strength being only sufficient to penetrate the coats of the aneurysm and the intervening tissues. The cylindrical pin tapers to a point, like an ordinary sewing needle, and has on its opposite extremity a somewhat rounded head. As the coats of aneurysmal sacs vary in thickness, these pins must be made of various calibres. They ought to be finely polished, not only to facilitate their introduction, but to help render them aseptic. The sterilised pin ought then to penetrate the sac and pass through its cavity until it comes into contact with the opposite side. It ought to touch this and no more. Then one of two methods may be employed: either to move the pin over the surface of the inner wall so as to irritate its surface, or to allow the influence of the blood-current playing on the very thin pin to effect the same object. If the walls penetrated by the pin be dense the former method will be preferable, as the force of the blood-current produces such a feeble action on the thin pin as to be unable to move it to and fro while it is firmly grasped by the dense wall. After acting thus for ten minutes at one part, the point of the pin, without being removed from the sac, ought to be shifted to another spot, and so on until the greater portion of the internal surface opposite to the point of entrance has been touched; this ought to be done in a methodical manner. A single insertion of the pin through the sac into its interior may be sufficient to enable the point of the instrument to come in contact with the greater part of its internal surface; but, in some cases, puncture from various sides of the external wall may be necessary, so as to reach portions of the tumour which cannot be attacked from the first puncture. While the pin is in the aneurysm, it is surrounded with sterile gauze. When it is withdrawn from the aneurysm, the part should be covered with an antiseptic dressing for some days. The period a pin may remain in an aneurysmal sac without doing damage is perhaps dependent on the individual, and the state of the aneurysm, but it ought never to exceed forty-eight hours. It is questionable whether all the necessary advantages derivable from irritation of the wall of the aneurysm could not be produced within a few hours. If the aneurysm be very large, several pins may be introduced from several points, always allowing a considerable interval to exist between each, otherwise there might be too much damage to the vessel wall at one spot. When the pin has been withdrawn, though there may be a little thickening of the tissues in the neighbourhood, there will probably be little or no diminution of the eccentric impulse. Occasionally it may be weeks before any distinct or tangible thickening of the coats can be made out. In other instances this may be discernible at a much

[1] *Lancet*, 1890, vol. ii, p. 1086.

earlier period. But, as a rule, a distinct thickening of the wall can be made out at an early period."

It will be seen that the aim in Sir W. Macewen's use of acupuncture differs somewhat from that of other surgeons in that his object is to irritate the wall of the aneurysm, the irritation being carried just so far as to set up reparative exudation in the parietes, infiltration of these with leucocytes, and then a further separation of these from the blood. The irritation is set up at as many points as possible, so as to produce numerous white thrombi, and so complete occlusion as soon as possible.

The following of Sir W. Macewen's cases is of great interest.

The aneurysm was here in the thoracic area, probably of the left subclavian, and accompanied by great pain, numbness, and loss of power in the left arm. Pins were introduced on February 27, March 3, 17, and 24, a gradual thickening of the walls ensuing, as made evident by the greater difficulty experienced in penetrating the walls, a pin of very fine calibre being used at first, some much stouter and more rigid being required later on. During the next four months there was much diminution [illegible] swelling and pain. Pins were again used on five subsequent occasions, but [illegible] of them it was doubtful if any cavity was entered, their use was [illegible]. During the following months there was slow but continuous decrease [illegible], and the œdema and pain gradually disappeared entirely, the patient [illegible] able to resume all her ordinary duties.

[illegible] Sir W. Macewen said:

"I have had three cases of aneurysm treated since I wrote my paper. One at root of neck, subclavian, but involving aorta; cure absolute. One aortic, transverse arch; greatly thickened and improved; patient can go freely about and follow his usual avocation, from which he was debarred prior to operation. One, a very large popliteal, in which consolidation took place rapidly, but owing to the great pressure exercised by the aneurysm on the surrounding parts, which was apparently increased by the consolidation, incision had to be made into the sac. Firm, laminated white thrombi were found inside the sac, part of which was turned out to relieve the pressure and to preserve the vitality of the limb. The patient made a rapid recovery, and is now quite well, the remainder of the white thrombus becoming converted into dense fibrous tissue, which subsequently has undergone great shrinking."

(3) **Galvano-Puncture.** This method has for its object the production of clotting without the risks and difficulties connected with the introduction of foreign bodies, *e.g.* wire. Galvano-puncture, the introduction of filiform material, and the merits of these compared with the combined use of electrolysis and introduced wire, are discussed in a paper by Dr. Stewart, of Philadelphia.[1]

Points to Pay Attention to. (1) To avoid production of heat, pain, and sloughing of the skin, the current used should be a comparatively weak one. As an anæsthetic is not usually required, the time occupied may be considerable. (2) The needles should be of steel, as fine as is consistent with perforating the tissues, in order to diminish pain, hæmorrhage, and risk of sloughing. (3) To avoid the same risks, the needles should be insulated within about half an inch of their points by two layers of spirit varnish. (4) As it has been proved that the effect of electrolysis on blood at the positive pole is a fairly firm and tenacious dark clot, while the negative rather produces a pinkish frothy substance, it seems wiser to connect the needle or needles introduced into the sac with the positive pole, while a large sponge, wrung out of warm salt water, is connected with the negative pole and applied to the chest wall near the swelling. (5) A sitting should not be prolonged over thirty or forty minutes. The punctures had best be closed by collodion. (6) The operation should not be repeated too soon; time should be allowed for all local reaction to cease, and for consolidation of the coagulum to occur, which often takes some time.

Drawbacks and Dangers. (1) As pointed out by Mr. Holmes, it is a radical

[1] *Amer. Journ. Med. Sci.*, October 1892, *vide infra*.

defect of this method that it acts by inducing "passive" coagulation of blood in the sac. Hence it is inherently uncertain, liable to cause relapse by the melting of the coagulum, or inflammation by its too sudden deposition. Again, it is very liable to set up inflammation in the walls and contents of the sac. Then, too, the needles sometimes produce eschars at the points of their insertion, and thus give rise to consecutive hæmorrhage. In fact, the cases are few in which a perfectly happy result has been obtained, but some of these are worthy of particular attention.

Use of Galvanism through Introduced Coiled Wire.[1] Dr. Stewart, of Philadelphia [2] has employed this method and considers it superior to the introduction of wire alone or galvano-puncture alone.

Owing to the conditions present in large aneurysms, the most that operative interference can usually promise is some prolongation of life and alleviation of symptoms.

Attention may be again drawn to the remarks at p. 721 (a point to which attention has not been sufficiently directed), that surgical interference may, in some cases of large aneurysms, do more harm than good by diverting the blood current from the original aneurysm into some outlying and unsuspected secondary sac, and thus cause dangerous and, it may be, fatal pressure on important parts which have hitherto escaped. Besides this danger, three other chief ones have to be remembered when wire is introduced. (1) Embolism. (2) Suppuration of the sac. Both these have been made much rarer by carefully rendering the wire aseptic. Any inflammation of the sac should at once be treated by ice-bags. (3) Introduction of the wire, &c., beyond the aneurysm, and consequent especial risks.

[1] Further information as to the indications for, and technique of, this and allied methods of treating thoracic aneurysms, will be found in the following papers: Dr. Hare, "Twenty-two Cases of Thoracic Aneurysm treated by Wiring and Electrolysis" (*Journ. Amer. Med. Assoc.*, 1912, vol. i, p. 1088); Dr. Finney, "Twenty-three cases of Thoracic Aneurysm treated by Wiring and Electrolysis"; Dr. W. C. Dusk, "Thoracic Aneurysm treated with Gold Wire and Galvanism" (*Ann. Surg.*, 1912, vol. lv, p. 789).

[2] *Amer. Journ. Med. Sci.*, October 1892 and *Philadelphia Med. Journ.*, November 12, 1898.

PART III

OPERATIONS ON THE THORAX

CHAPTER XXXIV

REMOVAL OF THE BREAST (Figs. 269–307)

Indications. The following remarks must be considered to refer to that most common and important of diseases carcinoma. Removal of the breast is an operation which deserves most careful attention, on the following grounds, viz. the frequency and the distressing results of malignant disease here, and the fact that, while there is reason to hope that the operation is becoming more successful, much still remains to be done. Women will always be unwilling to make known their fears here, on account of a natural delicacy; but another reason leads them to conceal the earlier stages of a growth (in which alone it can be thoroughly dealt with), and that is the well-known want of permanent success which too often follows operation. Precious time is also still too often lost by the medical attendant when he is consulted, in some cases from a mistaken kindness and desire to make light of fears, in others from a disbelief in the value of the operation.

Here, as in all cases of malignant disease, early and thorough operation is needed. With regard to the latter, the limits of wide and thorough operating have probably been reached, but can it be said that the patients are submitted to operation as early as might be the case? Is it not rather the truth that in the majority of cases the operating surgeon does not get his chance until the disease has had time to pass beyond its first stage, and to spread to parts outside the breast itself, as evinced by the adhesion to the skin and by the glands found when the axilla is opened?[1] While in malignant diseases of the sexual organs we shall always have to deal with a larger proportion of late cases than elsewhere, there is no doubt that we should diminish the number of these late cases if both the patients and the general practitioners who are first consulted realised more clearly, and if the latter impressed more strongly on their patients: (1) that there are, every year, an increasing number of patients who are living in good health several years after the operation; (2) that the operation, while serious, is not a dangerous one; (3) that if the disease does recur after the improved operation of the present day the recurrence will be delayed; (4) that the operation of the present day promises much better results, but that these results will only be secured by the operation being an early one, *i.e.* while the disease is in its first stage; (5) that in this first stage, in which operation is so essential, there is an entire absence

[1] Dr. T. S. Pilcher, whose opinion is always valuable from his thoughtfulness, mature experience, and candour, thus expresses himself (*Univ. of Penn.*, September 1903): "It cannot be too strongly emphasised that practically every case of carcinoma of the breast, when it has reached that degree of development by which a palpable tumour is formed, is already in such an advanced stage that, as a rule, metastatic deposits have already begun to be formed."

of pain, or of much or anything to see: thus, a "lump" must not be neglected because it is painless, as is so often the case; (6) that when in doubt as to whether a persisting "lump" which he is examining is carcinoma in its first and quiescent stage, or induration, or a deeply-lying cyst with thick walls, the general practitioner should consider it his duty to have the "lump" excised at once (*vide infra*), and the breast dealt with as may prove necessary.

Results and Dangers of the Improved Operation for Removal of Malignant Disease of the Breast: (1) Mortality of the Operation. (2) Results of the Operation.

(1) **Mortality of the Operation.** Recent statistics clearly show that though the severity of the operation has been much increased, its mortality is, *under the best conditions* (*vide infra*), very low. Thus, Sir W. M. Banks[1] gave a series of sixty operations without one death. Dr. Halsted[2] states that fifty of what he terms "complete" operations had been performed at the John Hopkins Hospital, Baltimore, and not a death had resulted from these operations. Sir Watson Cheyne[3] had only one death in sixty-one cases, and thought that "the ether had probably as much to do with this death as the operation."

With regard to this very low mortality, it must be remembered that such results are the work of men of special experience: that cases in private as well as in hospital practice are included: and, lastly, in Dr. Halsted's case, the operator was working with very highly trained assistants.

When due attention and weight are given to such conditions as shock in an obese patient with poor cardiac fibre, lung trouble in a patient with chronic bronchitis, unavoidable infection as from an ulcerated[4] growth, the readiness with which this operation is undertaken, and the personal equation of the skill of the operators, it will be admitted that if all fatal cases were published, the death-rate would not be so low as that given above. It has, however, proved what can be done *under the best possible conditions*. There are causes of death which, even when foreseen, no amount of care and caution will always prevent when an urgent operation is performed. For example, bronchitis after an anæsthetic, when the chest is hampered by bandages, and the patient, scarcely answerable for her actions, persistently slips down in bed: to the fading strength and vitality with which the flickering light of the life of a patient with a fatty heart or albuminuria is snuffed out, it may be two or three weeks after the operation. The severity itself of operations rarely brings about a fatal result, unless the patient prove unmanageable, another condition against which it is extremely difficult to guard.

(2) **Results of the Operation.** It is clear, from the statistics which have been furnished (*vide infra*), that a considerable proportion of patients submitted to the improved operation will be alive and apparently well three years and more after the operation. By many surgeons, some of them of eminence, this is looked upon and spoken of as [illegible]

[1] *Brit. Med. Journ.*, 1900, vol. i., p. 823.

[2] *Ann. of Surg.*, November 1894, p. 512.

[3] *Lettsomian Lectures*, 1896. The objects and limits of operations [illegible]

[4] Mr. Lockwood has drawn attention (*Transactions Path. Soc.*, [illegible]) to the [illegible] presence of an ulcerating carcinoma as a dangerous source of septic contamination during the operation for removal of the breast. In his opinion (*loc. supra cit.*, p. 163) [illegible] over the surface of the ulcer with pure carbolic acid is not always reliable, and he would advise destroying the entire surface of the ulcer with the actual cautery.

cure (*vide infra*). Dr. Halsted[1] had operated on 133 cases by his improved method between June 1889 and April 1898. Of these 133, 76 had been operated on more than three years. Of these 76 operated on more than three years, 31 (41 per cent.) were living at the time of publication of the above article, without local recurrence or signs of metastasis. Sir W. Cheyne,[2] from his private cases which he was able to trace, concludes that "from 50 to 55 per cent of the cases are alive and well after periods varying from six to thirteen years."

Sir H. Barlow,[3] from a collection of 47 cases operated on by Dr. Halsted himself, Sir W. Cheyne, and Rotter, gives a percentage of over 50 cases "cured," *i.e.* alive and well three years or more after the operation.

Sir W. Mitchell Banks[4] tabulates 213 cases, "of which 175 are available for statistical comparison. Of these 175, 108 have remained free from local recurrence. Of these 108, 73 lived over three years as follows:

Cases that have lived between 3 and 6 years after operation				40
..	..	.. 7 .. 14 ..	..	28
..	..	.. 16 or more ..	..	5

With regard to the results of operation, it is necessary to exercise the greatest caution with regard to the use of the word "cure." There has been a tendency for surgeons, both English and American, to adopt the view originally brought forward by Volkmann, that if three years have elapsed after an operation for malignant disease without recurrence, to look upon the patient as cured, and to speak of these cases as "cures." Such surgeons make light of any inaccuracy which it is admitted may be present in the above dictum, and they claim that, being "optimists," such

[1] *Ann. of Surg.*, November 1898, p. 575. Dr. Halsted in a later review of his results of radical operations for the cure of carcinoma of the breast (*Ann. of Surg.*, 1907, vol. xlv, p. 1) divides his cases into three groups: (1) cases in which on one occasion the complete pectoral and neck operation was performed; (2) cases in which at first the complete pectoral operation was performed, and later the complete neck operation; (3) cases in which the complete pectoral operation was performed, the neck being unexplored. He gives the following interesting statistics of each group, a patient who was alive and well at the end of five years being regarded as "cured." Group 1: There were 96 cases, of which 88 could be traced; of these 13 were cured and alive, 6 were cured but died from other causes, 5 developed metastases after five years. Group 2. This contained 16 cases, of which 3 were cured and alive, 1 was cured but died from other causes, and 1 developed metastases after five years. Group 3: Here there were 92 cases, of which 87 could be traced. Of these 23 were cured and living, 3 after living for five years or over died from other causes, while 4 developed metastases after the five years limit. Dr. Halsted's cases are very carefully tabulated and analysed, and his results are certainly most encouraging. At the same time, after reading his paper one cannot help feeling how difficult it is to use the word "cure."

Dr. Greenough, Dr. Channing Simmons, and Dr. Dallinger Barney investigated the end results of 376 primary operations for carcinoma of the breast at the Massachusetts General Hospital between 1891 and 1901 (*Ann. of Surg.*, 1907, vol. xlvi, p. 201). Of a total of 416 cases, 376 were traced to a conclusive end result at an average period of eight years after operation. Sixty four patients were alive and well and 7 died without recurrence three or more years from the time of the operation. Counting the operation mortality there were 320 cases, of which 67, or 20·9 per cent., were successful. It is interesting to note that no case of carcinoma of both breasts, or where there were palpable enlarged glands above the clavicle, was successful. 17 out of 88 cases who passed the three years limit with a recurrence developed metastases later, and in four a recurrence took place more than six years after the operation.

Interesting papers on the end results of this operation by Dr. Ochsner, of Chicago, who gives an analysis of 261 cases, by Dr. Nathan Jacobson, and by Dr. John Chalmers Oliver, will also be found in the *Ann. of Surg.*, vol. xlvi.

[2] *Lancet*, 1904, vol. i, p. 701.

[3] *Operative Surgery of Malignant Disease*, 2nd ed., p. 404.

[4] Lettsomian Lectures. "Practical Observations on Cancer of the Breast." *Brit. Med. Journ.*, 1900, vol. i, p. 823.

scientific is quite good enough for them, and that any other surgeons who hold a different view are to be looked upon as "pessimists." Now, there is one thing which is above optimism and pessimism, and that is the truth. What is the truth in this matter? It turns on what we understand by the word "cure," and—a matter of even greater importance—what our patients understand by it. On this point Mr. Shield's remarks may be quoted: "As regards the prospect of a definite cure, as the term is understood by the public, *i.e.* definite eradication of the disease, leaving the organism in a healthy state, it is the duty of a conscientious surgeon to be exceedingly cautious in pronouncing such definite opinions as have emanated from the German schools." And again at p. 437: "Fresh manifestations of the disease locally, or in the bones or viscera, may occur at any period up to ten or fifteen years after the original operation. These may be termed fresh outbreaks of the disease, or what name any pathologist fancies, but the fact remains that the word 'cure' will be used with great caution by any one who views the matter from the light of plain common sense, and a desire to act truthfully and conscientiously towards patients." It has been estimated that 20 per cent. of patients who survive three years die eventually of recurrences. With regard to the prognosis Mr Sampson Handley says, "Halsted's results show that when the modern complete operation is performed before the axillary glands have become involved two out of three patients are permanently cured, while when the axillary glands are already infected at the time of operation three out of four ultimately die of the disease."

Local Recurrence, when it occurs, is delayed by more Extensive Operations. While we cannot honestly hold, without watching longer and publishing later the results of recent operations, that patients can count on a cure of the disease, there is no doubt that local recurrence is less frequent, and when it does take place it is delayed, especially when X-ray treatment is called in to our aid. To ensure such improved results the following conditions are essential:

A. To operate widely and thoroughly, and thus to endeavour to remove every atom of tissue which recent researches have shown may be the seat of disease.

This will include (i) removal of the whole breast, which the facts given below will show to be far from as easy as it is often thought to be; (ii) removal of the costo-sternal portion of the pectoralis major, and, if advisable, the pectoralis minor also; (iii) clearing out the axilla; and (iv) this is as important as any—the breast, the pectoralis major, axillary fat and glands, should be removed in one continuous mass.

Mr. Sampson Handley[1] gives the following principles of the operation for cancer of the breast. (i) The area of the operation must be concentric with the growth. Only when the growth itself is in the centre must the nipple be taken as the central point of the area of skin and subjacent tissue to be removed.

(ii) The area of tissue to be removed must approximate to a circle in shape, in view of the centrifugal spread of permeation.

(iii) Since permeation spreads primarily by way of the deep fascial lymphatic plexus, the ablation of tissue must be most extensive in the plane of the deep fascia, and the area of fascia removed must be approximately a circle.

(iv) Smaller circular areas of skin and of muscle also require removal.

[1] *System of Surgery*, vol. v, p. 87.

on account of the secondary invasion of these layers from the permeated fascial plexus.

(*v*) The skin incision subject to the preceding conditions should afford convenient access, and should not be so placed that the scar will lie along the anterior axillary fold, since in this situation it will tend to bind the arm to the side.

B. **To exercise as far as possible a careful and judicious selection of cases.**

C. **To keep patients under supervision for a long time, and, at first, to see them at short intervals.**

A. **The operation to be wide and thorough, in order to remove every atom of tissue which may be diseased.**

(i) *Removal of the Whole Breast.* The importance of an extensive radical operation, even in early cases, has already been insisted upon. The following points, bearing on the way in which carcinoma attacks the breast, explain the necessity for wide removal. (*a*) The breast is, in reality, a much more extensive organ than is usually believed. In addition to the well-known prominence, there is often a ring of outlying gland-masses of varying size and extent. Mr. H. J. Stiles[1] thus alludes to the latter point: "The breast tissue is not encapsulated into a compact body, but is so broken up and branched at its periphery that the stroma becomes directly continuous with the superficial fascia. There is, therefore, no capsule in the ordinary sense of the term." (*b*) The ligamenta suspensoria may contain breast tissue and lymphatics. Both these facts make clear the futility and risk of niggardly skin incisions. (*c*) There are often lobules of breast tissue intimately connected with the pectoralis fascia.[2] These are certainly left behind if the breast is merely separated from the pectoral fascia, as used to be done. (*d*) A deep lymphatic plexus or lymph path runs in this fascia from the breast towards the axilla. Volkmann was the first to teach prominently that it was right to remove entirely the pectoral fascia. Prof. Halsted thus quotes from Volkmann's *Beitrage zur Chirurgie*: "I was led to adopt this procedure because, on microscopical examination, I repeatedly found, where I had not expected it, that the fascia was already carcinomatous, whereas the muscle was certainly not involved. In such cases a thick layer of apparently healthy fat separated the carcinoma from the pectoral muscle, and yet the cancerous growth, in places demonstrable only with the microscope, had shot its roots along the fibrous septa down between the fat lobules, and had reached and spread itself out in flat islands in the fascia. It seems to me, therefore, that the fascia serves, for a time, as a barrier, and is able to bring to a halt the spreading growth of the carcinoma."

Mr. Stiles[3] believes that "local recurrence of carcinoma after removal of the breast is usually due not to the rest of the breast being in a pre-cancerous state, but to the non-removal of small and often microscopic foci of cancer, more or less remote from the main tumour, and depending for their origin upon the arrest and growth of cancerous emboli disseminated

[1] *Edin. Med. Journ.*, June and July 1892.

[2] As will be shown later (p. 740), Mr. Hoolley is of opinion that "the use of the expression 'removal of the pectoral fascia' instead of 'removal of a wide an area as possible of the deep fascia' and the exclusive attention paid to the axillary glands as the channels of dissemination have led to neglect in the excision of the deep fascia over the lower part of the thorax and the upper part of the abdomen."

[3] *Loc. supra cit.*

more or less directly from the primary tumour along the lymphatics.[1] The importance of removing all the retromammary tissue, pectoral and axillary fascia, the axillary fat and glands, along with the breast, in all cases of carcinoma, cannot be too thoroughly insisted upon or too often repeated. The anastomosis and intersection of the lymphatics are so free that it is impossible to say towards which set of glands the lymph from any given point in the breast will be conveyed. I have seen cancerous lymphatic emboli at the axillary border of the mamma when the tumour was situated in the inner hemisphere, and vice versa."

The following case from an important paper by Mr. Raymond Johnson, read before the Pathological Society,[2] illustrates how unsafe it is to leave any portion, however small, of a breast the seat of malignant disease, not only, as shown by Mr. Stiles, on account of the frequent presence of minute foci of carcinoma, remote from the main growth, but also because changes of a "pre-cancerous" nature may be going on in parts of the breast not yet actually attacked by carcinoma.

In a case of infiltrating carcinoma in a woman, aged 27, microscopical examination of parts of the breast, which appeared normal to the naked eye, revealed masses of carcinomatous cells apparently lying in lymphatic spaces. In another specimen of the infiltrating variety the microscopical appearances strongly suggested that widespread carcinomatous change was involving the whole organ, sections showing the new growth arranging itself around the small ducts, which were themselves normal. In the case of a woman, aged 31, a small nodular carcinoma was situated at the axillary border of the left breast. After removal two small nodules were found at the sternal end of the gland, each having the typical structure of glandular carcinoma, whilst microscopical examination of the central part of the breast showed marked proliferative changes in the epithelium of the acini, these changes probably standing in the same relation to carcinoma of the breast as chronic superficial glossitis does to epithelioma of the tongue, namely, a possible "pre-cancerous" condition.

Heidenhain, in a most valuable paper,[3] teaches that in carcinoma of the breast there are proliferative changes in the lobules throughout the whole gland, which must be looked upon as the direct forerunner of carcinoma ("das mittelbare Vorstadium der Krebsentwickelung") and which sooner or later pass into this disease.

On this account, believing that, whether the whole breast is, in the great majority of cases, in a condition to become carcinomatous or not, partial operations are liable (especially when the coarse fat, which is often so abundant, and the hæmorrhage in the operations are remembered)

[1] Mr. Sampson Handley, *The Lymphatics of the Breast and their Operative Treatment*, chap. iii., pp. 17 and 19, 1889. The lymphatics of the skin communicate in the papillæ, and communicate in the corium by means of vessels from the subpapillary plexus. From this plexus vessels pass which pierce the dermis at right angles to the surface, and pass along the subcutaneous tissue to empty themselves into the main parietal lymphatic vessels which lie upon the deep fascia.

The lymphatic vessels of the pectoral fascia often look as if it were arranged in a definite manner, but they rarely form a conventional subdivision of the superficial lymphatic plexus. They usually communicate freely and intermingle all over the entire body. The lymphatic vessels of the skin on the median plane of the body, and by two horizontal planes passing through the clavicles and through the umbilicus respectively, into six areas, the lymphatic vessels draining each area may be into the corresponding axillary or inguinal glands. Within each area a special set of lymphatic vessels arises from the plexus and converges on the corresponding set of glands. The line, or rather zone, which separates any two adjacent areas is called the lymphatic water parting, and is anatomically a zone of narrow lymphatic channels nowhere traversed by trunk lymphatics, a region consequently where the lymph stream is at its feeblest, and where even very fine particles are liable to become arrested.

[2] *Path. Soc. Trans.*, 1882, vol. xxxiii. p. 70.

[3] "Ueber die Entstehung der localen Krebsrecidive nach Amputatio Mammae," *Verhandlungen der deutschen Gesellschaft für Chirurgie*, Berlin, 1889.

to leave behind potential foci of disease, the more wholesale operations are, in these days of modern surgery, absolutely essential.

(ii) *Removal of the Costo-sternal Part of the Pectoralis Major and the Pectoralis Minor.* It is now generally admitted that the sterno-costal portion of the pectoralis major should be completely removed. The necessity for this step in every case was first urged by Halsted. His reasons are as follows: (*a*) It has been microscopically proved by Volkmann and Heidenhain that repeatedly a carcinoma of the breast, though freely movable on the subjacent parts and separated from the muscle by a layer of fat apparently healthy, has reached and spread out in the fascia over the pectoralis major. Removal of the costo-sternal part of the pectoralis major is the surest method of getting quickly rid of this fascia. (*b*) It facilitates the removal of the diseases in one piece, which is so essential (*vide infra*, pp. 734, 752 and Fig. 308). (*c*) This step does not increase the danger of the operation; that this is so in Dr. Halsted's hands is shown by the very low mortality in his paper (*vide supra*), published in 1894, viz. seventy-six cases without one death. (*d*) The impairment of usefulness of the upper extremity, due to the operation, is but little increased by the above step. Indeed, it is most surprising that one, or even both, pectorals can be completely removed, with little or no impairment of the function or movements of the arm. In most cases the arm of the side operated upon has been quite as useful as before the operation. Some of the patients, when questioned, complain that they cannot dress their back hair. This disability is due to the loss of the skin, and not to the loss of muscle. The above small impairment of usefulness Dr. Halsted attributes to his securing primary union of the axillary end of the wound, and thus an absence of fixation of the arm to the side, by his flap (Fig. 306). With regard to those cases in which there is some impairment of usefulness, all will agree with his remark: "After all, disability, ever so great, is a matter of very little importance as compared with the life of the patient."

As regards the desirability of removing the pectoralis minor opinions still differ. Its division gives very free access to the axilla, and it must be remembered that there is usually a lymphatic gland between the pectoralis major and minor which is frequently diseased. It is probably best to remove, or at any rate to divide, the pectoralis minor in every case.

Sir Watson Cheyne[1] considers it advisable to take away practically the whole of the sternal portion of the pectoralis major. As to removal of the pectoralis minor, he removes this muscle where there is much glandular infection, as the nerve supply is almost certain to be injured. Where the axillary glands are not much affected, and where the nerve supply can be preserved, he generally leaves the pectoralis minor, as the axilla can be quite well cleared without taking it away.

"For myself, knowing that in the majority of cases carcinoma of the breast is not brought to the operator until it is no longer limited to the breast itself, feeling also that the growth may have invaded the sheath though the fat over this appears healthy (p. 731), that it may also have invaded the muscle itself though invisible to the unaided eye, having learnt that for myself a free removal of the muscle facilitates clearing out of the top of the axilla, and feeling that though this free operating leads to a thicker, wider scar, and therefore in some cases to impaired abduction and elevation of the arm, this must not weigh against any step that may

[1] *Lancet*, March 17, 1901, vol. i. p. 700.

help in extirpation of the disease. I advocate entire removal of the costo-sternal portion of the pectoralis major in all cases. And I would add here that the fascia over the serratus magnus should be removed as well, especially in those cases where the chief disease is situated over the lower and outer part of the pectoralis major, where the coverings of the chest wall are becoming thinner. When the patient is feeble, or has chronic bronchitis and a weak heart, the decision as to removal of the costo-sternal part of the muscle will depend upon the way in which the anæsthetic is taken, the condition of the pulse, and the amount of skilled help that is to hand. For free removal of the above part of the muscle leads to additional hæmorrhage and to some increase of the shock."

"As to removal of the pectoralis minor, I agree that when this muscle is but little developed, as is usually the case, the axilla can be cleared out, by efficient use of retractors, without division of the muscle. But the fatty cellular tissue over and under it is so delicate, and, on Dr. Halsted's authority, is so liable to be infiltrated, that removal of the muscle certainly facilitates clearing this tissue away thoroughly. Removal of this muscle will not increase the impaired mobility of the arm, but it does leave a deeper, more irregular floor to the wound, in which discharges may collect if it be not left dry. For the same reason immediate grafting is rendered less easy—a matter of minor importance, as it is wiser to defer this step if it be found needful (p. 751)."

(iii) *The Need of Clearing out the Axilla in every Case.* The need for this step in every case is now universally recognised. It is acknowledged that the axillary glands may be extensively involved without any external evidence; nay, more, the microscope has shown that axillary contents, apparently normal to the unaided eye, have been the seat of extensive carcinomatous deposit. We know now that opening and clearing out the axilla does not add to the risks of the operation as long as due precautions against infection are taken. Cases are still occasionally quoted in which though the axilla was never opened, the disease has not appeared there for many years, as long as the patient was kept under observation. The answer to this, as an argument against a routine practice of clearing out the axilla, is very simple. We must admit that such cases exist, but they are extremely few. Possibly, in one hundred cases in which the axilla has been cleared out as part of the thorough operating of the present day, in four or five this step might be superfluous, as the disease had not reached the glands. But which of the hundred were these four or five? Does any one pretend for a moment that our knowledge of carcinoma of the breast enables us to select them before operation?

(iv) *The Whole of the Disease should be Removed in one Continuous Piece* (Fig. 308). The following are Dr. Halsted's words[1] on this point, and it will be seen that to achieve this object is one of his chief reasons for removing the pectoralis major: "The pectoralis major, entire, or all except its clavicular portion, should be excised in every case of cancer of the breast, because the operator is enabled thereby to remove in one piece all of the suspected tissues. The suspected tissues should be removed in one piece (1) lest the wound become infected by the division of tissues invaded by the disease, e.g. of lymphatic vessels containing cancer cells, and (2) because shreds or pieces of cancerous tissue might readily be overlooked in a piecemeal extirpation." And again, at p. 760: "All that is removed in one piece (Figs. 307 and 308); there are no small

[1] *Ann. of Surg.* November 1894, p. 407.

pieces of shreds or tissue. . . . The division of one lymphatic vessel and the liberation of one cell may be enough to start a new cancer." [1]

B. A Careful and Judicious Selection of Cases.

(i) *Cases in which an Operation is Indicated or in which the circumstances are favourable.* (1) Cases somewhat advanced in life; for the younger the patient the more active is the cancer. (2) Especially if patients who are on in years are thin, dry and tough, clear-voiced and bright-eyed, with good pulses and digestion, and no cough or wheezing. (3) Small breasts and little fat. (4) Where the growth is circumscribed, with a distinct outline. The least defined tumours are the worst for recurrence. (5) Where the growth is very hard. The "stoniest" growths are usually the slowest. (6) Skin not involved. (7) Absence of fixity. (8) Either no axillary glands palpable, or but very few involved. (9) Rate of progress slow, and family history good.

(ii) *Cases to which an Operation is altogether unsuited, or especially Doubtful and (in many) Dangerous.* (1) The aged, *e.g.* after seventy: not only are the aged less healthy, but they are usually less troubled by the disease and more resigned. (2) The unhealthy, fat and plethoric. (3) Habitual over-eaters. (4) Tipplers on the sly. (5) The subjects of a confirmed bronchitis and weak heart. (6) Subjects of decided albuminuria, cirrhosis, or diabetes. The first two of these often should prohibit operation. Where glycosuria is present the prognosis will depend on how far the amount of sugar is affected by treatment. Where treatment has no effect, and where the operation must be an extensive one, it must be clearly put before the patient and her friends that the risks are much increased. (7) Extensive disease of the skin, accompanied by scattered tubercles, or oedema, or a condition of erythema (this is the "cancer-erythema" to which Sir J. Hutchinson has drawn attention), and worst of all, a brawny, leather-like, greasy condition of the skin, with firm oedema and open sebaceous glands, approaching the condition of cancer en cuirasse. (8) Quick growth with rapidly increasing fixity. (9) Enlargement of the supraclavicular glands. When this condition is present the general opinion of surgeons has been that the disease has taken too extensive a hold, and that operation is useless. Dr. Halsted's rule [2] would be to operate on the neck in every case.[3] This operation is not postponed, as it can never be done so well as at the first opportunity when the axilla is opened the subclavian vein fully exposed, and the clavicle free. This bone is not now divided as in former years, "for simple division of the clavicle does not facilitate the dissection much, if any, and the removal of a piece of the collar-bone is a procedure which maims without sufficient compensation." This dissection is begun at the junction of the internal jugular and subclavian veins, and the supraclavicular fat and lymphatics cleared away by working from within outwards and from below upwards. The great majority of surgeons are against this step.

Sir H. Butlin's opinion [4] is as follows: "I have not been in the habit of removing the supraclavicular glands, certainly not as a routine part of the operation for cancer

[1] Though there is no definite evidence that this is so, yet the possibility of this happening justifies every precaution. Should a preliminary exploratory incision be thought desirable the knife and other instruments used for this purpose should be cleaned and boiled before being again used.

[2] *Ann. of Surg.*, November 1898, p. 570.

[3] Later Halsted gave up this extreme step as a routine measure.

[4] *Operative Treatment of Malignant Disease*, 2nd ed., p. 399.

of the breast. The operations which are now performed are so extensive that any addition to them is fraught with danger. If the glands above the clavicle are to be removed I think it would be wiser to do this when the patient has recovered from the larger operation. If they are actually cancerous, I believe that the case is hopeless as far as radical cure of the disease is concerned. And that is an opinion which is shared by most operators at the present time." Sir W. Cheyne[1] would only clear out the posterior triangle if he found the fat which runs up behind the axillary vessels and nerves in the direction of the posterior triangle infected with enlarged glands. If the glands behind the sterno-mastoid in the root of the neck are implicated—and this is much the most common glandular infection in the posterior triangle—he would not interfere, "as the results do not justify operation." Writing a few years later,[2] Sir W. Cheyne would open the posterior triangle if any enlarged glands are felt there, or if in clearing the axilla infected glands are found high up. Marked enlargement of the supraclavicular glands in his opinion "renders the case inoperable from the point of view of radical removal."

The question may be summed up as follows: If the supraclavicular glands are enlarged and hard but still mobile, they should be removed as part of the primary operation. If large, adherent and fixed, operation is contra-indicated.

The only evidence of any value which we learn from Dr. Halsted's statistics[3] on this point is that two of the cases in which the supraclavicular region was cleared out were alive and well three and three and a half years respectively after the operation on the neck, which was here a secondary one.

There is one point which appears to negative success, and that is, that in dealing with disease here it is impossible to follow the cardinal rule on which Dr. Halsted has himself laid so much stress, viz. to get out the disease in one continuous piece. Where the disease has reached only a few of the axillary glands, and these lower ones, carefully operating on wide lines may succeed in extirpating in its continuity. But where it has extended above the clavicle, it is impossible to follow the above most essential rule. There will always be an infected lymphatic tract running between the two regions behind the clavicle, and even removal of this bone itself no slight operation—will not enable us to extirpate the above tract, considering what its relations are, however carefully the dissection is carried from below and above, and however much the shoulder is raised and depressed.[4]

Removal of the supraclavicular glands may be called for as a secondary operation. In this case the condition of the patient, her wish for further treatment, and the absence of recurrences or secondary deposits, will guide the surgeon as to the desirability of clearing out the posterior triangle. The latter may be a difficult and trying operation, and, if the enlargement of the glands is noticed at the time of the primary operation, it may often with advantage be postponed for a week or ten days after the removal of the breast and the axillary contents.

[1] *Lancet*, 1899, vol. i. p. 757.

[2] *Ibid.*, 1901, vol. i. p. 709.

[3] The supraclavicular fossa was cleared out in 67 cases, 53 being primary and 14 secondary operations. Of the 53 primary operations in 12 the supraclavicular glands were involved; of the subsequent history of these we are told nothing. Cancer was found in the tissues removed 23 times, or in 34 per cent. of these cases. In 30 cases there was no cancer, and in 14 the result was uncertain, as the tissues removed had not, at the time of publication of Dr. Halsted's paper, been submitted to the regular exhaustive examination which his specimens undergo.

[4] It is the same with cancer of the tongue when the glands in the neck are invaded. Radical cure is here almost hopeless, owing to the great difficulty in extirpating the lymphatic tract which lies behind the jaw and in the floor of the mouth. It is noteworthy that Mickulicz (*Twentieth Century Practice of Medicine*, vol. ix. p. 79), wrote on this point: "I regard the prospect of radical cure as excluded as soon as the deep glands of the neck become invaded."

(10) A young patient, especially with a voluminous breast, a rapidly increasing growth, and a bad family history. (11) Of course, the presence of carcinoma elsewhere—*e.g.* uterus—or secondary deposits in the liver, pleura, and bones.

The presence of palpable subcutaneous nodules over or below the xiphoid cartilage is an unequivocal indication that epigastric invasion has already taken place, and that operation is useless. It must never be forgotten that the first sign of epigastric invasion may be found, not in the epigastric region, but in the pelvis, from the gravitation of cancerous particles into it. A vaginal and rectal examination should be made as a routine measure prior to operation. Pelvic pain, enlargement of the ovaries, or induration in Douglas's Pouch, should raise a grave suspicion that the case is beyond the reach of operation.

Mr. Sampson Handley's advice [1] should always be remembered:

"In seeking for evidence of visceral deposits, examination of the spine for angular curvature should not be omitted. Prior to operating on a cancer of the breast, a careful examination of the epigastric parietes should always be made. The presence of tenderness or pain in this region should raise the suspicion that epigastric invasion has already occurred; and in such cases the liver should be carefully palpated under the anæsthetic, especially in the epigastric region, before the breast is removed. If any irregular nodular enlargement of the organ is present the operation should be abandoned; for it appears at present hopeless to pursue the cancer into the peritoneal cavity, and anything short of this would be futile in such a case."

(12) Cases in which the axillary vessels and nerves are clearly involved in a mass of growth. (13) Pregnancy and suckling. When these complications are present in carcinoma of the breast two questions arise. One refers to the diagnosis. In these cases the carcinoma is likely to be associated with evidence of inflammation, and to be mistaken for acute mastitis. The following points should be investigated: "The skin has a peculiar erythematous blush upon it (cancer-erythema, Hutchinson) which spreads over the skin of the mamma and thorax, gradually fading off into the surrounding tissues. There are local heat and tenderness and the temperature is raised. A close inspection of the skin usually declares the true nature of the case, for it is infiltrated with carcinoma over the breast, and has invariably the "peau d'orange" appearance. The lymphatics of the integument may be markedly implicated, so that they stand out as white cords and nodules of a yellowish or white and pearl-like aspect." [2] With regard to operation, the prognosis [3] is extremely unfavourable when the patient is either pregnant or suckling. If the patient be comparatively young, there is much vascularity and activity of the lymphatic circulation, and hence a very high degree of malignancy. However free the removal, return in the adjacent area is extremely probable, together with secondary deposits. If the patient survive, the other breast may not improbably be attacked. The outlook should be put before the patient. If operation be decided upon the risks of abortion or premature labour must be faced.

(iii) *Cases in which an Operation is Doubtful.* These lie intermediate between (i) and (ii), both as to the general and local points.

Operation [4] (Figs. 296–309). The *chief objects* to be borne in mind throughout the operation have been given at p. 731. Owing to the

[1] *Cancer of the Breast*, p. 189.

[2] Sheild, *Diseases of the Breast*, p. 358.

[3] There are no worse cases for operation than those in which malignant disease supervenes on mammary abscess and induration in suckling women. The more vascular the breast and the more abundant the fat, the more difficult will it be to make certain of extirpating not only the growth, but also every atom of the breast.

[4] By some the above operation is called "the complete operation." Till the cases submitted to it have been watched for a much longer period than three years, the period

age of many of these patients, the after-confinement to bed, and the restricted position which lies before them, especial care should be paid to the state of the bowels and kidneys, and any bronchitis, however slight this appears to be, should be treated. The parts having been very widely sterilised, the patient's neck and abdomen are well protected with mackintoshes with warm towels beneath, while sterilised towels are securely packed around the area of the operation, and one wrapped round the patient's hair. When the patient is weakly, the subject of any bronchitis, the warmth of the trunk and lower limbs should be carefully looked to. On a cold day the room should have a temperature of 70°. The operation should not be performed on a foggy day. The surgeon should be prepared at every point by the time that the patient is anæsthetised. It will be well to allude here to a preliminary point of much importance. Let it be supposed that the case is one of doubtful diagnosis, whether one of carcinoma, chronic mastitis, or cyst. When chronic mastitis, which has resisted judicious treatment, is present, the patient being at a carcinomatous age, is rendered much safer by removal of the whole breast (p. 732), and the same is true of many cases of cysts, where this condition does not occur singly; in any of these the operator's hands are sometimes tied, and he is pledged to save the breast if possible. In such cases—and here the patient must take the entire risk—in making any exploration to clear up the case, it is best not to make an incision into the supposed growth, but an excision of it, with a margin of apparently healthy tissue, as the risk of auto-infection is not a mere theoretical danger. If more requires to be done the wound is rapidly sutured, and the hands of the operator and any instruments used are re-sterilised.

The patient being brought to the edge of the table,[1] and raised on a pillow to a height convenient to the operator the arm is sufficiently[2]

too often considered sufficient (p. 729), it will be wiser and more honest not to write of operations on cancer as complete. By others the operation is described by the name of some operator, *e.g.* Dr. Halsted, whose operation has been given later. This has since been extended and modified as the result of the important researches of Mr. Handley. Sir W. Cheyne, in the discussion on Mr. Sheild's paper (*Med.-Chir. Soc. Trans.*, February 22, 1898), considered that as Heidenhain and Stiles had described the pathology and mode of spread of breast cancer, and shown in full detail what must be done as regards operation, before Halsted wrote, the operation should be called the Heidenhain-Stiles operation, "after the man to whom the whole credit of it is due." To give to any two operators the whole credit of an operation which, not a new one, has been built up by the labours of many, and which owes its present improved technique very largely to the advances of aseptic surgery, appears to involve injustice to others. The tendency nowadays to talk and write as if the origin of the modern operative treatment of cancer of the breast dated to the labours of Heidenhain, Stiles, and Halsted, ignores most unfairly the work of others who should not be forgotten. And one name at least—that of an English surgeon—rises pre-eminently as a worker in this field. That surgeon is the late Sir W. M. Banks. For twenty-three years this surgeon, with unfailing earnestness and characteristic vigour and terseness of expression, in many places urged the need of more extensive operations in this disease. His papers are: "A Plea for the more Free Removal of Cancerous Growths," 1877; "On Free Removal of Mammary Cancer, with Extirpation of the Axillary Glands as a Necessary Accompaniment," 1882; "Extirpation of the Axillary Glands, a Necessary Accompaniment of the Removal of the Breast for Cancer," read before the Harveian Society in 1887, a paper which deserved a much more comprehensive title, as in it several points of which we have lately heard so much, viz. removal of the disease in one continuous mass and the need of division of the pectoralis major, are dealt with. These papers are mentioned in the Lettsomian Lectures of Sir W. M. Banks (*Brit. Med. Journ.*, April 7, 1900), and prove that if honour is to be given where it is due a fair share of it must fall to him.

[1] This step, aided by careful packing of the towels, will diminish the tendency of blood to trickle backwards beneath the patient.

[2] It will be remembered that the more the arm is abducted and elevated the more superficial do the axillary vessels become.

abducted to open out the axilla, and fastened or supported in this position.

(1) **The Incision.** The surgeon then examines the probable extent of the breast [1] and determines the site of his incisions. The advice of Mr. Handley: "That the centre of the growth, not necessarily the nipple, must be taken throughout as the central point of the operation area," must be borne in mind. The following will give sufficient choice: A. The usual elliptical incisions, employed on a very wide scale. B. The same

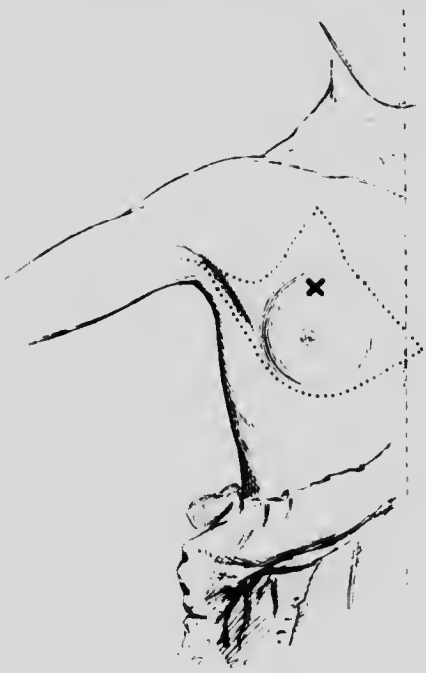


FIG. 296. Incision recommended by Sir W. Watson Cheyne. X indicates the site of the tumour.

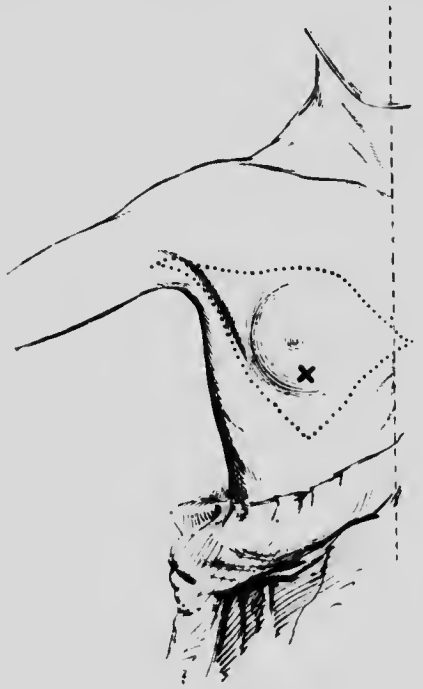


FIG. 297. Incision recommended by Sir W. Watson Cheyne. X indicates the position of the growth.

with angular incisions superadded, as in Figs. 296, 297, when the surgeon has to deal with a growth lying near the periphery of the breast. C. The incision adopted by Dr. Halsted (Figs. 306 and 307). D. That employed by Prof. T. C. Warren, of Harvard University (Figs. 302, 303).

The incisions used by Mr. Handley [2] are shown in Fig. 298. An annular one, five or six inches in diameter, surrounds the breast. A curvilinear one, AB, begins above at the lower edge of the pectoralis major, near its insertion, and ends by joining the annular one also near the lower border of the great pectoral. This incision crosses the base of the axilla and marks out an almost semicircular flap of skin, the convexity of which reaches back almost to the edge of the latissimus dorsi. The linear incision, CD, coming off from the lower part of the annular one and passing for two inches along the linea alba, allows of the exposure of the deep fascia over the upper part of the abdominal wall.

[1] Where the breast is large and pendulous it must be raised before the line of the lower incision is determined upon.

[2] *Cancer of the Breast*, 1906, p. 182.

(2) **Under-cutting the Edges of the Skin and Exposure of the Deep Fascia.** Before going further with the details of the operation attention must be drawn to a point on which Mr. Handley has insisted.[1] As a result of much painstaking work, Mr Handley concludes that, while mammary carcinoma may spread by the lymphatics of the skin, it is rather through the lymphatic plexus in the deep fascia that the chief advance takes place. Owing to the continuity of the deep fascia, the practical importance of the conclusion is obvious. The chief bearing on

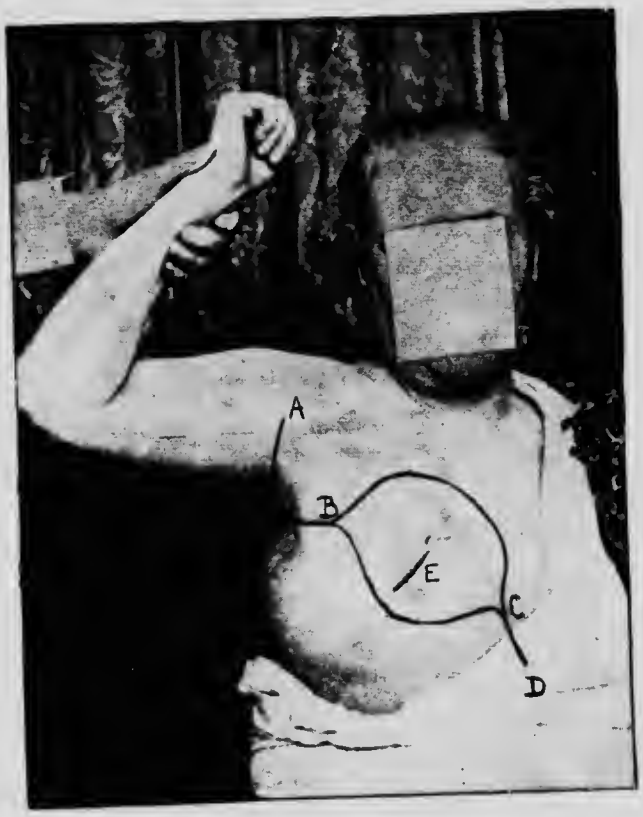


FIG. 298.

the operation of the investigations of Mr. Handley, alluded to above, is, in his own words, as follows: "*The aim should be to remove as widely as is practicable a circular area of deep fascia with its centre at the primary growth, remembering, however, that the growth extends in the fascia more readily in a vertical than in a horizontal direction.* He recommends that a circular area of deep fascia, ten or twelve inches in diameter, should always be removed, the situation of the growth and not that of the nipple being taken as the centre of the circle." The use of the expression, "removal of the pectoral fascia," instead of "removal of as wide an area as possible of the deep fascia," and the exclusive attention paid to the axillary

[1] *The Centrifugal Spread of Mammary Carcinoma in the Parietes and its Bearing on Operative Treatment*, 1904.

glands as the channels of dissemination, have led to the neglect in the excision of the deep fascia over the lower part of the thorax and the upper part of the abdomen. It seems to be in this direction that the scope of the operation requires extension, rather than in the direction of opening up the posterior triangle. The distance from the nipple to the clavicle may be taken as the radius of the circle of deep fascia round the growth which can be removed without difficulty by undermining the skin flaps sufficiently. If the growth starts under the nipple, the deep fascia should accordingly be removed—above, up to the clavicle; internally, one or two inches beyond the middle line; externally, just beyond the edge of the latissimus dorsi; below, to a horizontal line running at least two inches below the tip of the ensiform cartilage. If the growth is in the lower and inner part of the breast, the circle of infected deep fascia will encroach still more on the surface of the abdomen, and over the opposite side of the breast, and removal of the deep fascia in these directions must be carried out yet more widely. "In order to obtain access to the upper part of the abdominal wall for the purpose of removing its deep fascia, the lower angle of the incision should be prolonged downwards for two or three inches over the linear alba, and the flaps undermined to a corresponding extent. Great care should be taken to remove every part of the origin of the pectoralis major from the rectus sheath. The surface of the latter on both sides of the middle line should be most carefully cleaned, as should also the digitations of the external oblique, down to a horizontal line running two or even three inches below the tip of the ensiform cartilage."

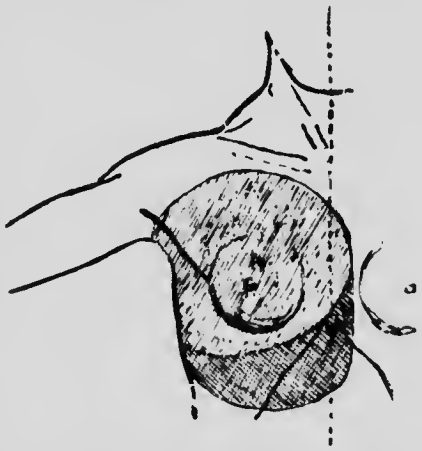


FIG. 299. The lightly shaded area represents the extent of deep fascia removed in the operation of incision of the breast as at present usually performed. The darkly shaded area represents the additional extent of deep fascia which should in future be removed to ensure that the circle of invaded fascia shall be completely circumscribed, and not intersected and partly left behind below. The line surrounding the whole shaded area represents the extent to which the skin-flaps should be undermined. (Handley.)

With one of the incisions recommended above there is no difficulty in undermining the skin edges sufficiently to expose this large area of deep fascia. A sufficient thickness of fat must be left on the deep aspect of the skin to ensure its vitality, but the knife must not be made to pass so deeply as to penetrate the breast tissue. Any bleeding vessels on the cut surface of the skin flaps should be secured, but those on the deeper surface of the wound should be controlled by pressure as they will have to be again divided at a later stage of the operation.

A circular incision is then made through the large area of deeper subcutaneous fat and deep fascia which has been exposed by the reflection of the skin flaps. Mr. Handley recommends that at this stage a fringe of deep fascia should be raised up all round the field of operation until the knife reaches either the margin of the great pectoral muscle, the margin of the axillary outlet, or the edge of the breast, as the case may be. Towards

the outer side of the field of operation, the fascia must be dissected up from over the anterior edge of the latissimus dorsi and from the serratus magnus.

(3) **Division of Musc** . The margin of deep fascia which has been dissected upon the inner side is then reflected until the sterno-costal origin of the pectoralis major is reached. This is cut through close to its attachment to the costal cartilages. When a part of its insertion has been divided a finger may be insinuated beneath the muscle, and by drawing

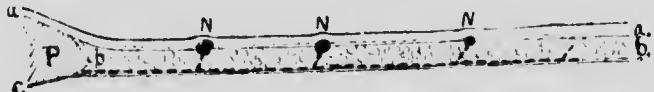


FIG. 300. To show that subcutaneous nodules do not necessarily imply the extension of growth along the skin. The above diagram (Handley) represents a section of the parietes at right angles to the surface in the region of the primary growth. P: *a a*, skin; *b b*, subcutaneous fat; *c c*, deep fascia. The subcutaneous nodules, N N N, may arise (1) from spread of growth in the skin in the direction of the lightly dotted line, a view generally held, or (2) from spread of growth in the deep fascia, along the heavy interrupted line, with occasional offshoots to the skin, giving rise to subcutaneous nodules. Though this is not the accepted view, it is the correct one in Mr. Handley's opinion.

this forward the division of the remainder is facilitated. In an early case, or where the growth is situated low down, the clavicular portion may be preserved. The breast and the detached muscle are then drawn outwards; the external anterior thoracic nerve and vessels which are seen piercing the costo-coracoid membrane and entering the deep aspect of the muscle, are divided and the vessel secured. The pectoralis minor now comes into view. This muscle is then divided and removed at its origin and insertion, so as to make certain of getting away the very delicate fatty tissue on it and beneath it which is rich in lymphatics and

FIG. 301. A key-diagram to show the conditions found in a section taken from the upper part of the abdominal wall, demonstrating the invasion of the deep fascia in carcinoma of the breast. The skin at this level was free from obvious growth, though subcutaneous nodules were present higher up. Above is seen the subcutaneous fat, separated from the rectus by A A, the anterior layer of the sheath. The dark masses, B, are cancer nodules, which originated from growth lying within the vessels of the fascial lymphatic plexus. Here and there they are sending prolongations towards the skin. (Handley.)

often cancerous. While the fascia and muscles are being reflected numerous vessels will be divided. They should quickly be secured with forceps, and as the number accumulates they should be tied off with catgut. The large raw surface should be kept covered with sterilised pads wrung out of hot saline solution except in the area in which the surgeon is actually working. This diminishes the shock, aids haemostasis, and lessens the possibility of infection.

(4) **Clearing out the Axillary Contents.** When the pectorals are removed the axillary space is freely exposed. The costo-coracoid mem-

brane is divided just below the clavicle, and the first part of the axillary artery and the termination of the subclavian vein are now exposed at the highest possible point (Fig. 304), and the sheath and overlying fatty tissue are carefully removed from the axillary vein in its whole length, and with these the fat and glands in the axilla according to the directions given below. The numerous small veins which are met with now should be carefully tied close to the axillary veins, and no particle of extraneous tissue should be included in the ligature. On no account is the operator to pull out the glands and fat from the axilla with his fingers a step certain to leave infected tissues behind. The need of getting away the disease in one continuous whole is now especially to be remembered. In cleaning the sheath a scalpel should be employed, but for the axillary contents blunt-pointed slightly curved scissors, which serve not only for cutting but for separating structures, are very useful. The inner and posterior walls of the axilla are then freed from all fat and fascia commencing above and working downwards. Mr. Handley recommends that the digitations of the serratus magnus muscle, which lie in direct contact with the deep surface of the breast, should be divided at their origin from the ribs, and that these same digitations should subsequently be completely removed by division further back towards the scapula.

Great care is needed in cleaning the fatty tissues, and especially so if enlarged glands are present, from the axillary vein. If this trunk be injured a lateral ligature may be applied if the opening is small, but if there is an extensive tear ligature of the vein below and above the opening will probably be required. This is spoken of by some operators as a slight matter, and as one which will not cause after-trouble. But this result is not to be relied upon. It probably depends upon the level at which the venæ comites of the brachial join the basilic (a somewhat variable point), and the relation of this to the part tied. As there is a most distinct risk of a heavy œdematous arm resulting, the only excuse for resecting part of the vein is when an enlarged gland is adherent to it. Whether it is needful to expose and clean the artery is doubtful; Dr. Halsted thinks it safer to do so, but it prolongs the operation considerably. Sir W. Watson Cheyne practises a careful step at this stage which is noteworthy. When the vein has been cleaned and the axilla cleared out there still remain some lymphatics which run up behind the vessel towards the posterior triangle. These may be infected. To remove them the vessels and nerves must be lifted up, and this mass of fat and glands lying in the triangular space between the vessels in front, the scapula outside, and the chest-wall inside should be taken away.

The axillary vessels having been defined and cleaned, the surgeon will now be more at ease in stripping out the contents of the axilla from its inner and posterior walls. The fatty fascia which ties the breast, &c., to these regions is further put on the stretch and dissected off from the serratus magnus and intercostals. As to the intercosto-humeral nerve, it is not worth while to dissect it out and preserve it. The lateral branches of the intercostal vessels need careful cleaning and securing, especially below at the juncture of the internal and posterior wall, where, in the thickest part of the serratus magnus, there is always an anastomosis between the above-mentioned vessels and the subscapular artery. This anastomosis will certainly be cut into if the fat and fascia over the serratus magnus have been efficiently removed. Unless these bleeding-points are promptly secured, much blood will be lost, and a collection of blood may

easily take place here, and cause trouble afterwards.[1] As the posterior wall is cleaned the subscapular vessels and nerves will come into view. It is very easy, by using undue force or haste in stripping clean the subscapular or other veins, to tear one or more of these away close to the parent trunk, sometimes leaving a small hole punched out in this vessel. In such cases the hæmorrhage is most embarrassing, and must be met either by taking up the aperture with a lateral ligature of fine catgut, or ligaturing the vein above and below—a point alluded to above.[2] If there be time, if the patient's condition be favourable, and if the fat strip easily away, the subscapular nerves, especially the long one, should always be spared. Under other conditions no time should be spent in dissecting them out.

Sir H. Butlin[3] writes: "I have not attempted to spare the subscapular nerves, and I have been surprised to find that the movement of the upper extremity is remarkably good, provided too large an area of integument has not been taken away." Loss of power in the latissimus dorsi should not, however, weigh for a moment against any step that favours complete removal of the disease; if primary closure of the axilla and primary union of the axillary end of the wound be secured—conditions which are always possible—and the precaution given below as to the position of the limb and early movement be followed, a very useful arm and shoulder-joint will result. Fig. 309 shows how much elevation and abduction may be gained three weeks after the operation, even where both pectorals have been removed on each side, if the after-treatment is attended to.

While cleaning the inner wall of the axilla the nerve of Bell will be found running downwards on the serratus magnus; this nerve should also be spared.

(5) **Removal of the Breast and the Axillary Contents.** The posterior wall of the axilla having been now cleaned to a point on a level with the latissimus dorsi, all that remains is to sever the mass of breast, &c., along the line where the deep fascia has been dissected forwards to the outer border of this muscle.

The operator now scrutinises the wound to see what scraps and tags of fatty tissue may remain in dangerous positions, *e.g.* over the subscapularis, or along the vessels, or in the apex of the axilla. In spite of the greatest care to get the diseased structures away in one piece, such shreds of tissue may be left. At this stage the huge wound, which has been kept carefully covered, wherever possible, with hot moist sterilised gauze, should show a floor consisting, from within outwards, of muscle—*e.g.* above, clavicular part of pectoralis major; a little lower, a narrow rim of the costo-sternal portion of the same muscle, external intercostals, upper part of external oblique, attachments of pectoralis minor, serratus magnus, subscapularis, teres major, and latissimus dorsi.

(6) **Hæmostasis.** Bleeding is next finally attended to. Throughout the operation, in order to diminish the shock inseparable from these

[1] Such a collection, leading to tension on the flaps, will require draining. Again, from the proximity of the axilla, which with its regrowing hairs it is not always easy to keep sterile, any fluid here may become infected.

[2] The remarks made above on injury to the vein apply, of course, with increased significance, to the artery. Mr. Sheild says that he has seen similar trouble to that described above occur by cutting arterial branches when pulled on, close to the main trunk. He has twice since seen lives in great peril from the step that was found needful, viz. ligature of the main trunk above and below the opening.

[3] *Operative Surgery of Malignant Disease*, p. 397.

extensive and prolonged proceedings, great care must be taken to secure every bleeding-point, and to tie off the forceps before they accumulate, instead of trusting to their being moved out of the operator's way as required, a course which often leads to their becoming entangled with each other. But at this stage there is another reason for rendering the wound as dry and bloodless as possible. Primary union depends largely on absence of any after-oozing and tension on the sutures, which are very likely to be themselves taxed to the utmost. Two difficulties arise here. One, that owing to a depressed state of the circulation, vessels may not bleed though unsecured. The other difficulty is of a different kind. The perforating branches of the internal mammary, when they are cut short and retract, may give much trouble. If they cannot be secured by the use of Spencer-Wells forceps the hæmorrhage should be treated by firm pressure.

At the conclusion of the operation the extensive wound may be irrigated with sterile water, or better, with hot sterile saline solution. This washes away any blood clots and helps to stop any general oozing which cannot otherwise be checked.

(7) **Drainage and Closure of the** [illegible] the axilla should be drained by means of a medium size rub[illegible]ch several lateral windows, inserted through a stab-wound n[illegible] f the posterior skin flap. Mr. Handley also advises a second [illegible]ra[illegible] the epigastric region, and where there has been much oozing this should certainly be employed. These tubes should be completely removed in twenty-four or forty-eight hours.

No definite rule can be given as regards suturing, since the incision chosen will, in each individual case, depend upon the size and situation of the growth. Generally speaking the wound should, if possible, be completely closed, drainage-tubes being inserted through conveniently placed small cuts in the flap. If the skin edges have been undermined, and the deep fascia extensively removed as recommended above, the skin is so free that in spite of the large area removed the divided edges can usually be brought together with little or no tension. In some cases the wound may be sutured in a continuous line, in other cases the edges of the wound may be more easily approximated in a tri-radiate fashion. Interrupted or continuous silkworm-gut sutures should be employed. Every care must be taken to avoid tension, for this is often responsible for much pain and also may lead to sloughing of the edges of the skin, thus interfering with primary union. The latter complication may also be met with, owing to deficient blood-supply, if the skin flaps have been cut too thin. If it be impossible to close the wound completely it should be sutured as far as possible, and the raw area treated by skin-grafting by Thiersch's method (p. 43). While this may be employed at the time of the operation in a wound which cannot be completely closed, it is best to defer it to a date between the eighth and fourteenth day. Though this involves a second anæsthetic, the patient will be in a much better condition; the surface of the wound will be small[illegible], and a level, uniform one, and there will be no oozing.

To enable the surgeon and patient to dispense with the necessity of skin-grafting, usually a second operation, Prof. Warren has adopted the method shown in his excellent illustrations (Figs. 302, 303, 304, 305).

In addition to the free racket-shaped incision, "a flap should be marked out on the outer side of the pectoral region (Figs. 302, 303, 304). To do this, the knife

divides the skin above the middle of the first incision, *i.e.* on the outer edge of the wound, on a line drawn at first at right angles to the said incision and gradually sweeping round until it becomes parallel to it and terminates at a point a little above the level of the lower margin of the wound. This flap is intended to be turned into the lower portion of the wound. . . . This flap is about the size of the hand, and when first turned in seems to be totally inadequate for the purpose. A few stitches

FIG. 302. Preliminary dissection of the integuments in all directions, leaving a pyramidal mass of tissues to be removed of which the primary nodule is the apex. The outer lateral flap is also shown. (Warren.)

should be taken at the axillary and sternal ends of the wound first. The flap is then turned in (Fig. 305), and held in place by a temporary stitch, while it is gradually pushed up into place from below by sutures firmly 'girding' together the edges of the skin to which the flap was originally attached. Thus it gradually comes about that the point B, which was originally in contact with point A, is rolled in underneath the flap, and forces it into position. Sutures should all be superficial, as deep sutures cut and do not give the skin included by them a chance to stretch. In order to enable the edges to come together easily, it should not be forgotten that it is necessary to dissect up the skin for a considerable distance in every direction. In stout patients

the cavity of the wound is easily closed, but the problem is more difficult in thin individuals. Experience only will enable the operator to determine how much tension can be put upon the flap in inserting the final stitches. In doubtful cases there is no objection to leaving them untied, as the opening thus left serves admirably for

FIG. 303. Division of the pectoralis minor. Note here and in Fig. 302 the care taken to leave a large circumferential zone well wide of the disease. The anterior edge of the latissimus dorsi is shown here and in Fig. 301, denoting the limit of the dissection outwards. (Warren.)

drainage." The wounds should be dressed at the end of twenty-four hours, and any gauze drainage then removed.

(8) **The Dressing.** The incision is then covered with sterilised gauze, over which is placed sterilised pads and a thick layer of absorbent wool, care being taken that a thick layer of dressings is placed behind where most oozing will occur. The dressings are kept in position by firm and even bandaging so as to distribute the pressure as evenly as possible. The forearm should not be included in the bandage but allowed to rest evenly and comfortably in a sling.

(9) **After-treatment.** Though there is usually some slight degree of shock it is, on the whole, less severe than might be expected after so extensive an operation. For the treatment of shock see p. 29. The

FIG. 304. The division of the pectorals permits the retraction downwards and inwards of the breast and axillary contents and enables the operator to expose freely the axilla, and to tie the main branches at their origin. (Warren.) It will be noticed that Prof. Warren removes the breast from without inwards. The advantages claimed are that the operation is shortened and the hæmorrhage lessened by dividing the vessels at their origin at the beginning of the deep dissection, while the greater part of the wound is not exposed until the close of the operation. Further, a free dissection of the axilla is permitted up to the point of disappearance of the axillary lymphatics beneath the clavicle before the mass to be removed has been dislodged from its attachments and allowed to interfere with the anatomical relations of the parts

patient should be kept on the sound side for the first few hours after the operation, as this promotes the escape of any vomit well away from the dressings, while it also helps to prevent any collection of fluid at the

axillary end, where the chief cavity has been made. Afterwards the patient should be kept, supported, up in the bed as much as possible, to prevent that tendency to stasis and broncho-pneumonia which is so liable to appear in the subjects of chronic bronchitis, obesity, &c. If possible

FIG. 305. A, The flap has been turned in and caught with one suture. It is gradually being pushed into position by peripheral sutures. B shows how the upper half of the outer edge of the wound is slid under the lower half. Note the shortening of the long axis of the wound by the stitching on the lower border. (Warren.)

after the fourth day the patient should be lifted into an arm-chair and spend an hour or two out of bed daily. These patients are not only kept too long in bed, but the arm is usually kept close to the side too long. For the first few hours, to check any oozing, and to meet any restlessness after the anæsthetic, the arm and forearm must be kept securely quiet in a sling. But after this the arm should be gently and easily abducted by a large pad of wool in the axilla. A little later the patient, while

[1] *Loc. supra cit.*

in bed, should be encouraged to keep the limb away from her side with the forearm extended, while at night a sling should again be resorted to. In about ten or fourteen days more active outward and upward movements should be practised. While after-limitation of movement is partly unavoidable owing to the necessary free removal of skin, &c., much of the after-stiffness will be prevented if care be taken at the time of the operation to secure primary closure of the axillary end of the wound without much tension, and if, later on, both surgeon and patient will dispense with the too usual rigid bandaging of the arm to the side, and be more persistent in practising early movements. A course of massage is often very beneficial.

With regard to the dressing of the wound, the first dressings will probably require to be additionally packed, especially behind, during the first forty-eight hours. And the patient, whatever position she take, should always lie on thick gauze pads during the first three or four days, lest any discharge come through, especially when she is left undisturbed to sleep, and reach the sheets. If drainage has been employed the wound should be dressed at the end of twenty-four or thirty-six hours, the drainage-tubes removed, any over-tight sutures cut, and the dressings left undisturbed for another three or four days. If no drainage has been employed, the need of dressing will generally turn upon the tension of the sutures. As the skin, owing to its elasticity, has great accommodating power, it will generally be found, if the tension has been distributed over a large number of sutures, that no stitch-necrosis, or very little, takes place. Such a step adds much to the comfort of the patient, and allows of the division of any sutures which are already causing, or about to cause, slight ulceration. Another advantage gained by not allowing the dressings to remain unchanged too long during the first ten days is that an opportunity is secured of cleansing the axilla. This step is rendered advisable by the difficulty of sterilising a region like this at the time of the operation, and the growth of hair which has taken place.

The desirability of *X-ray treatment as a prophylatic measure against recurrence* is discussed on p. 757.

Halsted's Method. Prof. Halsted published an account of his method of removal of the breast in the *Annals of Surgery*, November 1894.[1] On account of the excellent work done by him in many directions, and because he was the pioneer of the modern radical operation, the following brief details of his original operation may be quoted here.

"(1) The skin incisions are carried at once and everywhere through the fat. (2) The triangular flap of skin (Fig. 306) is reflected to its base. This flap consists of skin only. The fat which lined it is dissected back to the lower edge of the pectoralis major, where it is continuous with the fat of the axilla. (3) The costal attachments of the pectoralis major (Fig. 307) are severed, and the splitting of the muscle, usually between its costal and clavicular portions, is begun and continued to a point about opposite the scalene tubercle. (4) At this point the clavicular portion of this muscle and the skin overlying it are cut through up to the clavicle, exposing the apex of the axilla. (5) The loose tissue under the clavicular portion, usually rich in lymphatics, is dissected away. (6) The splitting of the muscle is continued outwards to the humerus and the part to be removed is now cut through close to its humeral attachment. (7) The whole mass, skin, breast, areolar tissue and fat, is raised up and is stripped from the thorax close to the ribs and the pectoralis minor.

[1] Dr. Willy Meyer, of New York, described independently a similar operation, about the same time (*New York Med. Rec.*, Dec. 15, 1894), in which the breast, pectoral muscles and axillary contents were removed in one mass. Dr. Meyer gives an interesting account of ten years experience with his method of radical operation in the *Journ. Amer. Med. Assoc.*, July 1905.

the sheath of the latter muscle being included. (8) The lower border of the pectoralis minor having been clearly exposed it is divided a little below its middle. (9) The areolar tissue over the minor muscle near its insertion is then divided as far out as possible and reflected inwards to allow of the turning upwards of this part of the minor. (10) The upper and outer portion of the pectoralis minor is drawn upwards

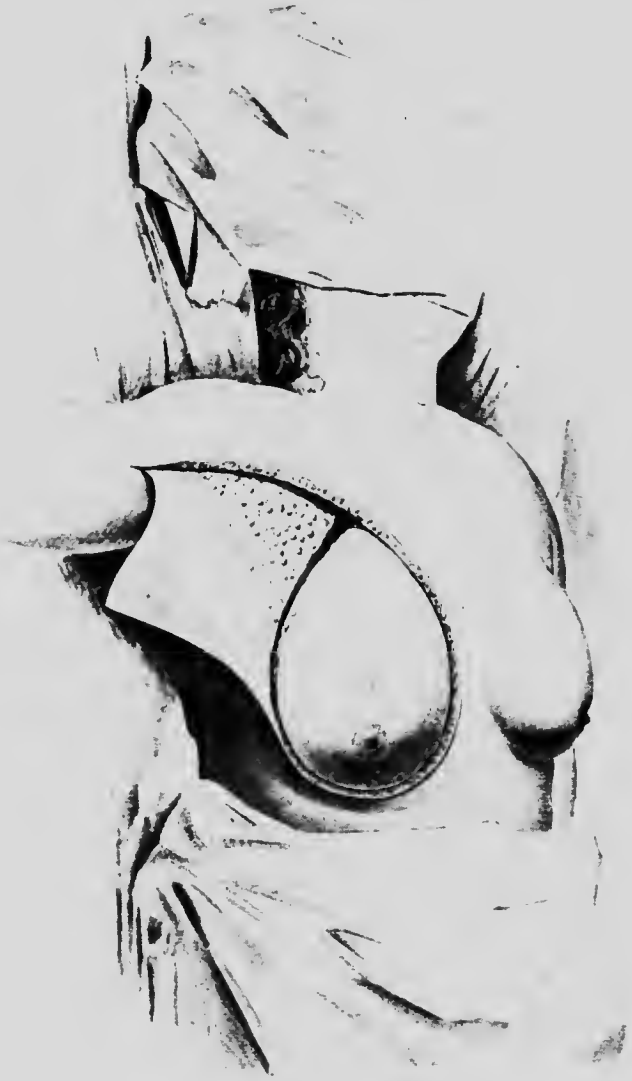


FIG. 306. (Halsted.)

and outwards. (11) The small veins under the pectoralis minor are dissected free and ligatured close to the axillary vein. (12) Having exposed the subclavian vein at the highest possible point, the axillary contents are dissected away with the greatest possible care with the help of a sharp knife. The axillary vein should be stripped absolutely clean. It may not be always necessary to expose the artery, but I think it is well to do this. (13) Having cleansed the vessels, the mass to be removed should be firmly grasped and pulled outwards and slightly upwards with sufficient force to

put on the stretch the delicate fascia which still binds it to the chest. This fascia is cut away close to the ribs and the serratus magnus. (14) When the junction of the lateral and posterior walls of the axilla has been reached, an assistant takes hold of the triangular flap of skin and draws it outwards to assist in spreading out the tissues which lie on the subscapularis, teres major, and latissimus dorsi. The operator,

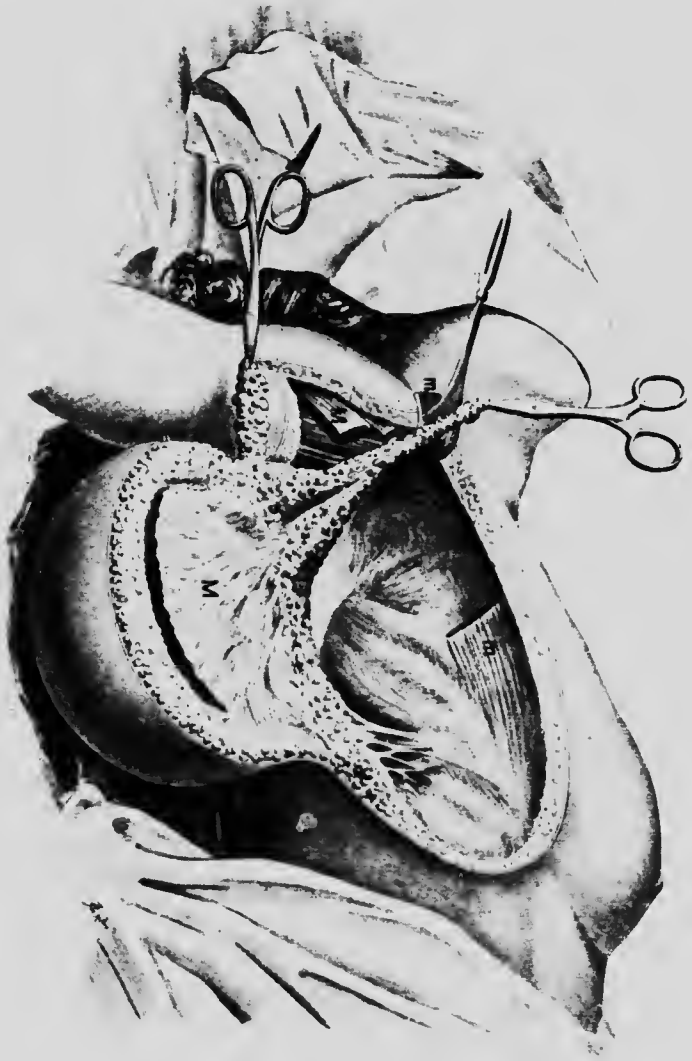


Fig. 307. (Halsted.)

having taken a different hold of the tumour, cleans, from within outward, the posterior wall of the axilla. The subscapular vessels are nicely exposed and are secured before they are divided. The subscapular nerves may or may not be removed, at the discretion of the operator . . . they may often be spared to the patient with safety. (15) Having passed these nerves, the operator has only to turn the mass back in its normal position, and to sever its connection with the body of the patient by a stroke of the knife. All has been removed in one piece. I believe

that we should never cut through cancerous tissue when operating, if it is possible to avoid doing so. . . . The operation as we perform it is literally a bloodless one. From the first to the last each bleeding-spot is secured with an artery forceps as quickly as possible. . . . The axilla is never drained and invariably heals by first intention."

C. **Long-continued supervision repeated at first at short intervals.** The patient should be kept under skilled supervision, and for the first few years an inspection of the scar should be made every three or four months.

FIG. 308. This shows the continuous whole or single piece, breast, axillary fat and glands, of which the part removed should consist. (Halsted.)

Any localised and superficial reappearances in or near the scar should at once be attacked widely and deeply (p. 756); operations, where the disease is fixed, involving resection of one or more ribs, if needful, as in the cases to which allusion has been made at p. 769, are very rarely to be advised.

There are still a few points of much importance to be discussed before the subject of removal of the breast for cancer can be said to have been dealt with. Such points as: (i) The removal of both breasts. (ii) The value of palliative operations. (iii) Operations for reappearance of the disease. (iv) The advisability of performing such operations as ampu-

tation at the shoulder-joint, or Berger's amputation. (v) Oophorectomy for inoperable carcinoma of the breast.

(i) *Removal of both Breasts.* It occasionally, though rarely, happens that, as in the case shown in Fig. 309, a patient comes for advice with cancer of both breasts. By some operation at this stage has been condemned on two grounds: viz. its certain futility and its additional

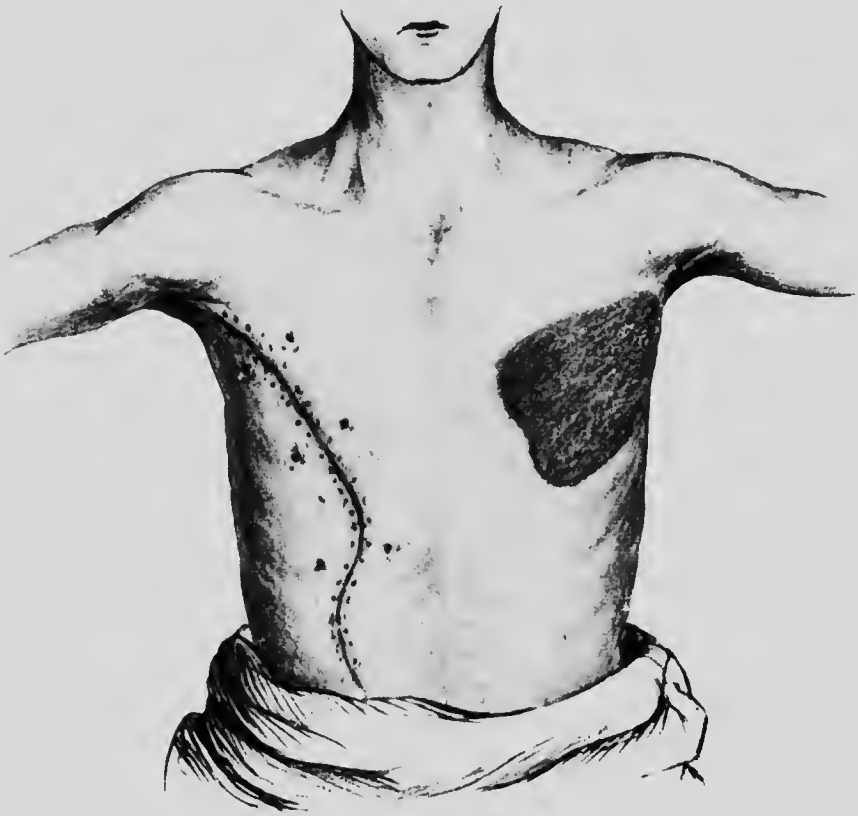


Fig. 309. E. S., aged 54. The left breast had been removed at another London hospital in February 1899, the pectoralis major being left entire. Recurrence took place in the scar towards the end of the same year. Patient was admitted to Guy's Hospital with a scirrhus of the right breast, the existence of which had been known for three months. Both sides were operated upon simultaneously by Mr. Jacobson and Mr. C. T. Hilton, on December 10, 1900, both pectorals being removed on each side. On the right side Mr. Jacobson found it possible, by extensive undermining, to drag the flaps together, the three larger dots on each side showing where the stout silver wire used had caused slight tissue-necrosis. On the left side the above step was impossible. The photograph was taken on January 3, 1901, and Thiersch's grafting was resorted to, on the left side, on January 4. The amount of elevation which can be regained in three weeks after a double operation is also shown.

severity. Such a rule can hardly be laid down. Each case must be considered by itself.

The following are the chief points which will guide in a decision. First and foremost, the surgeon must decide whether the growth is a primary

one on both sides, or whether on one side it is secondary to the other. In the latter case the disease is so widespread that operation is not to be recommended. In the former, if there be no evidence of visceral or secondary deposits (beyond any in the axillæ), operation may be recommended if the patient's age and vitality are favourable. And here age is a point of much importance. If the patient be young, the presence of bilateral disease is probably a sign of the mischief being widespread, and operation will be useless.

When operation has been decided upon, the question will arise as to whether the breasts should be removed simultaneously or no. If possible, the two breasts should be removed at one operation. And as the operation of the present day is so extensive and requires such prolonged care, it will be best if the operation is done simultaneously by different operators. Such a step much diminishes the risk and also the discomforts of the patient, especially that of the anæsthetic, while where the vitality is good, the shock is not dangerously increased. Extra care in nursing will diminish the additional trouble entailed by the needful restraint of both arms. But no fixed rule can be laid down here. Where the vitality is poor, where there is any bronchitis, where the breasts are large and the wounds necessarily extensive, it may be well to postpone the second operation for two or three weeks. Where it is clear that the operation on one side will be so extensive as to call for Thiersch's grafting, this may indicate the advisability of removing the breasts by two operations.

(ii) *The Value of Palliative Operations.* Patients occasionally come to the surgeon asking for operation under conditions which make it certain that any benefit given by surgical interference will be only temporary. The following may be among the reasons that arise for consideration: (*a*) Relief from pain, which otherwise increases daily; the misery of waking every day to the consciousness of an incurable disease; the ulceration in advanced cases with foul discharge and perhaps hæmorrhage; the restlessness for cure (Paget). (*b*) Death by deposits in the viscera, these being unseen, is less distressing to the patient than death by the original disease in the breast, which is always under her eyes. (c) The patient may have special reasons for wishing to live and get about in comparative comfort for a year or so.

Thus, in a case mentioned by Sir B. Brodie,[1] he declined at first to operate on a lady with a scirrhus of the breast on the point of ulcerating. In a few weeks the patient returned, begging to have the breast removed, that her life being rendered more comfortable and active, she might accompany in society an only daughter. The operation was successfully performed, and at the end of two years the patient died of secondary pleuritic effusion.

No general rule can be laid down here. Each case must be decided on its own merits. But the following cautions may not be superfluous. Especial care should be taken in these cases to exclude, as far as possible, the presence of metastatic deposits. If these are certainly present no operation should be performed. The patient's general condition and vitality must be sufficiently good. There must be grounds for honestly supposing that the local disease which it is proposed to attack will be got away; otherwise the latter condition of the patient may be rendered worse than the first. Again, in these palliative operations it should be clearly explained to the patient and her friends that the operation will only

[1] *Lect. on Path. and Surg.*, p. 202.

be palliative. Some patients, and especially the friends of some patients, are only too ready, when it becomes evident that no cure is possible, to forget the plain and honest warning that was given, and to place the entire responsibility on the surgeon. And this leads up to one more point. In these palliative operations, and in all doubtful operations for cancer, it is not only the individual patient that has to be considered: the thoughtful surgeon will remember the effect of his operation on many other potential patients. Thus, a palliative operation or an extensive operation under conditions doubtful of success is performed, both sides of the question having been honestly put before the patient. The operation is not permanently successful, as was fully explained might be the case. The want of permanent success becomes known to a circle of varying extent. We do not sufficiently consider what effect this want of success has on other patients also sufferers from cancer of the breast, but quite ignorant of the conditions in which the operation referred to was performed, in leading them to conceal their cancer, at the time eminently suited to operation, until the most favourable opportunity has passed away.

(iii) *Operations in the Case of Reappearance of the Disease.* A very poor prospect of success is offered here, chiefly because the disease always proves to be more extensive than appears to be the case. This is especially true of recurrence in the axilla. Such conditions as extensive infiltration of the skin either by shotty nodules or by the evidence of "peau d'orange"; infiltration of glands in the neck, evidence of visceral deposits, implication of the axillary vessels and nerves, prohibit operation absolutely. The only conditions which justify hopefulness in dealing with local reappearance are (1) small nodules in the scar or the axilla, or (2) infected areas of larger extent occurring in cases where the operation has been a limited one, and not on the wide lines which have been recommended above. And the chief points which help in the decision are the degree of mobility and the size of the reappearing mass. But even where these and other points appear favourable, the real extent of the disease, the fact that the operation has now to be performed in scar tissue and not in loose fat, and that the anatomical landmarks are much altered, militate greatly against success. Local reappearance after the improved operations of to-day is much rarer, but it does occur, and the fact that in these cases the preceding operation has been on wide lines shows that here the disease from the first has had an extensive hold on the patient. If the recurrence, though local, is deeply seated in the tissues of the scar, necessarily scanty after removal of the pectorals, the only operation likely to be useful is partial resection of the ribs, as in the cases alluded to at p. 769. If the recurrence is in the axilla the exploratory incision should be of the freest, as these are just the cases where the axillary vein may be easily opened.

Finally, we must all allow that the only real treatment for reappearance of the disease is preventive. It is only by *operating on the first occasion, on the widest possible lines*, and in the most thorough manner, that we can really meet recurrent disease. In Sir Watson Cheyne's weighty words, "the patient's chance lies in the first operation."

(iv) *Removal of the Entire Upper Extremities or Amputation at the Shoulder-joint for Recurrent Inoperable Carcinoma.* At the present day these operations will be very seldom, if ever, called for. They have been occasionally performed with the object of giving relief to the agonising pain and heavy, œdematous, swollen,

immobile state of the limb which sometimes is seen to follow implication of the axillary vessels and nerves. Any hope of cure, even by the most extensive of these operations, is quite out of the question. Decided relief will be given, but it will not be unmixed relief. If any such operation be performed it should be on the lines of that of Berger (*see* p. 234) and not an amputation at the shoulder-joint, in which the incisions may pass dangerously near to the disease. The late Mr. Clinton Dent brought such a case before the Medico-Chirurgical Society.[1]

The operation is scarcely to be recommended. It is palliative only, and the relief it gives is temporary and obtained only at great cost. It should certainly not be suggested until a trial has been made of X-rays, radium, or lymphangioplasty. Cases with agonising pain from involvement of the brachial plexus are extremely rare. Swollen, heavy, œdematous limbs are more common, but here lymphangioplasty is likely to be successful. In such cases too, relief can almost always be given by elevation of the limb at night, aided by careful bandaging or the wearing of a well-fitting support. Very rarely, owing to the patient's neglect, this condition of œdema has gone so far that recurrent attacks of erysipelas or sloughing are present. In some of these Berger's operation would be justifiable, but both sides of the case should be clearly put before the patient.

The heavy, swollen, œdematous condition of the arm mentioned above may often be treated, with marked relief, by the comparatively trivial operation of lymphangioplasty which has already been described at p. 55.

(v) *Oophorectomy in Inoperable Carcinoma of the Breast*[2] This operation is now seldom, if ever performed. It has, however, been performed with sufficient frequency to justify the following conclusions. While the operation has in a certain number of instances produced a decidedly beneficial result, these cases have not been numerous; and in every such case the benefit has been temporary only. Mr. Stanley Boyd[3] collected fifty-four cases and divided them into two groups: (*a*) those in which oophorectomy seemed to produce a clear and decided effect, such as shrinking and disappearance, sometimes rapid and even temporarily complete, of all the recurrent growth in the skin and glands, with disappearance of pain and swelling; (*b*) those in which oophorectomy had but little or no effect. Of the fifty-four cases thus classified, Mr. Boyd found that nineteen (35 per cent.) were more or less markedly benefited, thirty-four were not benefited or only doubtfully so, and one died of exhaustion. As to the duration of the benefit, when present, Mr. Boyd considered that, as far as the cases available for drawing conclusions went, in the majority the growths reappear or begin again to increase in six to twelve months. It is interesting to note that with one exception all the patients who had passed the menopause are included among the failures. When it is remembered that oophorectomy is not to be relied upon for checking the hæmorrhage and growth of uterine carcinoma, it is only probable that little might be expected from this operation for carcinoma of the breast. And it must be remembered that whatever temporary benefits the operation may confer, that it is likely to produce certain unpleasant effects of its own. Finally, it is to be noted that, in two of the cases collected by Mr. Boyd, oophorectomy for inoperable carcinoma of the breast has been fatal, in one case from exhaustion, in the other from intestinal matting.

X-ray Treatment and Radium Treatment of Malignant Disease. Some Conclusions. There is still considerable difference of opinion as to the results of treatment of carcinomatous growths, inoperable and recurrent, by X-rays and radium. Both these agents have the power of inhibiting the growth of cancer cells and sometimes, apparently, of completely destroying them, provided that the nodules are small and are near the surface. These conditions are fulfilled in those cases of carcinoma of the breast where recurrences appear as small nodules in and near the scar. Such cases, and also where the carcinoma is ulcerating, are therefore very suitable for this form of treatment. Relief from pain is a prominent feature. Hæmorrhage and discharge are decidedly lessened, and, in a

[1] *Brit. Med. Journ.*, March 12, 1898.

[2] The credit of suggesting this operation must be given to Dr. Beatson, of Glasgow. He considered that there were cases where it was of service in prolonging life and lessening suffering, but never claimed for it any curative power.

[3] *Brit. Med. Journ.*, 1900, vol. ii. p. 1161.

certain proportion, ultimately cease. Even in the hopeless cases X-ray treatment prolongs life, makes the patient more comfortable, and the last hours more free from pain. The treatment is most likely to fail in cases where the patient is young, the persistence large in amount and active in its progress, and on the other hand when much dense fibrous tissue is present. The treatment may in some cases be harmful (*a*) by stimulating the rate of growth, perhaps by the employment of too weak treatment, (*b*) by too rapid destruction of large areas and flooding the system with toxins. Deep secondary deposits in glands, bones, or viscera, are not likely to be affected. The following, written by Sir A. Pearce Gould in 1905, is still true at the present day :

"Ulceration of scirrhus mammæ is very often arrested, foul ulcers become clean, and in many cases the ulcers heal up. Growth is held in check, or partially, or in some cases wholly, disappears. I have seen many examples of each of these three results ; *e.g.* I have seen an extensive absolutely fixed growth in the breast become so much loosened and free from the chest walls, that it became a suitable case for excision, and the operation was satisfactorily accomplished. I have had two cases of those big œdematous arms from secondary supraclavicular growth in which the change has been so great that œdema has disappeared, and the woman has resumed work.

"Epithelioma of the tongue and mouth are only slightly benefited, and only occasionally are secondary epitheliomatous growths in the cervical glands improved. In one case of a large, deep ulcer threatening to open into the deep vessels of the neck, rapid healing occurred under the rays, and the patient died from another effect of the disease, broncho-pneumonia. In another case glandular growths have been held in check, and have very distinctly lessened in size ; but as a rule, the treatment is very disappointing in these cases.

"I have seen two or three very striking results in carcinoma recti. In one, a large fungating recurrence after excision entirely disappeared, and the man is leading an active life and in good general health. In another, a doctor, who was laid aside from practice entirely for six months, got rid of his locum tenens and resumed all his work in a busy practice."

X-ray treatment is often used as a prophylactic measure against recurrence after the complete operation. It is, of course, very difficult to estimate the effect of this. At any rate it can do no harm and should certainly be employed where the operation has been performed at an advanced stage of the disease. Mr. Handley recommends that the treatment as a prophylactic measure should not be continued for more than three or four weeks.

Other Indications for Excision of the Breast. *Sarcoma* of the breast is not uncommon. It usually appears as a soft rapidly growing tumour at a somewhat earlier age than is usual with carcinoma. In such a case extensive removal on the lines described above should be carried out.

Chronic Cystic Mastitis (Multiple Cystic Disease). This disease, which usually occurs in women over forty, is characterised by the appearance of large numbers of small cysts varying in size from a pin's head to a marble. While in the early stages palliative treatment alone may relieve symptoms and prevent its advance, excision of the breast is indicated in more advanced cases and where the whole breast is affected. The breast is removed by an elliptical incision including the nipple. There is no need to remove the pectorals or the axillary contents. Where the disease is limited to a part of the breast, excision of the affected portion will alone be required.

Tuberculous Disease of the Breast. In this disease there may be extensive sinuses and pockets preventing efficient local treatment. It

is then best to excise the affected breast by means of the elliptical incision mentioned above. Tuberculous axillary glands may be treated at the same time.

Treatment of Fibro-adenomata of the Breast. These innocent tumours usually occur in young women between the ages of 15 and 25, though occasionally at a much later age. They are easily removed by means of an incision in a radial direction where they are nearest the surface. The knife then passes through the breast tissue until the capsule of the tumour is reached. The adenoma then readily shells out. All vessels must be secured or a hæmatoma may result.

Thomas's Method of Removal of Innocent Mammary Tumours. An incision is made exactly following the groove between the skin of the lower half of the breast and that of the chest. On reaching the muscles, the breast is dissected from them sufficiently to allow of its being turned upwards so as to expose its posterior aspect. A straight cut is then made through this over the tumour, and the latter removed. The gland is then replaced. Adequate drainage must be provided. The scar is not noticeable save when a free incision has to be made, *e.g.* for a fibro-adenoma high up in the breast; the ends of it then show. Owing to the excellent results and very trivial ultimate disfigurement which the ordinary method of removing fibro-adenomata affords, that of Dr. Thomas is very rarely called for. The operation, too, is not always easy in practice, and its adoption will a good deal depend upon the position and mobility of the tumour.

CHAPTER XXXV

PARACENTESIS AND INCISION OF THE CHEST. RESECTION OF RIBS. EMPYEMA

PARACENTESIS AND INCISION OF THE CHEST

INDICATIONS for interference in pleuritic effusions. Before interfering operatively, the surgeon has two points to consider :

(1) **Whether fluid is present.** (2) **Whether it is purulent or not.** The answer to the first question will depend on the history and the physical signs and will require no further discussion here.

(2) **Is the fluid purulent or not?** If pus is present it will not be absorbed ; it may burst into the lung, may burrow about, making its way externally, causing hectic, caries, and lardaceous disease.

A. *Exploratory puncture.* A large hypodermic syringe and needle should be used, absolutely sterile, pervious, and the needle sufficiently long and not too flexible. The timely use of this may save much delay. A grooved needle should never be trusted to. It is readily plugged by a pellet of fat, and thick pus will not flow along it.

B. *Presence of pyrexia and hectic.* This is not always reliable. Fallacies : (*a*) They may be absent, or little marked, in empyema, especially in long-standing cases, the alteration of the pleura or the degree of tension preventing absorption. Occasionally the disease is latent for many months. (*b*) Well-marked pyrexia may be present in serous effusions.

C. *The aspect of the patient.* The tint is often anæmic and earthy in long-standing empyema, and the finger-ends, especially in children, clubbed. "If a child be seen with general pallor and finger-clubbing, one ought to think of empyema rather than of the other causes of clubbing, viz. chronic bone disease, bronchiectasis, and congenital heart disease" (Barlow).

D. *Age.* Empyema is common in children and young adults.

E. *Rigors.* These are often slight, irregular, and may occur only towards evening. In children they are often absent throughout.

F. *Any preceding disease.* Empyema is not unfrequently seen after pneumonia, scarlet fever, measles, childbirth, pyæmia, small-pox, and especially typhoid fever. The onset is most insidious and often overlooked. If a patient during convalescence seems to go back, loses his appetite, any embarrassment of the breathing must be at once looked for, and empyema suspected.

G. *Œdema.* This is often absent, though pus is present.

H. Other signs, especially in children, must be remembered, viz. unexplained and obstinate diarrhœa, emaciation, &c.

Treatment of Non-purulent Serous Effusions. *Question of operation.* If medical treatment, *e.g.* absorbents and diuretics, counter-irritation,

dry nutritious diet, &c., fail, two questions arise: A. What is the danger of leaving the fluid? B. What is the risk of paracentesis?

A. *Danger of leaving the fluid.* (1) There is the risk of sudden death when a large, quiet effusion persists.[1]

Dr. Moxon showed that the effect of the effusion varied with the side affected. Thus an effusion into the right chest not only pushes the heart over to the left, but also compresses the right auricle, and so shuts off blood from the heart, thus tending to produce syncope from cardiac anæmia. Effusion on this side also tends to make lateral pressure on the inferior vena cava, which is the more readily bent over as it has just passed through a rigid ring. Effusion into the left chest drives the heart over to the right, and, pressing on the left auricle, distends the right side of the heart, by impeding the passage of the blood into the left ventricle, and thus tends to bring about syncope from cardiac plethora. There is also a tendency for the right lung to become œdematous, owing to its being engorged with blood.

(2) The lung may become more and more tied down with adhesions, *e.g.* when much lymph has formed.

(3) The sound lung may become engorged, especially if the patient is submitted to a chill.

(4) There is the risk of slow pus-formation, especially in a patient much run down, where the effusion is secondary to some other disease, and where there is the history of a chill.

B. *The risks of paracentesis.* (1) Shock. This is especially possible in delicate patients with a nervous dread of the operation. (2) Syncope. A special cause of this is perhaps alteration of the position of the heart and large vessels by removal of the supporting fluid. (3) Embolism from the detachment of clots in the pulmonary veins. That this is a real risk is shown by a case of Sir B. Foster's in which clots dislodged from the right pulmonary veins caused embolism of both renal and iliac arteries, with a fatal result from albuminuria, suppression of urine, and gangrene. Both (2) and (3) may perhaps be prevented by not drawing off all the fluid, and drawing it off slowly. (4) Œdema of the lung. This is an undoubted danger. Shortly after the tapping (the effusion being usually a large one), urgent dyspnœa comes on with frothy serous expectoration rich in albumen. Death usually takes place in about twenty-four hours. Dr. Duffin's explanation of this is probably the correct one. The compressed lung, after the removal of a large effusion, corresponds to a limb after the use of an Esmarch's bandage, *i.e.* the vasomotor nerves are paralysed: thus when the lung expands, sudden stress is thrown on toneless vessels; hence the transudation of sero-albuminous fluid, equivalent to the oozing so common after removal of the bandage.

Indications for Paracentesis in Non-purulent Effusions. (1) Threatened failure of the heart's action, shown by the failing pulse, the extremities growing cold, &c. (2) In all cases, and at any date, when the fluid is so copious as to compress the opposite lung. The base of this should be carefully watched, and any expectoration noted. (3) In all cases where, with a large effusion, there have been one or more attacks of orthopnœa. Relief will be most emphatically called for when, with this history, the

[1] Sir T. C. Allbutt records the case of a girl who had been brought to Addenbrooke's Hospital with a large, quiet, serous effusion. Having got out of the cart which had brought her, she was walking slowly across the green in front of the hospital, when, without a cry or a stagger, she was seen to fall dead.

patient lives some distance off, when he is no longer young and the chest no longer yielding, or when the opposite lung is at all œdematous. (4) In all cases in which a pleuritic effusion, occupying half one pleural cavity, has existed three or four weeks, and shows no sign of progressive absorption.

Paracentesis for Serous Effusions. *The site of puncture.* This is decided by: (1) Physical signs. (2) The result of the exploring needle. Common sites are: (*a*) The sixth space in front of the posterior axillary fold, a spot which has the advantage of being thinly covered, and where the ribs are well apart. (*b*) In the seventh, eighth, and ninth spaces behind, in the scapular line. The eighth space is here very frequently used.

The patient having been turned somewhat over on to his sound side, if he can bear this, and brought to the edge of the bed, or, if he must be raised, so supported that he can be readily lowered in case of faintness, the surgeon, having seen that the spot chosen for puncture is sterilised, and that his aspirator is thoroughly clean and in good working order, fixes his nail just above the lower rib, and, holding the needle so that it cannot penetrate too deeply, plunges it straight into the pleural cavity, and then brings it into connection with the vacuum. If the skin is very thick, and the needle slender, it is well just to make a puncture with a scalpel's point. In either case it is the skin wound which pains.

The following practical points should be remembered: (1) Not to catch the needle on a rib, a mistake which is easy when the ribs are close together. (2) To be sure and enter the chest cavity, a thickened pleura or false membranes sometimes interfering with this. (3) To avoid injury to the lung, by not plunging the needle in too deeply, or by guarding the point when it has entered. Usually the lung is at a considerable distance, but when the collection is a localised one this accident may easily take place. (4) The fluid should not be drawn off too quickly or completely; if successive vacua are required, the later exhaustions should not be too complete. The patient should always be warned against making any sudden movement or a deep inspiration. If the flow stops suddenly, it may be due to a kink in the tube, or to a pellet of lymph plugging the needle. The flow should always be stopped at once: (*a*) if the patient faints, this being due sometimes to the consequent displacement of viscera; (*b*) if any blood suddenly appears in the fluid, this coming usually from the rupture of vascular adhesions, more rarely from a wound of the lung; (*c*) if an irritating cough is set up, this being due sometimes to the unfolding of a temporarily compressed lung.

When the needle is withdrawn, the puncture should be at once closed with collodion and sterile wool or gauze.

On the question of anæsthesia or local analgesia the remarks at pp. 582, 765 should be referred to. As a rule the pain is so momentary that these are not needful.

Incision of the Chest for Serous Effusions. This is indicated in certain cases of long-standing effusion where paracentesis has been performed more than once, and has on each occasion been followed by rapid re-collection of the fluid. A warning is needed here—as to the great risk of a sinus following and thus infection, especially where the chronic effusion is tuberculous, an incision here being a very risky step.

Sir R. Godlee[1] is emphatic upon this point: "The surgeon is often asked to open these, especially if the fluid has become slightly turbid. My experience is

[1] *Diseases of the Chest*, with Dr. Fowler, p. 596.

that if this be done, the fatal conclusion is hastened. Such patients are able to get along very well with a very considerable collection of fluid in the chest; but when a free opening is made, they become much more short of breath, and, as the discharge is copious for a long time, it is very likely that septic organisms will be allowed to enter. This is the beginning of the end. I have in a few tuberculous cases which were, so to speak, halfway between serous effusions and empyemata, given considerable relief by inserting two cannulæ, one, in front, made to communicate by a tube with a large bottle of sterilised boric lotion, the other, far back, being put in communication with the syphon or bottle aspirator. The fluid was slowly exhausted, and its place taken by the boric lotion. As soon as the latter flowed quite clear into the bottle, the anterior cannula was removed, and as much as possible was exhausted from the chest. This appears sometimes to diminish very considerably the rapidity of the reaccumulation. Possibly other fluids, such as tincture of iodine and water, might prove more efficacious."

EMPYEMA

The frequency of this in children[1] has been already alluded to. At this time of life the prognosis is good, as the lungs are more likely to be free from morbid changes. The formation of pus may be very rapid at this early stage of life, pus being present by the fourth, fifth, or seventh day. The importance of this is considerable. Thus: (*a*) the pleura is soon altered, thickened, and less prone to heal; (*b*) the lung becomes tied down; (*c*) the drainage-tube is readily blocked; (*d*) subdivisions may form in the cavity, and so thorough drainage and obliteration are rendered difficult.

Another important point is, that pus in the pleural cavity is frequently localised and encysted in children. This is not uncommon in the middle third of the thorax, the pus being limited above by adhesions, and below by the fixing of the lower lobe to the chest wall.[2] Thus, at this spot hard bronchial breathing and modified resonance may be present. Finally in children small multiple collections are not uncommon.

The surgeon will very likely be asked the question whether the pus need be withdrawn, and if it will not be gradually absorbed. The chances of this are extremely small, and the risks of leaving it very great. They are: (*a*) external perforation, leading to the unfavourable results of insufficient drainage, caries, and amyloid disease. The most likely sites are—in front, above and below the nipple; antero-laterally, in the fifth space, just outside the rib cartilages. (*b*) Lung perforation, leading to gangrene and hectic. (*c*) General tuberculosis, an old empyema, even if caseated and inspissated, being infective. (*d*) The empyema may also burst into the œsophagus or pericardium. In other cases it has been known to track downwards behind the diaphragm and give rise to a lumbar, gluteal, or even a psoas abscess. In such cases pulsation of the swelling has been observed, synchronous either with respiration or with the heart-beat.

TREATMENT OF EMPYEMA

A. Simple Puncture with Aspirator or Fine Trocar. This is seldom curative. The cannula will entirely fail to remove the flocculent or fibrinous masses which are often present, and the existence of which we

[1] Out of forty-four and sixteen consecutive cases of pleuritic effusion at Great Ormond Street, Sir T. Barlow found twenty-seven and fourteen to be purulent.

[2] While the commonest form of localised empyema is that lying between the lung and costal pleura, two others may be met with: that between the diaphragm and the lung, and the variety situated between two layers or between the lung and mediastinum.

have no means of foretelling (p. 766). Aspiration will certainly need repetition and is only justifiable in a few conditions: (*a*) in bilateral empyemata; (*b*) if the patient is very young or very timid; (*c*) if the collection is very small or multiple; (*d*) in advanced phthisis or pyæmia; (*e*) as a temporary or palliative measure in malignant disease, or in old or feeble patients. Patients thus treated should be kept under close observation. In some cases preliminary aspiration is to be strongly recommended before opening and draining the pleural cavity, namely in large empyemata of the left side where the heart is displaced. By aspiration, twenty-four or forty-eight hours before the chest is opened, the danger of syncope (which may be fatal), arising from sudden displacement of viscera, may thus be averted.

B. **Incision.** This, with a very few exceptions, is the best method. Its chief advantages are the free drainage which it gives. Although the method of simple incision has met with success, yet generally speaking a piece of rib is resected as well, to allow of free drainage.

The *chief advantages* of this are as follows: (1) Perfectly free drainage is provided for, since the largest sized drainage-tube can be used, and there is no longer the fear of compression of the tube by closely placed ribs. (2) The aperture is large enough to allow the surgeon thoroughly to explore the cavity with his finger. Its extent and the character of its walls may thus be gauged, and further valuable information at times obtained, *e.g.* a case of pyæmia under Sir W. Savory, in which a distended pericardium was felt through an opening in the left pleura. This was opened through the same wound, and twenty-four ounces of pus evacuated.[1] (3) The large masses of fibrinous lymph so often found lining the cavity can escape, and prolonged discharge perhaps thereby prevented. Where such masses are present the empyema is very frequently due to the pneumococcus, and especially requires early and complete evacuation. Such empyemata are common in children, and while sometimes of a mild type, are always liable to cause serious complications, *e.g.* pericarditis or, more remotely, peritonitis and arthritis. It is the large masses mentioned above which especially call for a free opening and removal of a rib, for if retained they not only prevent complete evacuation, but are sources from which further invasion by the cocci or their toxins may take place.

The disadvantages are that the operation is more prolonged and also somewhat more difficult than simple incision. There are practically no disadvantages as regards the effect on the rib itself, for new bone formation is generally quite rapid enough and caries and necrosis are almost unknown. Removal of a piece of rib is then to be recommended, except where the necessary appliances are not to hand, or the condition of the patient forbids any but the shortest possible operation. The question will occasionally arise whether a single or a double opening is required. A single opening is usually sufficient in children and in young adults, especially where the history is a recent one. The site usually chosen is the seventh, eighth, or ninth space in the posterior axillary line, or in the same space just outside the line of the angle of the scapula. In adults the chief part of the opening should be anterior to the latissimus dorsi, an incision through a well-developed muscle having certainly the risk of causing oozing afterwards, which may be very serious in a very

[1] *Path. Soc. Trans.*, 1884. See also a case recorded by Dr. Fawcett and Mr. F. J. Steward (*Clin. Soc. Trans.*, vol. xxxiv, p. 46).

weakly patient. Hutton [1] recommends incision over the sixth rib in the mid-axillary line, because (1) this is the last point to which the lung expands; and (2) it is more comfortable to the patient. A double opening is very occasionally required, *e.g.* in very large cavities in adults when the pus is fœtid; when the case is of very long standing; when the pus is pointing high up and anteriorly, and thus the drainage is inadequate. The best instrument to cut upon in making the counter-operation is a stout silver probe. To this a drainage-tube can be attached by silk, and easily drawn into place.

The chief points of importance in the operation are the following: Amongst the first will arise the question of giving an *anæsthetic*. An anæsthetic may safely be given in the vast majority of cases. Chloroform is the most suitable, on account of the greater struggling (undesirable with viscera displaced), the dyspnœa set up by the mucus, and the bronchitis subsequent to the administration of ether; but the way in which the anæsthetic is given is of more importance than the anæsthetic itself.

Sir F. Hewitt says:

"With regard to the most appropriate anæsthetic, it is difficult to lay down definite rules. The condition of the patient must be the chief guide. From the point of view of the surgeon chloroform is preferable to ether; but there are many cases in which this latter anæsthetic should be used in preference to chloroform. Whenever possible, ether or an ether mixture should be chosen; for although it may cause some increase in the difficulty of breathing, the circulation will be well maintained. It should, of course, be given by a semi-open inhaler. The greater the respiratory difficulty the lighter should be the anæsthesia."

The position of the patient is a matter of considerable importance. Though the breathing will be less affected if the patient is on his side with the healthy side uppermost, yet in many cases the operation can be far more satisfactorily and quickly performed with the affected side uppermost. The position should always be the subject of a consultation between the anæsthetist and the surgeon, but, generally speaking, when the respiration is seriously affected the healthy side should be uppermost to allow free action of the healthy lung.

Local analgesia (p. 582) should certainly be used where a general anæsthetic is thought inadvisable. Mr. G. L. Chiene [2] used the following mixture: four parts of 2½ per cent. eucaine B; one part of 1 to 1000 of adrenalin chloride. Thirty minims of the above solution were injected into the subcutaneous tissue over the line of the long axis of the rib. Twelve minutes were allowed to elapse, and then the usual operation performed; this was accomplished painlessly, more of the solution being applied to the periosteum before the rib was excised. The tissues in the region of the injection became blanched; there was practically no bleeding, no pain even when the bone was cut through, and no after-hæmorrhage.

When no rib is removed the operation is performed as follows: The patient being supported over the edge of the bed or table, partly rolled over to the sound side, or, if this is impracticable, suitably propped up, the surgeon, having cleansed the part, fixes a finger-nail just on the upper margin of the lower rib in the space chosen (p. 762), and makes an incision down to the muscles for one and a half or two inches, just above his nail.

[1] *Brit. Med. Journ.*, vol. ii. p. 1324, 1898.
[2] *Scot. Med. and Surg. Journ.*, September 1904, p. 215.

In every case the presence of pus at the spot chosen should first be verified with an exploring needle. This incision having exposed the muscles, a steel director is driven through into the chest cavity, care being taken not to plunge it too deeply.[1] A pair of dressing-forceps is then run along the director and opened widely both horizontally and vertically. Owing to the gush of pus which is now violently expelled, it is well to throw a sterilised piece of gauze over the wound, while the pus is escaping.[2] This prevents any entrance of air, and regulates an otherwise perhaps too rapid exit of fluid. The opening is next thoroughly dilated by means of a pair of lithotomy-forceps or sequestrum-forceps, the jaws of which are carefully separated, and the size of the cavity, the proximity of the lung and the degree of granulation formation all investigated.

When, as will usually be the case, *a portion of rib is to be removed*, the steps of the operation are slightly different. The incision is made directly over the rib and straight down to the bone, the periosteum being divided. The periosteum is now stripped off the rib for a distance of about an inch and a half with a slightly curved raspatory, care being taken thoroughly to clear the pleural surface. The rib is then divided in front and behind. This can in most cases be accomplished with a strong bone-forceps, or special rib-forceps, but if the ribs are large and dense it may be necessary first to cut a groove with a saw.

The piece of rib is now removed, and the cavity opened with director and dressing-forceps as above described, care being taken to push in the director exactly over the upper border of the rib, in order to avoid the intercostal vessels. Having in this way made a free opening, and the pus having been evacuated, any large flakes of lymph may be removed by the surgeon's finger or a blunt-edged scoop, and a drainage-tube inserted. This should be of large size, and just sufficiently long to reach the cavity without projecting too far into it. Any coiling of the tube in the cavity is useless, and may be harmful. The inner end of the tube should carry one or two large lateral openings. An ordinary tube should be securely fixed in position by means of safety pins, in order to prevent it from slipping into the pleural cavity, or a silkworm-gut suture may be used to stitch the tube securely to the skin. Another method easily provided is to slit the outer end of the tube into four strips and attach each of these by silver wire to a small square of india-rubber sheeting. Mr. Bilton Pollard's tube (Fig. 310) is very simple and efficient. One of the methods given should always be adopted to prevent the tube slipping into the pleural cavity.

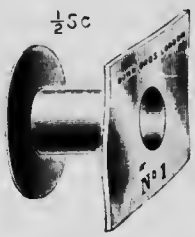


FIG. 310.

Hutton[3] has recently described a drainage-tube fitted with a duck-bill valve, which, while allowing the exit of pus during expiration, prevents the entrance of air during inspiration, thus promoting a more rapid expansion of the lung. The advantages claimed are:

(1) That it hastens materially the expansion of the lung.

(2) That it is simple, inexpensive, and comfortable.

[1] If the chest is being opened low down, and the above warning not remembered, the director, or the dressing-forceps which follow it, may easily be sent into the peritoneal cavity.

[2] Occasionally, if the patient struggles, air is drawn into the pleural cavity after the escape of the pus, and then is expelled into the connective tissue of the wound, constituting emphysema. This will all pass off spontaneously.

[3] *Loc. supra cit.*

(3) That by hastening the expansion of the lung it will obviate, in many cases, the necessity of Estander's operation, which means the deprivation of the use of one lung.
(4) It is devoid of risk, as it only aids nature by enabling the lung to keep the advantage it has gained by each expiratory effort.

Judging from the above points, and from the satisfactory results which Mr. Hutton describes, this apparatus is worthy of more extended trial.

Hæmorrhage during the operation is usually slight, and gives no anxiety afterwards. If any point give trouble, resisting ligature, after picking up the tissues with Spencer-Wells forceps, a pair of these left on for twelve hours will meet the case; a bit of a rib quickly resected will give access to a wounded intercostal artery.

The opening must be sufficient, and, if there is any doubt about this, a further portion of rib should be resected without hesitation, especially where these are very close together, or where the pus is foul (*vide infra*), or contains large flocculent masses.

If the question of washing out the cavity arise, probably from the discharge being foul, it should be remembered that this proceeding, however gently done, has occasionally brought about grave and even fatal results very suddenly. Whether these have been due to absorption, to reflex nervous disturbance, or to dislodgment of thrombi is uncertain, but it is beyond question that in several cases symptoms of impending collapse and even death have followed on washing out an empyema, and that, too, in a patient well on in convalescence. Again, it cannot be too strongly insisted upon that fœtor calls for a freer opening, not for washing out. If, however, it is decided to make use of injections, dilute and bland ones, *e.g.* tr. iodi, should be used, and these should be gently run in with a funnel and tubing, the elevation of which does not exceed eighteen inches; fluid should never be thrown in with a syringe. Care must be taken that the fluid escapes as fast as it runs in; the patient must always be recumbent.

During the prolonged after-treatment everything should be done to improve the general health. Change of air is here a cardinal point, first getting the patient from his room, then outside the house, and lastly, if possible to the seaside.[1]

A point of no small importance in the after-treatment,[2] especially in young subjects with flexible spines, is to encourage early, systematic deep breathing and gymnastic exercises, thus to promote expansion of the chest, and so minimise that sad sequela of empyema, irremediable lateral curvature.

Bier's treatment is often of the greatest service in the after-treatment of these cases. A Bier's glass cup of sufficient size to encircle the wound completely, usually three or four inches in diameter, should be employed. It should be applied for ten minutes once or twice a day, when the dressings are being changed. Its action is threefold: (*a*) it sucks out pus from the

[1] Last and most important of all—unfortunately for hospital patients a treatment that cannot often be utilised—comes Margate air. Any seaside air is beneficial, but weather and season permitting, I do not believe there is any corner of England so quickly restorative to children with empyema as that in which Margate and Broadstairs are situated; and, personally, I set more store by a change of this kind after the first three or four weeks have passed than in any continuation of antiseptic dressings." (Goodhart, *Diseases of Children*, p. 345.)

[2] Should a sinus persist injection of an emulsion of bismuth may be tried. This method of treatment is described and a number of cases thus treated, by Dr. Oehsner, of Chicago, in a paper on "The Treatment of Fistulæ and Abscesses following Operations for Empyema" (*Ann. Surg.*, 1909, vol. I, p. 151).

cavity; (*b*) it causes passive hyperæmia and thus has the antibacterial action of Bier's treatment; (*c*) it probably assists in the expansion of the lung. In cases which are not doing well, *i.e.* where the temperature remains high and where suppuration continues, the effect is often remarkable. It may, with advantage, be adopted as a routine treatment after the third day.

Before leaving the subject of the operative treatment of empyema a few words should be said about the dressing of these cases. This should be strictly aseptic from first to last, *i.e.* cleansing the parts incised, disinfection of instruments, taking care that the pus escapes into antiseptic dressings, a sufficiently free opening, adequate drainage, abundant dry gauze and wool dressings, changed twice perhaps in the first twenty-four hours, and then daily for the first week. Later on, when the patient is going to the seaside, he can easily be instructed to remove with clean hands and cleanse daily the short pieces of drainage-tube which keep the external opening patent, and to apply over the sinus a dressing of boracic acid lint and carbolised tow, or whatever antiseptic dressing is thought desirable.

Where an empyema exists on each side, the wisest course is to open and drain one, and at the same time to aspirate the other, which should be opened a few days later.

Date at which the drainage-tube may be dispensed with. In children with a recent history a few days may suffice; in adults three to four weeks must usually elapse.

Complications of Empyema and Reasons for Cases not doing well. (1) A persistent infected condition, in spite of two openings, free drainage, &c. (2) Failure of the lung to expand owing to dense adhesions and also, possibly, to fibroid changes in the lung itself. (3) Tuberculous disease. (4) Lung mischief on the opposite side—*e.g.* broncho-pneumonia, bronchitis. This is especially dangerous in patients over forty. (5) Caries of the ribs, multiple spontaneous openings, with burrowing sinuses beneath the skin. (6) Age, from the feebler powers of repair and the more rigid condition of the chest as life advances. (7) Cardiac dilatation. (8) Inflammation of other serous and the synovial membranes, *e.g.* when the pneumococcus is present. (9) Size of the empyema. The smaller and the more localised the collection the better the prognosis. (10) Collection of pus forming in the opposite pleura. (11) A broken-down constitution; intemperance; kidney disease. (12) Sir R. Godlee [1] reminds us that a curious complication, viz. cerebral abscess, has been noticed in a sufficient number of instances to make it unwise to overlook the possible association of one with the other. Judging from Dr. Fagge's remarks on thoracic disease as a cause of cerebral abscess,[2] it would appear that disease of the lung itself is oftener the primary lesion upon which the abscess of the brain depends.

According to Sir W. Gowers,[3] these abscesses "never result from true tuberculous cavities; the abscess is single in about half the cases, and is generally situated in the cerebral hemispheres, especially in the posterior lobes. The cerebellum is not often affected, and never suffers alone." Sir R. Godlee[4] writes: "These abscesses are seldom amenable to surgical treatment. I have opened one without good result, probably because it was not single, and I have searched for one which appeared to give positive evidence of being situated in the motor area, but was really in the occipital lobe."

[1] *Dict. of Surg.*, vol. i. p. 459. [2] *Prin. and Pract. of Med.*, vol. i. p. 546.
[3] *Diseases of the Nervous System*, 2nd ed., vol. ii. p. 477. [4] *Loc. supra cit.*, p. 617.

RESECTION OF RIBS

Indications.[1] These are chiefly :

A. Caries of ribs.

B. In the majority of cases of empyema.

C. For a wound of an intercostal artery.

D. For removal of growths.

Dr. E. Rixford, of San Francisco, in an instructive paper,[2] quotes the following four cases. He points out that, as in the modern operation for carcinoma of the breast, all the subcutaneous tissues are removed down to the periosteum and intercostal muscles; if any reappearing nodule is to be successfully dealt with, the underlying portion of the chest wall must be removed with it. The following are the abstracts of Dr. Rixford's four cases. There were no deaths from the operation.

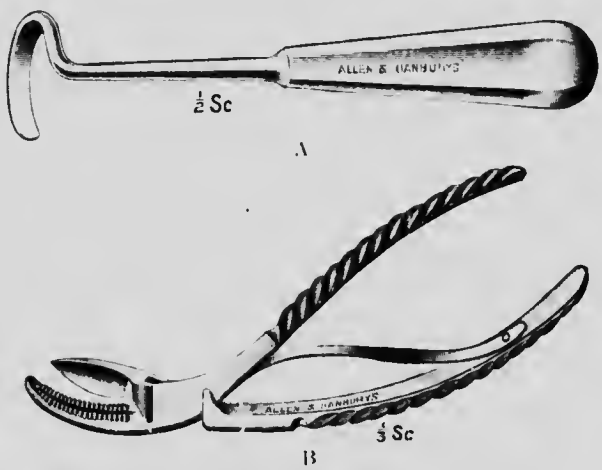


FIG. 311. A. Doyen's rib raspatory. B. Rib shears.

CASE I. Reappearing carcinoma of breast over fifth rib; resection of fourth and fifth ribs; no evidence of reappearance after two years. CASE II. Reappearing carcinoma of breast at edge of sternum; resection of fourth and fifth costal cartilages with edge of sternum; reappearance [illegible] sternum after eight months, disappearing under the X-rays, but reappe[illegible]e months later. CASE III. Reappearing carcinoma of breast at edge of ste[illegible]; resection of t[illegible] and fourth costal cartilages with half of breadth of sternum; reappearance in original scar apart from the field of the last operation; death from general carcinosis five months later. CASE IV. Reappearing carcinoma of breast at edge of sternum; removal of ends of first and second ribs and portion of sternum and mediastinal glands; internal mammary artery tied at its origin; further recurrence below; resection of third and fourth ribs; patient well six months after last operation, twenty-two months after operation by Halstead's method.

Dr. Rixford's method of meeting the complication of pneumo-thorax is given at p. 775. This subject is further discussed at p. 780.

A. *In obstinate caries*, where more than one rib is affected, where previous treatment, including gouging, fails, resection should be at once

[1] See also chapter XXXV, on operations on the lung and the mediastinum.

[2] *Ann. of Surg.*, January 1906, p. 35.

performed. It is a very simple operation in these cases, as the soft tissues are nearly healthy and the periosteum is retained.

An incision about two inches long being made over the centre of the carious rib, and the muscles peeled off with a blunt dissector, the periosteum is next incised and separated from the upper and under aspect with an elevator, blunt and slightly curved, so as to pass readily under the rib and lever it upwards. The rib being thus raised, it is easily divided at one limit of its exposed part, partly with a narrow-bladed saw, partly with sharp, curved cutting-forceps. The soft parts are next peeled away from the under aspect, and the rib divided at the corresponding spot and removed.

B. *In most cases of empyema, e.g.* (1) when the drainage is insufficient, the discharge foul, in spite of one or two free openings; (2) when the ribs are too close together for a tube of sufficient size; (3) when an empyema cavity still persists, though sweet, in spite of free incision, good drainage, and careful dressing. In the first two classes of cases removal of a small piece of one or two ribs, as above described, will be sufficient, but in some of these latter cases the operation will necessarily be a much more severe one. When called to a case of persistent sinus and discharge after the incision of an empyema, the surgeon on examination may find that the cavity which remains is small, and that the discharge is due to a persistent sinus-track only. This should be dilated, part of a rib removed, and both sinus and cavity thoroughly curetted. Other causes which have to be thought of where a sinus persists with an empyema cavity of small size are: a small collection of pus after inefficient drainage, caries of a rib, poor vitality of the patient, and a drainage tube which has slipped into the cavity.

But in the majority of cases of long-standing empyemata the cavity remaining is an extensive one,[1] and the condition of things is not so simple and so easily dealt with. Obliteration has taken place, often very imperfectly, owing to the lung not being able to expand, to the ribs having fallen in all they can, to the diaphragm having risen, and the opposite lung, the heart, &c., having come over as far as they are able; while the cavity, often large, which thus remains is lined with much thickened scar-like tissue, covered with granulations of but poor vitality. Here portions of several ribs must be removed, and the operation perhaps repeated, in order that the walls of the cavity may still further collapse, and thus obliterate the cavity while an opportunity is given for exploring this thoroughly.

The spot chosen for the resection of the ribs should be, as far as possible, opposite to the lung which can expand no more, and the pieces of ribs removed should correspond as closely as may be to the anterior and posterior limits of the cavity which it is desired to close. The size of the cavity should be estimated as far as possible with the aid of sterilised bougies and pewter probes. But the use of these through a fistula gives very little information. Any really useful estimate can only be arrived at after removal of parts of at least two ribs.

Operation (Fig. 312). Estlander removed portions of three or four ribs through small incisions. Schede went further, making use of large flaps, removing the ribs more extensively and, in addition, all the perios-

[1] If the empyema is satisfactorily opened and drained, with excision of a portion of a rib, at an early stage, and if after-treatment, including the systematic use of Bier's cupping glasses, is carried out, these cases will be very rare.

tenm, intercostal structures, and costal pleura over the empyema cavity. While this operation is based upon sound reasoning, it is usually an extremely severe one, and the patient's vitality and resisting power are often low. In the case of a cavity of moderate size situated anteriorly or antero-laterally, the operation can be quickly done, and a result is obtained in a short time. The cavity is usually extensive, and its worse feature, owing to the rigidity and inability to collapse of the parts behind -it is here, viz. under the scapula and vertebral portion of the ribs, that the chief part of the cavity will be found. Further, it is only the bones which here add to the difficulties of the operation, but the muscles are larger and the loss of blood greater.

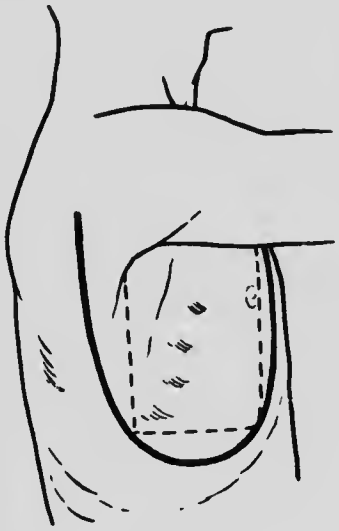


Fig. 312.

If the surgeon begin by raising an extensive flap in order to obtain adequate exposure of the cavity, he may find that he has done too much. It is better to find out what has to be done as his operation proceeds. The first step is to make out the lowest part of the cavity. As a rule the fistula does not correspond to this. As there is not sufficient fluid present to enable an exploratory puncture to decide the lowest level of the empyema, this point must be cleared up with a finger introduced from the fistula, sufficiently dilated, with the additional removal of pieces of one or two ribs here to begin with. The operator having placed himself on safe ground by finding the base of the empyema, begins the central part of his free curved incision here. All the soft parts down to, but not including, the periosteum are raised from the lowest two ribs, and two to three inches of these are freely resected. Care must be taken now and later to leave the periosteum on the rib (the only safe guide being not to strip off all the muscular tissue) and by no means to detach it. If it be left behind, it will throw out material which will be quite as unyielding as the bones taken away. The ribs are removed by carrying a periosteal elevator under them, keeping it close to the posterior aspect, to one limit of the exposed surface, and the bone divided here, partly with a strong-backed narrow saw, partly with curved cutting-forceps or rib shears. The rib is then raised where cut, and severed with the shears at its other extremity. Each piece of rib removed should show clean-cut edges and be covered with periosteum. Now, and throughout the operation, the finger should keep the surgeon accurately informed as to the limits of the cavity, especially when he approaches these in dividing the ribs. As the use of the fingers is the only way of safely delimiting the cavity, the hands must be repeatedly resterilised. By thus freely removing two ribs at the lowest part of the cavity, the surgeon has rendered himself safe in this direction, and also obtained access for more complete palpation of the extent of the empyema. We will suppose that it extends anteriorly and posteriorly as well as upwards. The incision down to the bones is enlarged upwards and forwards and the soft parts raised as before; with two or more fingers as a guide, the ribs or costal cartilages, according

to the extent of the cavity anteriorly, are cut through successively, the remaining intercostal structures being severed with blunt-pointed scissors. The amount of bleeding now met with will vary with the condition of the costal pleura. If this be much thickened, the intercostal vessels will be partly obliterated, but in every case, owing to the condition of the patient, each vessel is to be clamped and, if possible, tied. This is rendered easier by the free access given. The ribs being severed in front, the incision is prolonged in a curvilinear direction backwards and upwards over this aspect of the empyema, the flap still more raised, and the ribs and intercostal structures severed above and finally behind. If the parts removed do not include the costal pleura, and if this be much altered, thickened, and gristly, it must be taken away. Serious hæmorrhage need not be feared if the structure be snipped through gradually with curved blunt-pointed scissors, any vessels met with being easily secured as they are divided. If the cavity be a foul one, or coated with ill-formed lymph and granulation tissue, it should be gently wiped over with sterilised gauze, but no curette should be employed, as is shown by the following case:

A woman, æt. 56, was admitted with a right-sided empyema cavity of some months' duration and fœtid discharge. The left lung was evidently the seat of bronchitis. The cavity, moderate in size and antero-lateral, was easily dealt with on the lines given above. Believing that toxæmia from the very foul condition of the cavity largely explained the condition of the patient, Mr. Jacobson thoroughly curetted the lining membrane, trying to exercise especial care when he approached what might be the root of the lung, pericardium, &c. The next morning the right foot was noticed to be cold. Gangrene followed, necessitating amputation above the knee joint, the patient sinking four days later. The necropsy did not clear up the spot whence the thrombus had been detached. The left lung was the seat of tuberculous mischief.

The flap of soft parts, however large and bulky it may have appeared, will always prove too scanty for the covering in of the gap left. It must be fastened, well depressed, so that it is in contact with the lung, by means of a few salmon-gut sutures and large gauze pads. "Decortication" of the lung is referred to later.

An operation performed on the above lines, with the view of obtaining a thorough exploration of the cavity and then the gradual removal of all ribs and pleura that is needful, is the one best adapted to the largest number of cases. But owing to the condition of the majority of the patients, the operator must be prepared for having his hand stayed and the need of completing the removal of the needful parts in more than one stage. While such later operations destroy in a measure what has been gained at the first, it is the choice of a lesser evil, and the patient or the friends must be prepared for it.

A few points still need to be referred to.

Where the greater part of the cavity proves to be posterior, in the vertebro-scapular region, the condition of the patient will be the chief guide. The improvement in these cases, local and general, brought about by a well-executed operation in front is always very great. If the condition of the patient justify further attempts at obtaining an absolute cure, the choice lies between removal of the lower part of the scapula by a continuation backwards of the posterior horn of the free curved incision (Fig. 312), or resection of the posterior parts of the ribs by raising a trapdoor-shaped flap over them, between the vertebræ and the scapula. Continental surgeons have frequently employed the first method. C. Beck, of New York, mentions[1] two cases in which he removed the lower part of the scapula, one in a boy of 6½, as part of a single operation, complete healing following. In the other case, a man of 40, the

[1] *Ann. of Surg.*, 1904, vol. i, p. 419.

lower part of the scapula was taken away in the last of a series of seven operations. The cavity had now gradually filled up, but a large defect was still left where the axillary region was not yet covered by skin. The same surgeon [1] advises the following method in those rarer cases where the persistence of the trouble is due to the main cavity being apical. The increased local risk here, owing to the vicinity of the subclavian vessels and the fixity of the parts, is obvious.

With the arm at right angles, the incision is led close to the lower border of the pectoralis major till it ends at the lower part of the anterior margin of the deltoid. The muscles are then dissected superiorly until the axillary region is free. The vessels and muscles are grasped by strong blunt hooks and pulled upwards. Sometimes separation is possible only by the aid of lateral incisions into both pectorals. Thus the vessels are temporarily put *hors de combat*, and the ribs can be removed according to the indicated principles. If it is very difficult to reach the first rib by means of the pectoro-axillary incision, then the clavicle is to be resected temporarily.

Decortication of the Lung. Removal of the pulmonary pleura with the view of allowing the lung to expand was advocated by Delorme in 1894 [2] and G. R. Fowler.[3] It has been claimed that this method should largely replace the operations of Estlander and Schede, but as, owing to the usual position of the lung, free removal of the overlying parts will be first needful, it appears to me to increase considerably the severity of an operation already very great. The visceral pleura is rarely in that thickened altered condition with which we are so familiar in the case of the costal pleura. Lastly, even if the visceral pleura be successfully removed over the needful extent and the movements of the diaphragm and pericardium are sure to be embarrassing the lung will not expand. It is not from within, but from without, by sufficiently extensive removal of the rigid overlying parts, that we must hope to gain the obliteration of the cavity.

In all these operations precautions against shock must be taken before and during as well as after their performance, and it is always well to have a supply of oxygen at hand.

With regard to **the date at which ribs should be partially resected in long-standing cases of empyema,** most surgeons who see much of these troublesome cases will agree that the operation should be performed as soon as the natural powers of obliteration are at a standstill, care being taken that the patient has recovered from the effects of the first operation, and perhaps recruited his strength at the seaside. About three months will be a sufficient interval, as a rule. Waiting longer only encourages local and general conditions which affect the operation unfavourably.

C. *Wound of Intercostal or Internal Mammary Artery.* When haemorrhage from one of these vessels cannot be otherwise dealt with, removal of a rib will give much readier access to the spot, and a ligature will arrest the bleeding far more satisfactorily than the ingenious devices mentioned in the text-books.

D. *For Removal of Growths.* An attempt may justifiably be made to remove a growth arising from the ribs if the following conditions are favourable. The growth should be of a moderate size, not involving parts of more than four ribs; its history should be a slow one; its outline should be nodulated, well-defined, and its surface hard, pointing to a chondroma or osteo-chondroma, the skin over it thinned, perhaps, but not infiltrated. There should be no dulness in the neighbourhood of the growth, the breath sounds should be normal, and there should be no enlargement of the axillary or the inguinal glands. The following is one of the first successful cases:

Zarubin, of Kharkov, related [4] the case of a young Cossack who sought his advice for a steadily growing and occasionally painful tumour of seven years' standing.

[1] *Ann. of Surg.*, 1901, vol. i. p. 449. [2] *Amer. Year-Book of Med. and Surg.*, 1902.

[3] *Ibid.* and *Med. News*, June 15, 1901.

[4] *Trans. of the Kharkov University Society*, 1891. Supplement to *Brit. Med. Journ.* August 1, 1891.

It measured 21 centimetres horizontally and 19 vertically, occupying the right side of the chest between the nipple and the post-axillary lines from the sixth to the ninth rib. The new growth was hard, nodulated, immovable, and non-adherent to the skin. The integuments over it were thinned, but otherwise normal, and the nearest lymphatic glands apparently unaffected. An osteo-chondroma of the thoracic wall was diagnosed. The huge mass was removed, together with the involved portions of the seventh, eighth, and ninth ribs. The gap left in the chest measured 17 centimetres in a horizontal and 16 in a vertical direction. On opening the thoracic cavity the lung collapsed, but only partially, owing to pleural adhesions around the periphery of the new growths. No serious respiratory or cardiac disturbances occurred, and the haemorrhage was only trifling. The cavity was gently cleansed with gauze soaked in a 1 per cent. solution of boracic acid, and the skin wound, conical in shape, closed. The growth, much larger than an adult head, weighed over 6 lbs. For the first two days the patient was much collapsed and cyanosed, and suffered from agonising cough and obstinate vomiting. The healing of the wound was complete in two months. The author alludes to ten other cases of resection of the thoracic wall for new growths, of which six recovered, while four died. The methods of dealing with the pneumothorax in such operations are given at p. 780.

The two following cases [1] illustrate most of the points in operations on such growths.

Case I was under the care of Prof. Keen, of Philadelphia. A woman, æt. 25 noticed a swelling about the size of an egg near the angle of the right scapula three months after an injury to the right side. On admission, eight months later, she presented a swelling in the postero-lateral aspect of the right chest, extending from the erector spinæ to the right breast, and from the fifth to the eleventh ribs inclusive. The skin was not infiltrated, and there was no evidence that the lung was involved. On exposure of the growth by a horse-shoe shaped flap it was found to be mushroom-like, with an attachment much smaller than the main mass. In order to remove as little of the chest wall as possible, Prof. Keen first separated the growth gradually from the ribs, of which the fifth, sixth, seventh, and eighth, with the intervening tissues, were involved. The pleura was next separated from the anterior surface of the ribs with a periosteal elevator, and each of the four ribs mentioned above divided with forceps anteriorly and posteriorly without opening the pleural cavity. With scissors the soft parts, including the pleura, were rapidly divided, an aperture being thus made in the chest wall measuring 18 cm. vertically by 12 transversely. The patient "suffered very little indeed" from the pneumothorax, which was dealt with by the operator drawing the lung up into the opening with his hand and suturing it to the circumference of the opening with a continuous catgut suture. The patient recovered, and seven months later there was no evidence of reappearance of the disease. The growth was a mixed spindle-celled sarcoma.

Case II. A man, æt. 41, was admitted under the care of Dr. C. B. Porter, of Boston, with the history of three months' pain and swelling in the right side. A dome-shaped swelling, the size of half a cocoa-nut, was present with its centre at the level of the eighth rib in the anterior axillary line. There was no evidence of involvement of the lung. By a flap-incision the greenish-black capsule of the growth was exposed. On opening this severe haemorrhage took place, only controlled by curetting away the growth from the ribs. Of these the seventh, eighth, and ninth were divided in the mid-axillary line, three-fourths of an inch from the growth. On elevating the ends of the cut ribs the lung was seen partially collapsed. The sudden shock now anticipated was not experienced. The intercostal muscles between the sixth and seventh ribs were next divided, with the costo-chondral ligaments and cartilage. On elevating the upper portion of the ribs thus divided, the growth was found to have extended into the pleural cavity, its intra-thoracic portion being covered by parietal pleura. The intercostal muscles, costo-chondral ligaments, and cartilage of the ninth and tenth ribs were next divided. It was now found that the lower end of the intra-thoracic growth was adherent to the diaphragm. As it could not be dissected away, the diaphragm was cut through by an elliptical incision half an inch from the margins of the growth; the ribs, piece of diaphragm, and growth were removed together. When the diaphragm was opened the intestines came through; they were replaced and held back by gauze while the opening was sutured. The pleural cavity was drained by gauze. Considerable shock supervened,

[1] *Trans. Amer. Surg. Assoc.*, 1901, pp. 383, 494.

coming on gradually and not due to the pneumothorax. Dyspnœa was much relieved by oxygen administered during the first week. About a month after the operation it was necessary to reopen the upper end of the incision to evacuate several ounces of serum. The patient was seen sixteen months after the operation with no evidence of reappearance of the growth. A hernia of the lung was present, due in part to the patient's work in a stooping position. The growth was chiefly a giant-celled sarcoma originating in one of the ribs.

The conditions contra-indicating operation will be made plain from those already given. Cases of sarcoma dating to an injury and of rapid growth, and those of secondary origin, *e.g.* after an amputation of a limb, should be left untouched, owing to the probable involvement of lungs, liver, &c., and the certainty of rapid recurrence.

The occurrence of pneumothorax is the complication which chiefly requires attention. While rightly dreaded, and while special means have been devised to meet it (*see* p. 780), it is clear from the cases published that, as long as the entrance of air is not large and sudden, operations involving partial removal of one side may be safely completed without the need of any special devices or of resorting to artificial respiration. The means adopted have been dragging up the lung with blunt-nosed forceps, attaching it by sutures to the margin of the wound, and the use of tampons. On this point Dr. E. Rixford, of San Francisco, writes of his cases in which he removed part of the chest wall for reappearing carcinoma of the breast (p. 769): "In these cases there were no outward symptoms incident to the production of pneumothorax. It was noticed, of course, that the respiration became immediately deeper and more rapid so soon as air entered the pleural cavity, but, aside from the violent flapping of the heart from right to left, terrifying to look at but without noticeable effect on the pulse, there was no special inconvenience to patient or operator. . . . In the cases here reported the writer found that the respiration could be greatly modified and the tremendous lateral excursions of the heart and mediastinal tissues almost completely checked by the simple procedure of stopping up the opening in the chest wall with a wet towel. The towel, folded into two or three thicknesses, is made to slip beneath the partially loosened section of chest wall which is to be removed, and is drawn forwards as new cuts are made. It is important to close the opening at the moment of complete expiration, when the chest is largely emptied of air. When this was done the lung expanded, and the exaggerated and fatiguing expiratory efforts were at once quieted."

Thus far removal of growths from the ribs has been considered. Those affecting the sternum are rarer.

Prof. Keen[1] relates a case in which he resected the manubrium inner third of left clavicle, and lower third of the sterno-mastoid for a sarcoma. The muscle was divided first at the junction of its middle and lower thirds, and the inner end of the left clavicle removed. The cartilage of the first rib having been divided about one inch from the sternum, and the soft parts behind the sternum separated with the finger, the manubrium was divided horizontally just above its junction with the gladiolus. Fifteen months after the operation there was no reappearance of the growth. A list of seventeen other cases in which resection of the sternum was performed for growths is given.

Dr. P. B. Griffiths, of Cardiff, records a case of resection of the sternum for sarcoma.[2] The most interesting feature is that, while the growth appeared to be well defined and limited, its extensions were wide and deep. Complete removal was impossible. In this case also but slight shock was noticed when one pleural cavity was opened. The patient survived four months. The necropsy showed the existence of deposits in both pleura, in the liver, and about the spine below the pancreas.

[1] *Med. and Surg. Rep.*, March 27, 1897.

[2] *Lancet*, October 11, 1902.

OPERATIVE INTERFERENCE IN INJURIES OF THE CHEST

Reference here will first be made to a most important class of injury occasionally met with in hospital practice, viz. :

Penetrating Wounds of Chest involving the Diaphragm and Contents of the Abdomen. These injuries are only rarely met with in this country.

Dr. D. H. Williams, of Chicago,[1] draws the following conclusions. In many penetrating wounds of the chest hermetic sealing of any wounds and conservative treatment is indicated where there is no evidence of injury to the heart, internal mammary or intercostal vessels. Wounds below the fifth rib, especially on the left side, should be explored in order to ascertain whether the diaphragm and abdominal viscera have been injured. Without such exploration no diagnosis can be made until perhaps it is too late. Parts of the fifth to the eighth rib, according to the site of the wound, having been resected,[2] if the injury be on the left side, any opening in the diaphragm will probably be found filled with omentum. This is cleansed and reduced into the abdomen, and the opening closed with a purse-string stitch. The incision is now extended over the left lateral abdominal wall into the abdomen, and the condition of the liver, spleen, kidney, and colon investigated. Three most instructive cases are given in which injuries to some of the above viscera were operated on with complete success.

Modern Gunshot Injuries of the Chest. Such recent wars as that in South Africa and the American one in the Philippines show that wounds of the chest are the most hopeful of all visceral injuries. Wounds of the large vessels, roots of the lung and heart, and those involving the abdomen also are exceptions. G. H. Makins, C.B.,[3] states that the frequent escape of the thoracic viscera from injury, putting aside the lungs, was remarkable; and that, as a rule, the frequent pulmonary wounds needed little interference on the part of the surgeon. While pneumothorax was rare, hæmothorax was the most frequent of the complications of wounds of the chest. In 90 per cent. or more of the cases, the hæmorrhage was of parietal source. With regard to the treatment of hæmothorax, if rest was employed early few serious cases occurred. For hæmothorax of a later date Mr. Makins lays down the following rules: (1) Hæmothorax, even of considerable severity, will undergo spontaneous cure. An early rise of temperature may be disregarded. (2) Tapping is indicated when pressure on the lung causes serious symptoms. In such cases the collection has usually been rapid; hence a fresh hæmorrhage is always probable when the local pressure has been removed. Evacuation, therefore, should not be necessarily complete, and should be followed by the most absolute rest. (3) Tapping may be needed as a diagnostic aid, or (4) for the evacuation of serum pressed from the clot. (5) Early free incision is, as a rule, to be steadfastly avoided. (6) Incision and ligature of a parietal artery are very rarely needed. (7) If a hæmothorax suppurates, it must be treated on the ordinary lines of an empyema. As to primary empyema, Mr. Makins only saw one case which illustrated the disadvantages of extracting bullets on the field where the conditions present prevent the ensurance of asepsis. In the early part of the campaign secondary empyemata not uncommonly followed drainage of a hæmothorax. At this time an early rise of temperature was believed to be due to breaking down of the clot. Subsequent experience showed that this was not the case. Owing to the difficulty in clearing out the clot and the need of drainage, suppuration was common and most troublesome, small collections usually forming and late residual abscesses following not infrequently.

Major Holt, R.A.M.C., D.S.O.,[4] writes that: "In many of the cases examined, from the anatomical sites of the wounds of entry and exit coupled with the justifiable assumption that the small bore bullet passes between these points in a straight line, it is impossible to avoid the conclusion that the heart or pericardium, or lung, as the case may be, was wounded; yet the symptoms present were only such as were at other times found in cases where these structures were undoubtedly not within the wound area, in fact they were purely negative." He further says: "External

[1] *Ann. of Surg.*, 1904, vol. ii. p. 675.

[2] The operator must now be prepared for the risks of pulmonary collapse and pneumothorax (p. 780).

[3] *Surg. Exper. in South Africa*, p. 382.

[4] *Surg. Cases noted in the South African War*, edited by Surg.-Gen. Stephenson.

hæmorrhage was distinctly rare. . . . As a rule, small bore wounds of the chest remained aseptic and healed immediately."

A. "When the thoracic wall was penetrated, the symptoms mentioned in the 214 cases noted were, in order of frequency, as follows: (1) Hæmoptysis; (2) Dyspnœa; (3) Fever; (4) Dulness to percussion; (5) Hæmothorax; (6) Pain; (7) Pyothorax; (8) Collapse and shock; (9) Extensive surgical emphysema; (10) Severe cough; (11) Friction rubs; (12) Deficient chest movement; (13) Cyanosis; and (14) Pneumothorax."

B. "Bullet tracks were recorded in almost every conceivable direction and of every possible length, from one an inch or so long which opened the pleura to the full length of the thorax. As a rule, antero-posterior penetrating wounds were much less serious than the longitudinal ones, and, generally, the nearer the middle line the more serious was the lesion; even the cardiac area was apparently traversed with but unimportant after-results in a considerable number of instances. Longitudinal tracks were mostly of greater severity, being complicated by injuries to abdominal viscera, and the mortality was correspondingly high. Probably most of the wounds about the root of the lung were immediately fatal, though several cases of recovery were recorded. Several cases, however, were recorded where the bullet passed from the upper to the lower outlet of the chest, or vice versa, with very little harmful result."

CHAPTER XXXVI

OPERATIONS ON THE LUNG AND THE MEDIASTINUM [1]

DURING the past ten years or so there has been a great advance in this branch of surgery, and it is probable that the next few years will see still further progress. Until a few years ago the surgery of the thorax was practically limited to incision of the thoracic wall, with or without excision of one or more ribs, for the purpose of draining collections of pus. Now as the result of much brilliant work by many surgeons it has been shown that the thorax can be freely opened and that operations on the lung, heart, and mediastinal contents can be readily and safely accomplished. The great danger of these operations consists in the free entry of air into the pleural cavity leading to collapse of the lung. The pneumothorax thus produced is at once followed by the appearance of very serious symptoms, and often by the death of the patient. The advance of surgery of the thorax has been possible owing to a better understanding of the production of a pneumothorax, the reasons why serious symptoms are caused, and especially of the ways by which collapse of the lung can be prevented.

It will thus be necessary first of all to consider the symptoms of traumatic pneumothorax, and the way in which they are produced: the means of preventing collapse of the lung will then be considered. Of course, only a very brief sketch of this subject can be given here. For a full account, with many references to the bibliography of the subject the reader is referred to the "Surgery of the Lung," by Profs. Garré and Quincke, translated into English by Dr. Barcroft, 1912.

Symptoms produced as the result of a large opening in the thoracic wall. The air can now enter freely the pleural cavity, and the pressure of the air in the pleural cavity of the injured side is that of the external air. The result is that the lung on the injured side immediately collapses. Dyspnœa, with irregular jerky breathing, and cyanosis quickly appear; then the respiratory movements become slow and deep and the pulse tense and slow, and finally cessation of breathing and arrest of the action of the heart.

Something besides the mere collapse of the lung is necessary to account for these symptoms, for one lung is capable of supplying the blood with sufficient oxygen to support life. Neither is displacement of the heart a satisfactory explanation. The correct explanation is that given by Murphy.[2] He has proved that the symptoms are due to a displacement of the mediastinum interfering with the action of the sound lung. When

[1] For further information on this subject see "Surgery of the Lung," by Garré and Quincke, translated by Dr. Barcroft, 1912. Reference may also be made to the discussion before the International Congress of Surgery, 1911; and to a paper on "Recent Advances in the Surgery of the Lung and Pleura," by Mr. Morriston Davies (*Brit. Journ. Surg.*, vol. i, p. 228).

[2] *Journ. Amer. Med. Assoc.*, 1898.

there is a large opening in the pleura the pressure of the air in that cavity will be that of the atmosphere. When inspiration occurs there will be a negative pressure in the sound pleural cavity, while, owing to the free entry of air on the injured side, the pressure remains unaltered, *i.e.* is that of the atmosphere. The result is that the mediastinum is sucked over to the sound side, interfering with due inflation of the uncollapsed lung. On expiration, or with such efforts as coughing or groaning, there will be a positive pressure on the sound side, while owing to the air in the pleural cavity on the injured side being able to escape freely, the pressure there will remain unchanged. The mediastinum will therefore bulge over to the damaged side, thus impeding proper emptying of the sound lung. There will thus be alternate movements of the mediastinum, to the sound side in inspiration and to the damaged side in expiration, which prevent satisfactory action of the uncollapsed lung. These movements have been described as "fluttering" of the mediastinum.

The following well-recognised clinical facts are explained by, and indeed confirm, the above explanation. It is well known that *a small opening may be made in the pleura without any untoward result.* In this case the air cannot enter freely, so that there is always a small negative pressure on the injured side. Under these circumstances, though the action of the healthy lung is slightly impeded, the loss is so small that it is compensated for by increased frequency and depth of respiration.

When adhesions exist between the parietal and the visceral surfaces of the pleura, the thorax may be widely opened without serious symptoms. Here the adhesions prevent collapse of the lung on the injured side, the mediastinum is more or less fixed, and only very slight oscillation can take place. This fact gives an important hint as to the mode of preventing a pneumothorax in the course of an operation on the thorax.

It is well recognised that an extensive opening may be safely made for the purpose of draining an empyema. Here, though the lung on the injured side may be completely collapsed and air enters the pleural cavity on this side with the greatest freedom, serious symptoms are comparatively seldom met with. The explanation of this is that owing to inflammatory thickening the mediastinum has become so fixed that little or no "fluttering" can take place.

Pneumothorax is *more serious on the right side than the left.* This is owing to the greater size of the right lung.

Methods of preventing and guarding against the dangers of extensive pneumothorax. The following have all been employed in operations on the thorax. Generally speaking the methods fall into two groups: (*a*) Where collapse of the lung on the injured side is prevented by mechanical fixation. As has been shown, this limits movements of the mediastinum and so prevents serious symptoms. (*b*) Collapse of the lung is prevented either by supplying air and the anæsthetic at a pressure higher than that of the atmosphere, and hence of the air in the opened pleural cavity: or by supplying the anæsthetic at the ordinary atmospheric pressure and diminishing the pressure in the opened pleura. The former are simple and require no special apparatus, while the latter are complicated and can only be carried out by means of special apparatus which is generally both elaborate and expensive.

In all cases in actual practice a small opening in the pleura should first be made and the effect of the gradual entry of air on the patient noted. The small opening is subsequently enlarged to the required extent.

(1) When the proposed operation is for any septic process in the lung it is very probable that **adhesions between the two pleural surfaces already exist.** If this is so, collapse of the lung will be prevented and the pleural cavity may be safely opened.

(2) Adhesions are not always found, even when some inflammatory disease of the lung is present, or the adhesions may be at some distance from the opening. Under these circumstances the lung will collapse and serious symptoms are very probable. A most important practical observation as to the treatment to be adopted under these circumstances was made by W. Muller.[1] He was removing a sarcoma of the ribs adherent to the lung. "The pleura was rent and an opening was made in the thoracic wall quite as big as the palm of the hand. At this moment the tumour released sank somewhat with the lung into the thoracic cavity, which was immediately followed by a condition of the most critical collapse: the breathing ceased, the pulse was not perceptible, but the symptoms changed as soon as the tumour was grasped and drawn forward. Now it was clear that it was inseparably adherent to the right lower lobe of the lung. When the lung, thereupon set free, suddenly collapsed, immediately a condition of serious collapse again occurred. The lung, quickly seized again and drawn up immediately, filled again on inspiration and the symptoms of collapse disappeared."

It may be taken for granted then that **when serious symptoms follow collapse of the lung, danger can be averted by grasping the lung with special forceps** (Fig. 315), **which, while securing a firm hold, do not lacerate its substance, and drawing the lung into the wound.** In this way the mediastinum is fixed sufficiently to prevent any serious oscillation.

(3) **Suture of the lung to the parietal pleura.** While the above simple manœuvre may be employed to relieve the immediate symptoms it is only a temporary measure. For the operation to proceed it is necessary to fix the lung to the chest wall by sutures. These should be made to pass for 1 or 2 cm. into the lung tissue and then through the intercostal muscles or even round a rib. Owing to the likelihood of infection of the pleura this cavity should be completely cut off. In some cases, and where the condition of the patient admits of it, an interval of a few days may be allowed to elapse and the operation be completed in two stages.

(4) Macewen [2] found that the following very simple manœuvre was quite efficient in averting the danger of a free opening in the pleura. **The patient is turned over so that the opening occupies the lowest position of the thorax.** The weight of the heart and of the lung on the injured side are then sufficient to prevent the fluttering of the mediastinum and the symptoms are at once relieved. He also recommends compression of the chest and of the abdomen to force the air out of the pleural cavity, to bring the lung into contact with the parietal pleura.

(5) **By means of a cabinet enabling the operation to be performed under a reduced pressure.** This ingenious method was first employed by Sauerbruch and has proved most successful in practice. The chief objections are its costliness and elaborate construction, which have prevented its ever coming into general use.

A detailed description of these chambers is not called for here. The principle on which they work is as follows. An air tight chamber is constructed of sufficient size

[1] *Deutsche Zeitschrif. f. Chir.*, vol. xxxvii.
[2] *West London Medical Journal*, July 1906.

to contain the body of the patient, the operator, and the necessary assistants. The pressure of the air within the chamber can be reduced by 7–10 mm. of mercury by an electrically driven suction pump. In one of the walls is an oval opening through which the head of the patient projects to the exterior, the neck being encircled by an air-tight collar of india-rubber. The anæsthetic is thus administered at the pressure of the atmosphere while the pressure of the air in the chamber and also of that admitted into the pleural cavity is about 7 mm. less. The anæsthetist and the operator can only communicate by telephone.

Various attempts have been made to modify the original apparatus to render it more efficient, and at the same time less cumbersome and costly. One of the best known of these is that of Willy Meyer, of New York, which he calls "the universal differential cabinet." Briefly, it consists of two air-tight chambers, a smaller and a larger, the former being contained within the latter. The larger is the operating room, while the smaller, which is provided with an opening guarded by an air-tight rubber collar for the neck of the patient, is for the anæsthetist. The smaller is the positive pressure chamber and the larger the negative pressure chamber.

(6) **By means of a cabinet enabling the anæsthetic to be administered under increased pressure.** This method was first employed by Bratter. It consists of an air-tight chamber with an aperture for the head of the patient and two smaller side apertures for the arms of the anæsthetist. Compressed air is conveyed to the chamber and [illegible] by a shaft in which a sliding weight ensures the necessary resistance to its escape. The anæsthetic may be administered in the usual way on a mask, or the Roth-Drager apparatus may be used.

(7) **The anæsthetic may be administered under increased pressure by means of an air-proof mask.** This method was first used by Tiegel, whose apparatus need not be described here.

(8) **By intra-tracheal insufflation of ether.** This is the most recent method and is probably the most satisfactory. It has the advantages of comparative simplicity and portability, and, as has already been pointed out, is the most satisfactory method of administering the anæsthetic in many other cases, *e.g.* goitres and growths in the mouth, and hence is more likely to be available. The method has been put on a thoroughly practical footing by Dr. Elsberg, of New York, who first described his apparatus in the *Annals of Surgery*, February 1911.

"The apparatus consists of a blower driven by an electro-motor. In reserve are bellows worked by foot. The air passes through a vessel containing warm water, where it is warmed and saturated with moisture; in another it absorbs the anæsthetic (ether). On the far side of the reservoir a pipe conveying oxygen from a cylinder opens into the air-pipe; this can be made use of, or not, as desired. There is a mercury manometer. A rubber tube leads to the cannula. Dr. Elsberg recommends a woven silk catheter, about 30 cm. long, which is pushed through the glottis till it nearly reaches the bifurcation of the trachea, and is then inflated from a blower with air at a pressure of 20 mm. mercury. By this powerful current of air a sufficient quantity of oxygen to arterialise the blood reaches the alveoli, but there arises immediately just as powerful a counter current, which streams outwards along the walls of the trachea. With it the exhalations of carbon dioxide are carried away; it also at the same time hinders the influx of blood or secretions into the larynx and trachea." For the introduction of the catheter a direct vision laryngoscope (such as Brüning's) is employed.[1]

Dangers of operating under differences of pressure. (*a*) *Failure of the apparatus.* This may occur with any of the above-mentioned methods, and failure may happen just at the critical time. Should this occur the

[1] Garré and Quincke, *loc. supra cit.*, p. 48. A paper by Dr. F. E. Shipway entitled "A Criticism of some recent Methods of Anæsthesia" (*Brit. Journ. Surg.*, vol. i, p. 96) may also be advantageously referred to. In addition to the intra-tracheal insufflation of ether, the intravenous injection of ether and hedonal is considered.

patient should be put into the position recommended by Macewen, or the lung drawn forward as recommended by Muller.

(*b*) *Vomiting.* This is one great objection to the use of the tight-fitting mask, though Tiegel has endeavoured to guard against it by adding an extra bag to receive any vomited material.

(*c*) Garré and Quincke mention the possibility of acute dilatation of the stomach and refer to one case in which this led to a fatal result.

(*d*) The same authors point out that, as the result of the difference in pressure, the capillaries of the lung are compressed. This impedes the circulation through the lung and soon throws a strain on the right auricle. In cases of weak or diseased hearts they recommend that the difference of pressure should not exceed 4 or 5 mm. of mercury. In no case with cabinet or mask should there be a difference of pressure of more than 10 or 12 mm. of mercury, and only in intratracheal insufflation can a pressure of 20 mm. of mercury be safely used.

The following conditions may call for operative treatment. Needless to say, in all cases, the greatest possible care must be taken in the diagnosis and localisation of the disease.

(1) **Injuries.** Only a small proportion of these will call for operation, even when pneumothorax or hæmothorax is present. The chief indication is hæmorrhage into the pleural cavity which does not improve with palliative treatment. In such cases the effused blood may be removed by aspiration and the patient then carefully watched: if in spite of this the dyspnœa and cyanosis increase, and the pulse becomes progressively more rapid and feeble, showing a continuation of the hæmorrhage, operation may offer the only chance of saving the patient's life. Other indications are: (*a*) Where there is a large wound of the thoracic wall allowing free entry of air. (*b*) Immediate operation is indicated when there is a double pneumothorax (Kocher). (*c*) When the diaphragm has been injured, allowing the protrusion of some abdominal viscus into the pleural cavity. It is usually extremely difficult to diagnose the exact nature of the injury, and it must be remembered that a large number of even serious cases recover without operation. In all cases the possibility that other thoracic structures in addition to the lung may be injured must be borne in mind.

(2) **Pulmonary suppurations** (excluding tuberculous cavities). This is probably the most frequent indication for operations on the lung. Garré and Quincke [1] classify these abscesses as follows:

(1) Acute abscesses.[2]
  (*a*) Acute simple abscesses. These may follow pneumonia.
  (*b*) Acute putrid abscesses and pulmonary gangrene.
(2) Chronic simple abscesses (and bronchiectases).
  (*a*) Chronic simple abscesses.
  (*b*) Chronic putrid abscesses.

(3) Abscesses caused by foreign bodies. In many of the above the suppuration is really due to minute particles of septic foreign material such as vomit, or septic material from the upper air passages. Foreign bodies in the surgical sense may, however, be drawn down into the smaller bronchi and may then cause bronchiectasis with formation of much foul pus. Or the foreign body may ulcerate through the bronchus and cause an abscess in the surrounding pulmonary tissue.

[1] *Loc. supra. cit.*, p. 109.

[2] *See* Dr. B. T. Tilton, "The Operative Treatment of Acute Abscess of the Lung" (*Ann. Surg.*, 1907, vol. xlvi. p. 405).

Before operating accurate diagnosis and localisation of the disease are essential.

Garré and Quincke lay down the following principles for operating on pulmonary suppurations. (*a*) Pulmonary suppurations should be treated surgically on principle, above all acute ones, so that they may not become chronic. Acute suppurations may, it is true, clear up without operation, and may therefore be observed from three to eight weeks before being operated upon. (*b*) Putrescence and accompanying gangrene render operation imperative. Only in the case of small septic foci and general good condition can one wait in the hope of spontaneous healing. (*c*) In cases of acute diffuse gangrene an attempt may be made, if a local diagnosis is successful, to make an incision in the diseased area and to drain it. (*d*) In the case of chronic abscess and bronchiectasis an operation is to be recommended on principle; here extensive resection of the thorax is as important as the opening of the abscess. (*e*) When secretion is slight, success has been achieved also by mere collapse of the lung (extra-pleural thoracotomy or artificial pneumothorax). (*f*) Pulmonary lobes transformed by bronchiectasis should be resected. (*g*) When there are several cavities each case must be decided on its own merits. (*h*) In chronic cases with several cavities in one lobe, extensive fissure or resection of the lobe is indicated. If two lobes on one side, or even both lower lobes are affected, this is generally a contra-indication to any operation. (*i*) Even incomplete healing of a pneumotomy with permanent bronchial fistula may be of considerable benefit to the patient. (*j*) Pleural adhesions, it is true, make pneumotomy easier, but are not a necessary preliminary. (*k*) Profuse haemoptysis may demand, when local diagnosis of the source is possible, opening and plugging of the cavity.

(3) **Tuberculous disease.** In only very few cases can there be any reasonable prospect of success in operative treatment of tuberculous disease of the lung.

The following operations have been carried out, and the surgeons using them claim a certain amount of success.

(*a*) *Excision of tuberculous foci or even of the whole of an affected lobe.* If the disease is advanced or extensive, the opposite lung will also probably be affected. If not extensive, general treatment will probably be successful. Hence this operation can seldom or never be called for, especially with the improved modern methods of medical treatment. One of the most remarkable cases of successful excision for tuberculous disease is a patient whose left lung was completely removed by Sir W. Macewen for extensive tuberculous disease in 1895; sixteen years later this patient was well and able to earn his living.

(*b*) *Formation of an artificial pneumothorax.*[1] It has been argued that the natural process of healing a cavity in the lung is hindered by collapse of the lung being impossible, so that the cavity is kept open by the rigid chest wall. Forlanini and Murphy suggested that the process of healing might be rendered possible by gradually injecting air into the pleural cavity so as to bring about collapse of the diseased lung. The pneumothorax is produced by introducing a hollow needle through the sixth or seventh intercostal space in the anterior axillary line. Filtered air, or, better, nitrogen, is then cautiously injected into the pleural cavity until the pressure, as shown by a manometer connected with the needle, is about that of the atmosphere. Subsequent injections are necessary at first at intervals of a few days and afterwards at intervals of three or four weeks. The pneumothorax has to be kept up for a long time, possibly 1½ to 2 years. The treatment may be impossible owing to extensive adhesions.

(*c*) It has been proposed that the retraction of the lung in the process of natural cure should be aided by resection of the overlying ribs. Various operations have been carried out, especially in Germany, with this object. They vary from excision of large portions of the first and second ribs only, to the formation of a wide gap in the axilla, by excising portions of many ribs so that a lateral gap in the bony wall of the thorax four or five inches wide is produced. Excision of about one inch of ribs one to nine at their angles, with removal of a narrow strip of the corresponding costal

[1] Dr. Clive Riviere, in a paper on "The Pneumothorax Treatment of Phthisis" (*Practitioner*, December 1914), describes the indications for this method of treatment and the technique of the operation. *See also* a discussion on "The Treatment of Phthisis by the Induction of Pneumothorax," opened by Dr. T. D. Lister before the Therapeutical Section of the Roy. Soc. Med. (see *Proc. Roy. Soc. Med.*, Ther. Sec., May 1915).

cartilages close to the sternum, has also been carried out. These severe operations have a very distinct mortality, even in the hands of those who frequently perform them, and the benefit derived in many cases is not great. The justifiability of these procedures is thus open to doubt.

(*d*) It was pointed out, as long ago as 1858, by Freund, that in many phthisical patients there is an abnormal shortness and fixity of the first rib, narrowing the antero-posterior diameter of the superior aperture of the thorax.[1] It has been thought that, by impeding or actually preventing the inflation of the apex of the lung, there was, under these circumstances, a predisposition to tuberculous disease, and that when it had once appeared the natural process of cure was hindered. It has therefore been suggested that in cases of apical phthisis, where the disease does not extend below the second costal cartilage, that division of the first cartilage or excision of 2 or 3 cm. of the first rib or of its cartilage should be carried out. Division of the first, second and third cartilages has also been carried out.

(4) **Actinomycosis of the Lung.** This rare disease may spread to the lung from adjacent organs, or the fungus may be directly drawn down into the lung through the bronchi, usually with some foreign body such as a grain of corn. It is liable to extend to the thoracic wall forming abscesses and fistulæ. A number of cases have been successfully treated by incising and opening up the various sinuses and fistulæ and scraping away the diseased tissues. Garré and Quincke [2] recommend wide resection of ribs over the diseased area and extensive resection of the diseased tissues. Kocher is in favour of the former, and less severe mode of treatment.

(5) **Hydatid disease.**[3] This is by no means uncommon and is said to account for from 7 to 12 per cent. of all cases of hydatid disease. The diagnosis is usually made from the occurrence of portions of ruptured cysts in the sputum. The two layers of the pleura are likely to be adherent, thus simplifying operation. The ribs over the affected area are incised, and the lung tissue is then incised until the cyst is reached. Incision and drainage are to be preferred to excision.

(6) **Tumours of the lung.** These may be sarcomata or carcinomata extending inwards to the lung from the chest wall, or dermoid cysts, or sarcomata or carcinomata occurring primarily in the lung or bronchi. The latter are extremely rare, and are not likely to be diagnosed sufficiently

[1] This question has been recently investigated by Mr. Morriston Davies in a paper on "The First Rib and Apical Tuberculosis, based on a study of 402 specimens" (*Brit. Journ. Surg.*, vol. i, p. 55). He comes to the following conclusions: (1) Neither abnormal shortness nor ossification of the first costal cartilage predisposes to apical pulmonary tuberculosis. (2) Abnormal shortness of the first costal cartilage does not encourage ossification in that cartilage. (3) The formation of a false joint in the rigid cartilage does not tend to lead to the cure of apical tuberculosis. (4) The balance of evidence is against the probability of the operation for the division of the first costal cartilage in cases of apical tuberculosis producing any material improvement.

[2] *Loc. supra cit.*

[3] John O'Connor, of Buenos Ayres, discusses the treatment of pulmonary hydatids and reports three cases on which he has operated (*Lancet*, May 23, 1903). Of the three cases two were very serious ones; all recovered. The diagnosis of pulmonary hydatids may be attended with much difficulty, especially where the cyst has not ruptured into a bronchus. In such cases, the locality in which the patient has resided, the unilateral situation of the affection, with probably a sharply defined outline not corresponding with the usual site of a pleural effusion or hepatic enlargement, taken in connection with diminished breath sounds, vocal and tactile fremitus, with an antecedent hacking, irritating cough with or without pain, and associated with bronchitic sputum, should lead one to suspect hydatid disease. When rupture has taken place, there is a history of sudden evacuation of a quantity of fluid, followed by frequent and, at times, considerable haemoptysis. Later an intra-pulmonary abscess may develop, in which case symptoms of general toxæmia promptly show themselves. Microscopical examination of the sputum is the only means of making a positive diagnosis. An exploring needle should be used not only for diagnosis but for localising the cyst. Mr. H. B. Robinson has recorded a case of successful removal of a hydatid cyst of the upper lobe of the right lung (*Clin. Soc. Trans.*, vol. xxxii, p. 115).

early to admit of operation. Lipomata, fibro-sarcomata, and myxo-sarcomata of the pleura also occur. The prospect is best where the growth has extended from the thoracic wall to the lung, for here the tumour can be grasped and the lung thus drawn forward into the opening in the thoracic wall. In a few cases malignant growths of the lungs have been treated by resection of the diseased lobe or lobes after a more or less extensive opening in the chest wall.

Transpleural Operations on the Abdomen. These may be mentioned here, as resection of one or more ribs and opening of the pleura are necessary parts of the operation. Transpleural laparotomy may be called for for

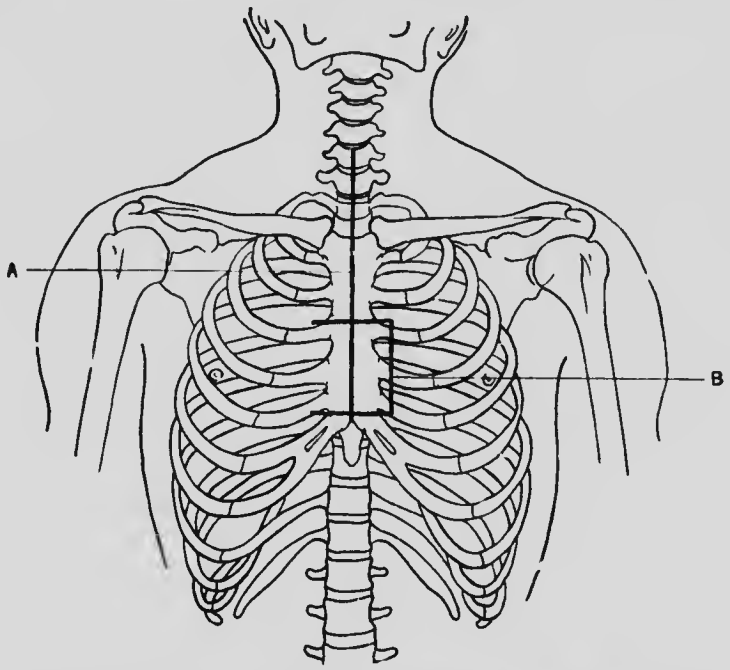


FIG. 313. Incisions for exposing the mediastina: A, Incision for Milton's anterior mediastinal thoracotomy, for exposing the superior, anterior, and middle mediastina. B, Incision for anterior thoracotomy by an osteoplastic resection of the part of the sternum corresponding with the third, fourth, and fifth costal cartilages (exposing the anterior and middle mediastina). (Bickham.)

opening and draining an abscess of the liver which is situated on the superior surface and is pushing up the diaphragm, and for opening a subphrenic abscess. The presence of pus must always be verified by an exploring needle. Portions of the seventh, eighth, ninth, tenth ribs or their cartilages will have to be excised according to the position of the abscess. The pleural cavity is then opened, and must be shut off by suturing the costal to the diaphragmatic pleura around the proposed incision in the diaphragm. This structure is then incised and a drainage tube inserted into the abscess cavity.

The Operation. It is not necessary to describe in detail each of the above-mentioned operations. The general principles of each have already been indicated and these may be amplified by the following remarks.

Asepsis. The greatest care must be taken to avoid infection, for should this occur an empyema will be the probable result and this serious complication may lead to a fatal termination. If, as will very likely be the case, there is already some septic process going on in the lung, the pleural cavity must be shut off by suturing the parietal to the visceral pleura around the field of operation, or by plugging with sterile gauze, or both these means may be combined.

The anæsthetic, and the **dangers of pneumothorax.** These have already been discussed, and the latter, especially, will receive the close attention of the operator. If high or low pressure chambers are at hand they should certainly be used, but they are not essential, and

Fig. 314. Powerful rib retractor for operations on the lung.

even the most extensive operations have been carried out without their assistance. The advantages of the intra-tracheal insufflation of ether may be again insisted upon.

Opening the thorax and exposure of the lesion. The disease should be exactly localised and the incision must be made where this is nearest the surface. Garré and Quincke advise against excision of ribs over the heart or pericardium, as, if this is done, there will be a pulsating scar and very possibly cardiac disturbances. The thorax may be opened in one of the following ways: (*a*) A long incision is made along a rib and the soft parts are dissected up so that when retracted three or four ribs are exposed. The rib immediately over the focus is then excised subperiosteally. It is best not to widely open the chest at first, but only to make an opening sufficient to allow of an examination to ascertain the extent of the disease. If necessary, then, one or more ribs may be excised above and below the first. In any case, more room may be obtained by retracting the ribs above and below by powerful retractors. Often excision of one rib combined with retraction will give sufficient room. Air should not be allowed to enter the pleural cavity too rapidly: hence,

a small incision into the pleura is made at first and the effect of this noted. The opening is then increased. The lung should be drawn to

FIG. 315. Special instruments for operations on the lung. A, Lung spatula. B, Lung-seizing forceps. C, Lung hilus forceps. D, Lung clamps.

the wound by special forceps which secure a firm grip and do not damage the tissue.

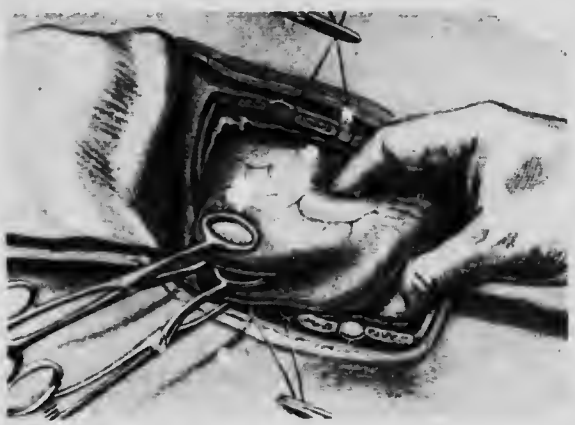


FIG. 316. Fixation of the lung and investigation thereof. (Picot.)

(*b*) The ribs may be exposed freely by a curved incision, and by reflecting a flap of the soft parts.

(*c*) A rectangular flap of skin and soft parts may be turned back. The ribs are then divided, either by bone forceps or by a Gigli's saw at the free margin of the flap, and partly divided and fractured at the base

of the flap; a hinge-like flap of ribs and intercostal muscles can then be turned back and the lung thus widely exposed (Fig. 317).

(*d*) Either of the above incisions may be enlarged or converted into a **T**-shaped, **H**-shaped, or **L**-shaped incision if more room be required.

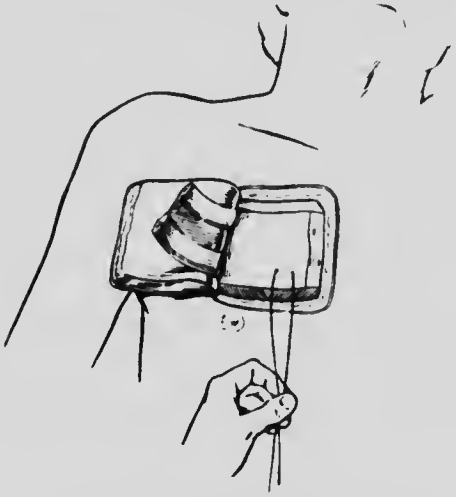


Fig. 317A. Temporary resection of the thoracic wall accordance to Delorme with the lung fixed.

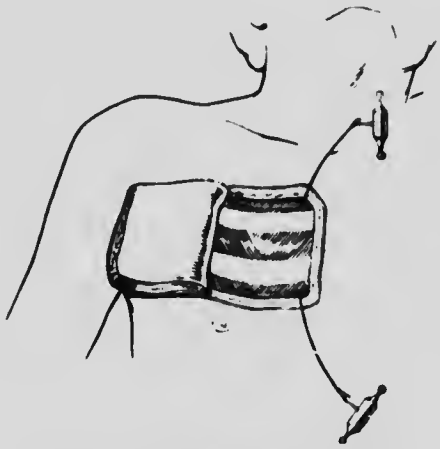


Fig. 317B. Temporary resection of the thoracic wall accordance to Delorme with the lung fixed.

Opening and draining a cavity in the lung. If the cavity is an old standing one, the pulmonary tissue around will probably be indurated and it may be incised with the knife. If recent the lung tissue will be unthickened and a Paquelin cautery may then be used. The cavity may safely be sought for by a large exploring needle. When deeply placed

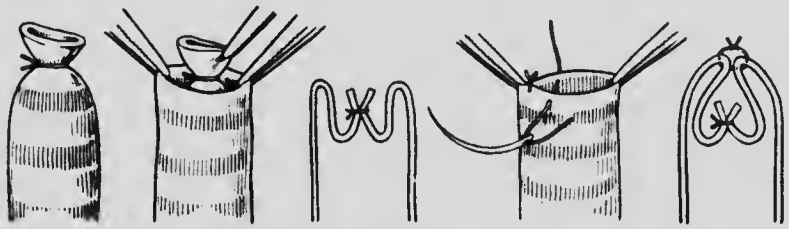


Fig. 318. W. Meyer's suture of the bronchus. (According to a drawing by Schumacher.)

the needle may be left *in situ* and the incision gradually deepened, using it as a guide. In the case of an old cavity Quincke and Garré advise extensive resection of the thickened overlying lung tissue so as to allow sinking in of the chest wall, and thus helping obliteration. In a gangrenous cavity loose sloughs may be removed, but any which are adherent should be left to loosen gradually and come away. Drainage is best effected by moist sterile gauze. The cavity must not be irrigated on account of the danger of fluid entering the bronchi.

Excision of a lobe or a portion of a lobe. Two important points here are (*a*) the control of hæmorrhage and (*b*) the closure of divided bronchi. Hæmorrhage may be controlled by temporary compression of the hilum; special forceps have been designed for this purpose (Fig. 315). If only a small portion is to be excised the lung can be compressed with long wide clamp forceps. When the diseased part has been removed all fine bronchi and all vessels that can be seen are tied with fine silk. For suturing the wound in the lung Garré and Quincke recommend fine silk and advise that the stitches should be inserted not far from the margin, and that they should be made to extend close to the bottom of the wound. When a whole lobe or lung is removed the vessels must be separated and secured at the hilum. Great care has to be taken in closing the main bronchus on account of the danger of tension pneumothorax, if air escapes, and also of infection. It can be closed by ligaturing not too tightly and then sewing lung tissue

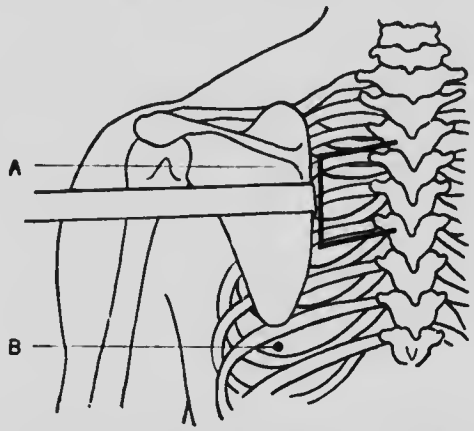


Fig. 319. Operations upon the thoracic cavity: A, Posterior mediastinal thoracotomy, by thoracoplastic flap. B, Position for paracentesis thoracis in the eighth intercostal space in the line of the inferior angle of the scapula. The scapula is here represented retracted slightly outward, to increase working-space between vertebræ and scapula in the removal of parts of the fourth, fifth, and sixth ribs. (Bickham.)

over it. Willy Meyer recommends crushing several centimetres of the bronchus with stout crushing-forceps, after the vessels have been secured. The crushed portion is ligatured and invaginated and the bronchus sutured over the stump (Fig. 318).

Closure of the opening in the chest wall: Drainage of the pleural cavity. In the case of aseptic operations of short duration the wound in the chest wall should be completely closed. If ribs have been resected the intercostal muscles and the parietal pleura are accurately united with sutures of catgut. Before the opening is finally closed all air must be forced out of the pleural cavity. This may be done by fully inflating the lung, if one of the methods of securing differential pressure has been employed; or Macewen's method of compressing the thorax and abdomen may be tried. The muscles and skin are then accurately sutured. The whole wound must be quite air-tight. If the operation has been performed for some septic cavity in the lung the ribs should always be freely resected in order to allow of falling in of the chest wall and obliteration of the cavity. If the ribs have been at first resected subperiosteally the peri-

osteum should be dissected away, or an area of periosteum, intercostal muscles and parietal pleura may be completely removed; the cut edge of the parietal pleura should then be sutured to the lung and the superficial soft parts sutured, sufficient space being allowed for drainage of the cavity. When the operation has been prolonged, when all air cannot be expelled, *e.g.* after excision of a lobe, or when some septic focus has been opened, the pleural cavity should be drained. Most operators recommend that the original wound should, if possible, be completely closed and that a tube should be inserted through a small incision in the lowest part of the pleura, *e.g.* in the tenth space in the scapular line. Some form of valvular drainage-tube, *i.e.* one that will allow any effusion to escape but will not allow of the entry of air, should be used. Thiersch has suggested a simple method which can be easily improvised; it consists of a stout rubber tube which projects into the pleural cavity, while to its outer extremity is fastened an open rubber finger stall, or a short length of thin rubber colotomy tubing. On expiration any effusion is forced out, but on inspiration the thin tube collapses and forms a valve preventing the entry of air.

Difficulties and dangers in opening a lung cavity. These have already been indicated, but they may be summed up as follows:

(1) Dyspnœa, coughing, and choking expectoration with the anæsthetic.

(2) Dyspnœa, cyanosis, and collapse on opening the pleura.

(3) Missing the cavity. This is best guarded against by careful preceding localisation, and the use of an exploring needle after the lung has been exposed.

(4) Getting as the result of the operation, diffuse broncho-pneumonia in the lung operated on or its fellow.

(5) Severe hæmorrhage, causing much trouble, owing to hæmoptysis with the anæsthetic, or later on setting up broncho-pneumonia.

(6) Finding a large branching cavity, difficult or impossible to drain.

(7) A cavity near the large vessels at the root of the lung.

(8) Much consolidation of the lung tissue over the cavity.

(9) Septic infection of the pleura leading to empyema. Serous pleural effusion may occur, independent of infection, and call for aspiration.

(10) Post-operative pneumothorax, possibly of a valvular nature.

(11) Emphysema of the cellular tissue, or more serious, emphysema of the mediastinum. The latter will probably be due to leakage after incision or division of a main bronchus.

Operations on the Mediastinum. These must be conducted on similar lines and with similar precautions as with operations on the lung. They may be called for under the following circumstances. (1) For the drainage of collections of pus. Such abscesses may be due to breaking down lymphatic glands, to spinal caries, or to perforations of the bronchi or the œsophagus. (2) For the removal of growths. These can often only be distinguished with difficulty from growths of the lung. Indeed, it is not infrequently impossible to say exactly where the growth started. The following growths may occur. Dermoid cysts or teratomata.[1] These are especially likely to be present in the anterior mediastinum. Other simple tumours are lipomata, fibromata, gummata,

[1] A paper by Dr. Christian (*Med. Surg. Rep. of the Boston City Hospital*, 1901, p. 114), in which he has collected forty cases, may be referred to for information as to these tumours.

simple cysts, and hydatid cysts. Enlargement of the lymphatic glands may be due to tubercle, Hodgkin's disease, to secondary deposits of carcinoma or to primary lympho-sarcoma. Primary sarcoma of the lung is extremely rare but metastatic growths are very common. Primary carcinoma of the bronchi may occur and also fibrosarcomata and myxosarcomata of the pleura, the latter though reaching an enormous size not being very malignant growths. The non-malignant growths are alone likely to be suitable for operative treatment, though successful cases of removal of growths of the pleura have been reported. (3) Operation through the mediastinum may also be indicated for some growths of the œsophagus and also for some cases of foreign bodies in the œsophagus or bronchi, when attempts at extraction by other means have failed.

Operation on the anterior Mediastinum. In the case of suppuration, if there be any sinus or evidence of pointing at the side of the sternum,

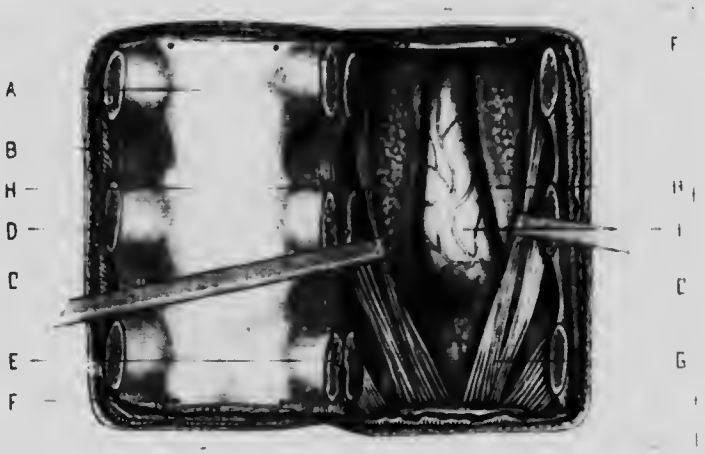


FIG. 320. Anterior mediastinal thoracotomy, by an osteoplastic flap consisting of soft parts and sternum corresponding with third, fourth, and fifth costal cartilages. A, Osteoplastic flap turned to left. B, Pectoralis major muscle. C C, intercostal arteries. D, Costal cartilage divided. E, Costal cartilage partly broken in hinging back the flap. F F, Drill-holes for wiring. G, Triangularis sterni muscle. H H, Lungs and pleuræ, the latter extending further toward the middle line. I, Heart and pericardium. (Bickham.)

the deep opening is enlarged with a finger as a guide, by removal of as much of the sternum and ribs as is needful. The field of operation must be exposed by a long incision or flap appropriate to the conditions found in each case. Drainage should be secured by a large tube or by gauze. For thorough exposure for exploration and for the removal of growths further steps are necessary. (*a*) The manubrium may be trephined and sufficient bone then removed by means of Hoffmann's forceps. A single trephine opening will not give sufficient room. (*b*) Milton's operation, in which the whole length of the sternum is divided vertically by saw and bone forceps, the ensiform cartilage being removed. By retraction of the two halves of the sternum a space of two to two and a half inches may be obtained. (*c*) By means of an œsteoplastic flap (Fig. 320). Kocher recommends a rectangular incision commencing over the sternal end of the right clavicle, passing across to the left sterno-clavicular joint, then extending down the left border of the sternum to the lower border of the

manubrium from whence it is continued transversely to the right side (Fig. 322). The periosteum with the attachments of muscles is stripped from both surfaces of the bone. The left sterno-clavicular joint is opened, the first and second costal cartilages are divided, and the manubrium is divided transversely at its lower border. The whole manubrium is then turned over to the right as an osteoplastic flap, the right costal cartilages being partially divided. In this way the anterior mediastinum, inno-

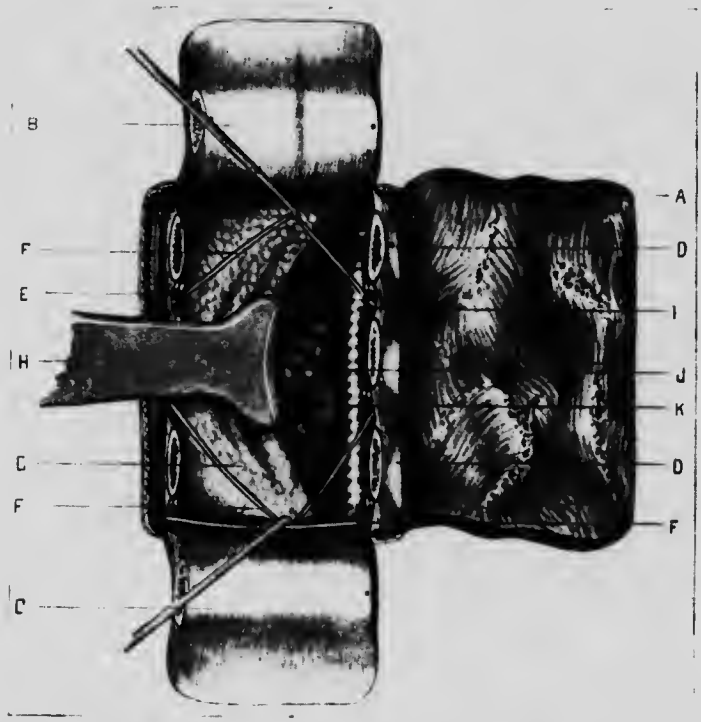


FIG. 321. Posterior mediastinal thoracotomy, by thoracoplastic flap. A, Skin and muscle flap turned horizontally backward. B, Flap of part of fourth rib and intercostal muscles turned upward. C, Flap of part of sixth rib and intercostal muscles turned downward. D D, Vertebral ends of fourth and sixth ribs, drilled for wiring. E, Intercostal artery, vein, and nerve. F F F, Fourth, fifth, and sixth dorsal nerves exposed and retracted. G, Pleura and lung. H, Broad retractor displacing pleura and lung. I, Thoracic aorta. J, Left bronchus. K, Œsophagus protruded into wound by a sound introduced through the mouth. The operations of bronchotomy and thoracic œsophagotomy are shown at J and K respectively. The pulmonary and bronchial vessels are omitted, for clearness. (Bickham.)

minate artery, and auricles can be satisfactorily exposed. Or the manubrium may be divided transversely below, the first and second costal cartilages divided on each side and the manubrium turned upwards.

Operations on the middle Mediastinum. These will be described in the chapter on operations on the heart and pericardium.

Operations on the posterior Mediastinum. The patient is placed in the semi-prone position, and the scapula is drawn outwards. The thick skin in this neighbourhood requires very careful sterilisation. All preparations must be made for dealing with a pneumothorax as the pleural

cavity is very likely to be opened. An incision, four inches long, is made parallel to the vertebral column and about three inches from it, over the ribs from the third to the sixth, and at each end transverse incisions are carried inwards. The musculo-cutaneous flap thus marked out is turned inwards. The subjacent portions of three or four ribs are now resected subperiosteally. To obtain sufficient access, the resection must be carried with the help of bone forceps as near the spine as possible, the transverse processes being also removed. Especial care must be taken to avoid opening the pleura; any such opening should be temporarily plugged with gauze and then sutured. All bleeding being arrested, the pleura should be detached with the fingers and, with the lung, pushed forwards (Fig. 321). If the operation is undertaken for a foreign body in the œsophagus the presence of a bougie will facilitate its identification. This is carefully separated from its surroundings, and the bougie being partially withdrawn, the œsophagus is drawn into the wound, opened, and the foreign body withdrawn. During the manipulations of the œsophagus, the trunks of the vagi must be carefully protected from injury, and the vena azygos, if met with, must be either drawn aside with a blunt hook, or secured between double ligatures. The question of complete suture of the œsophagus must depend on the character of the foreign body and the amount of damage inflicted by this and by the necessary manipulations. Sufficient drainage of the mediastinum is imperative. The œsophagus is best approached from the left side in the upper part of its course through the mediastinum and from the right side below.

Those interested in trans-thoracic resection of the œsophagus should refer to a paper by Dr. Willy Meyer,[1] with its accounts of the work done in this direction by Sauerbruch and the late v. Mikulicz.

Jaboulay has exposed the œsophagus through the pericardium. The middle mediastinum is exposed by an osteoplastic flap of sternum and costal cartilages, the pericardium is opened, the heart drawn aside, and the œsophagus reached by incising the posterior wall of the pericardium.

Transpleural Œsophagotomy. Sauerbruch employs an incision through the third right intercostal space, and reaches the œsophagus on the right side above the root of the lung, and as low as the azygos vein. The lower part of the œsophagus is reached through the fourth or fifth left intercostal space. An incision of the desired length is made by sliding down the skin and cutting firmly down on to the rib and cartilage. A portion of the rib is then excised subperiosteally and the underlying periosteum, endothoracic fascia, triangularis sterni and pleura, are incised, without appreciable bleeding, and without the risk of entering the pleural cavity too soon. By forcibly separating the ribs (by Mikulicz's retractors), the lung can be pushed aside by a special spatula, and the œsophagus identified by the introduction of a bougie. The pleura covering it is then incised, and the whole thickness of the œsophagus, from which the nerves and vessels have been freed, is grasped with forceps and pulled forwards. The surrounding parts are packed off with gauze and the œsophagus may then be opened in its long axis and the foreign body extracted. The mucous membrane is seized with forceps so that it may subsequently be recognised and invaginated with Lembert's sutures. The muscular coat of the œsophagus is sutured with silk and the wound closed or if necessary drained.

[1] *Ann. of Surg.*, May 1905.

CHAPTER XXXVII

TAPPING OR INCISING THE PERICARDIUM. SUTURE OF WOUNDS OF THE HEART

TAPPING OR INCISING THE PERICARDIUM

Indications. (1) When a pericardial effusion has resisted previous treatment, and signs of cardiac distress are increasing.

(2) When there is a steady increase of præcordial dulness.

(3) When the heart-beat and pulse are becoming feeble.

(4) When cyanosis, dyspnœa, and epigastric distress are present.

(5) When the effusion persists, when it is accompanied by œdema, rigors, and pyæmia, *e.g.* in cases of osteomyelitis; when it occurs in a much weakened patient, the fluid is probably purulent.

The spot usually chosen for puncture is the fifth or fourth space, about one inch from the sternum, so as to avoid the internal mammary vessels, and, if possible, the pleura, which varies greatly in the extent to which it lies under the cover of the inner ends of the fifth and sixth cartilages and even of the sternum. Mr. Rowlands [1] writes on this point: "From anatomical considerations and experiments on the cadaver it is certain that the safest point to tap or to insert the needle of the exploring syringe is the left costo-xiphoid angle as suggested by Roberts years ago. The instrument should touch the lower end of the gladiolus and should pass backwards, upwards, and a little inwards behind the sternum, until it is felt to enter the cavity of the pericardium at a distance of not more than two inches and a half from the skin. The pleura and internal mammary vessels are too far out to be injured, and the peritoneum too low, and the heart, unless adherent in front, lies too far back in its distended sac to be reached if the above precautions are taken. The inner extremity of the fifth space is probably the next best situation, where the needle should be passed backwards and inwards in close contact with the sternal edge; but though the internal mammary vessels are quite safe, the pleura will certainly be pierced occasionally. The sixth left space is to be preferred, if wide enough at its sternal end, which is not often the case."

Whichever site is chosen for puncture, strict aseptic precautions must be taken, and the following risks of paracentesis must be remembered, viz. pleurisy, empyema, and injury to the heart. While upwards of a pint of serum has been removed in some cases, the withdrawal of only three or five ounces has been followed by recovery in others.[2]

[1] *Loc. infra cit.*, p. 796.

[2] With regard to the amount to be withdrawn, Dr. Stewart (*Edin. Med. Journ.*, August 1885) thinks that, if serous fluid is found, aspiration should be made use of, but only enough withdrawn to give relief. He points out that it is a sound rule, in dealing with vital organs, that only a minimum amount of interference should be had recourse to, and that this is especially necessary in cases which threaten pulse-failure. The tapping should be repeated rather than too much fluid be drawn off at once.

On the fluid ceasing to flow, the puncture should be closed with sterilised gauze and collodion.

Thayer [1] found no fluid on aspiration, though the area of dulness was large. At the necropsy, 1200 cc. of fluid were found in the pericardium. Though the heart was not fixed by adhesions it lay in front of the effusion, and the needle had come in contact with this viscus. In such cases, to obtain better access, a rib must be resected. In some cases, the co-

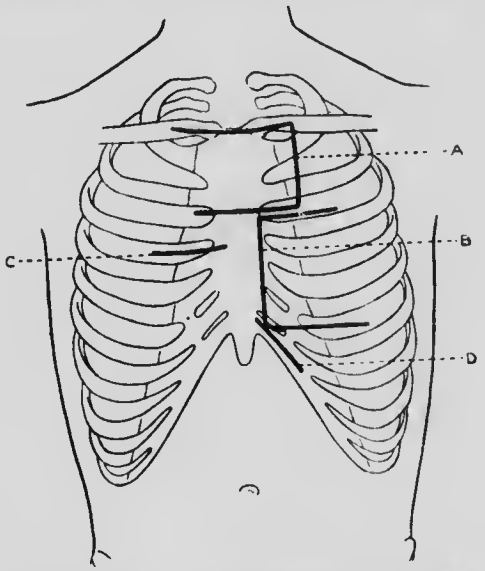


FIG. 322. A. Incision for [illegible]lastic resection of the manubrium sterni. B, Incision for an osteoplastic flap containing the third, fourth, and fifth costal cartilages for exposing the heart. C, Incision for ligature of the internal mammary artery. D, Incision for drainage of the pericardium.

existence of effusion into the pleural and peritoneal sacs must be remembered.

If pus is present [2] the case must be treated by free incision. An anæsthetic having been given, the trocar is taken as a guiding director, and a narrow, sharp-pointed bistoury carefully thrust in by its side; the opening is then further dilated with dressing-forceps or a blunt-pointed bistoury, care being taken to keep the internal opening into the pericardial sac free. A soft drainage-tube should next be inserted, and when all the pus that will come away has escaped antiseptic gauze dressings should be applied.

As, however, the proximity of the costal cartilages to one another will only allow of the introduction of a small-sized drainage-tube, and as flocculent matter may be present, *e.g.* where the pneumococcus is present (p. 764), it is wiser to resect part of the fifth costal cartilage (Fig. 323), or the seventh (Rowlands, *vide infra*). This, while increasing the length of time occupied by the operation, will allow of the insertion of a large drainage-tube, and thus of free and efficient drainage. An incision is made from the sternum outwards over the fifth costal cartilage to its

[1] *Johns Hopkins Hosp. Bull.*, 1904, p. 149.

[2] For the signs, symptoms and diagnosis of Pyopericardium reference should be made to a standard textbook of medicine.

junction with the rib. The soft parts are carefully separated as at p. 766, care being taken not to wound the pleura. The cartilage is then divided with a narrow saw and sharp bone-forceps at its junction with the rib and sternum. The internal mammary vessels now exposed are divided between two ligatures or drawn aside. The triangularis sterni is detached from the sternum and drawn inwards. The pleura, the relation of which to the chest-wall and pericardium varies greatly, is peeled aside and drawn outwards. It is much thinner than the pericardium and its border may

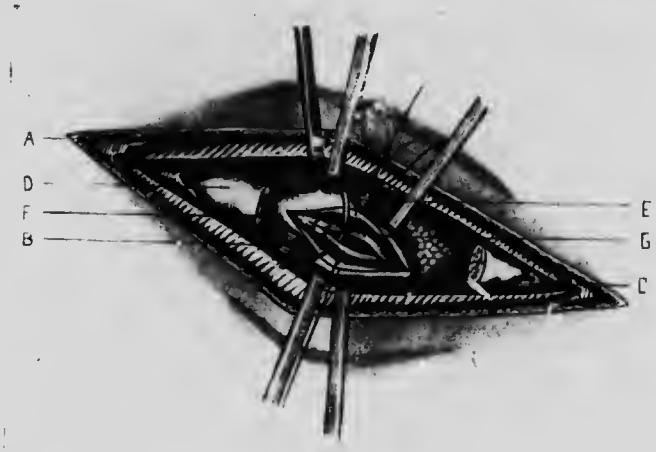


FIG. 323. Exposure of pericardium and heart by partial excision of left fifth costal cartilage. A, Pectoralis major muscle retracted, overlying the retracted intercostal muscles and membrane. B, Internal mammary vessels. C, Intercostal vessels. D, Sternum and part of fifth costal cartilage. E, Pleura and lung retracted. F, Pericardium, incised and margins retracted. G, Heart, showing incised wound being sutured. (Bickham.)

contain fat. If there be difficulty in displacing the pleura outwards, the adjacent part of the sternum should be removed (Rowlands). In children, owing to its cartilaginous nature, this is readily effected with a gouge. A little further use of a director will now expose the pericardium. Before this is incised it is well again to use an exploring needle. The incision into this sac should be made downwards and outwards, and if time admits, the cut edges should be sutured to the lips of the wound. Any opening in the pleura should be closed with a stitch, or gauze secured with silk.

If, as is not uncommon, an empyema be present, the critical condition of the patient will usually render it advisable to defer further operation for a day or two.

On the subject of the best incision for drainage of the pericardium two very instructive papers by Mr. R. P. Rowlands [1] should be consulted.[2] The cases, aged 2½ years and 1 year 8 months respectively, were under the care of Dr. Coutts at the East London Hospital for Children: his remarks on purulent pericarditis and the complications which may, as in these cases, be present, will repay careful study. In the second of the two papers mentioned above, Mr. Rowlands is of opinion that removal

[1] *Brit. Med. Journ.*, January 2, 1904, and April 15, 1905.

[2] See also a case shown by Mr. Douglas Drew and the discussion thereon (*Proc. Roy. Soc. Med.*, Sec. for Study of Diseases in Children, April 1912, p. 161).

of the seventh left costal cartilage from near its costo-chondral junction to within an inch of the sternum, together with a portion of this bone, if needful, gives the easiest, widest, safest mode of access and the best drainage. When the thorax is opened the diaphragm is pushed downwards, and never need be separated or pierced. The pleural margin can be pushed upwards and outwards, and the pericardium opened and drained at its lowest and outermost point, so that when the patient is turned on one side the pus drains away better than with an incision close to the mid-line, which is also more liable to trespass on the abdomen and the deep epigastric artery. It is also possible to pass a finger into the various recesses of the pericardium, and to introduce a tube behind the heart into the oblique sinus with ease. This space cannot be satisfactorily drained if a portion of the fifth costal cartilage be excised.

Epigastric Route. This method, first brought forward by Larrey, was strongly recommended by the late Mr. H. W. Allingham,[1] on the ground that the pericardium is thus incised at the lowest part of its anterior wall. Stated very briefly, this operation consists in incising the left rectus abdominis, and, after avoiding the peritoneum, opening up the cellular interval between the sternal and costal fibres of the diaphragm (in which lies the superior epigastric artery), and thus exposing the lowest part of the pericardium. A good account of this method of reaching the pericardium is given by Mr. Pendlebury,[2] with a successful case. The collection here was serous. Mr. Rowlands[3] considers that the above ingenious operation has the following drawbacks: (*a*) The little room available in most adults, who have wide, firm, or even ossified ensiform cartilages and rigid costal cartilages; the costo-xiphoid space is too narrow in these cases. (*b*) The operation is necessarily performed somewhat in the dark and under cover of the sternum and seventh costal cartilage, and it is not easy to ensure whether the exploring finger is above or below the diaphragm, especially by an operator not quite familiar with the anatomy of this region. For these reasons a portion of the seventh, or even of the sixth, costal cartilage, may have to be removed in order to provide the necessary room, as practised by Mr. Allingham and Mr. Pendlebury. (*c*) The superior epigastric artery may be wounded as it comes through the diaphragm, and cause troublesome hæmorrhage in the depth of the wound. (*d*) The pericardium may be separated by the finger from the parietes, and pus may then leak into the loose connective tissue and set up a fatal mediastinitis. When the pericardium is very distended these dangers and difficulties are much diminished; the reverse will be the case where the collection of pus is small. In the second case related by Dr. Coutts and Mr. Rowlands the amount was between one and two ounces.

During the first few days after the operation the drainage of the cavity may be materially assisted by keeping the patient propped up, and turned on to his face at intervals.

Causes of failure. (1) The tissue of the heart may be degenerated, or the organ dilated. These changes may come on very rapidly.

(2) Toxæmia, septicæmia, and pyæmia.

(3) Co-existing effusions into the pleura and peritoneal sacs, or into joints, or pneumonia. During the after-treatment measles and bronchitis may cut short a case that otherwise promises well, as occurred in one of the children under the care of Dr. Coutts and Mr. Rowlands (*vide supra*).

(4) Œdema of lung. Evidence of this should be most carefully watched for. It proved fatal in the case of a patient of Sir James Goodhart's, a girl of 14.

(5) Co-existing diseases—*e.g.* phthisis, or renal disease.

[1] *Lancet*, June 1900.
[2] *Lancet*, March 10, 1900, p. 693.
[3] *Brit. Med. Journ.*, January 2, 1904.

SUTURE OF WOUNDS OF THE HEART

Apart from the recoveries that have taken place after suture, severe wounds of the heart have been almost invariably fatal. Surgical intervention has, however, undoubtedly saved a considerable number of lives, as may be gathered from the following figures: Loison [1] collected 90 cases of wounds of the heart by cutting instruments. Of 72 cases not operated upon, 71 died; of 18 cases treated by operation, 10 recovered.

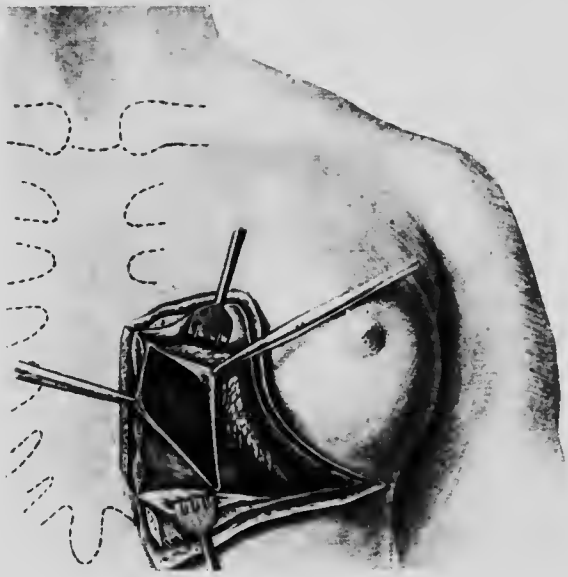


FIG. 324. Long intercostal incision in fifth space, with division of fourth, fifth and sixth cartilages at their sternal attachments, forming two triangular flaps. Pleura freely opened.

Hill [2] gives seventeen cases of heart suture, seven of which, or 41 per cent., recovered. Dr. Charles Peck [3] in a most interesting paper on the operative treatment of heart wounds has collected 158 cases of sutured heart wounds of which 58 recovered.

A large proportion of wounds of the heart are either immediately or very quickly fatal, but a certain number survive long enough for operative treatment, which alone offers a chance of recovery. Wounds of the heart may be either penetrating or non-penetrating—the great majority of them belonging to the former class. The ventricles are more often injured than the auricles, and the right ventricle more commonly than the left. It has been shown, both by experiments upon animals and by the operations that have been performed on man, that interrupted sutures, passed deeply into the myo-cardium, produce perfect hæmostasis. The sutures should be passed during diastole, since the heart sinks back during systole into the pericardial space. Wounds of the auricle are stated to be more serious than those of the ventricle, while the prognosis is stated to be better in the case of operations for bullet wounds than for stabs.

[1] *Revue de Chirurgie*, 1891, Nos. 1, 2, 6.
[2] *New York Med. Record*, December 15, 1900.
[3] *Ann. of Surg.*, 1909, vol. xl. p. 100.

After wounds of the heart death may occur from external hæmorrhage, or from internal bleeding, *e.g.* into the pleural cavity with little or no external hæmorrhage. A fatal result may also be brought about from the so-called "heart tamponade," that is distension of the pericardium with blood, so that the large veins and the auricles are compressed, preventing entrance of blood to the ventricles. It is in this latter group of cases that operative treatment is most likely to be successful.[1]

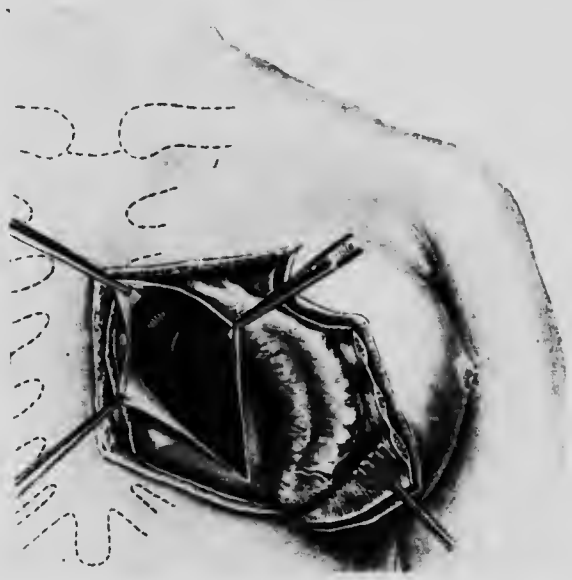


FIG. 325. Quadrangular flap of third, fourth and fifth ribs, hinge external. The drawing represents in addition the removal of parts of the sternum, additional transverse incision in pericardium, accidental tear of pleura, and wound of auricle—author's case. With care in elevating the flap, the pleura may be pushed back without injury.

Generally speaking, an anæsthetic should be given, though in several of Dr. Peck's collected cases it is noted that either local anæsthesia or no anæsthetic was employed.

Reference to Dr. Peck's tabulated list of cases shows the frequency of septic complications such as pericarditis, pleurisy, empyema, and wound infection. Hence, though rapidity is essential, all possible aseptic precautions should be taken. It is also desirable to commence infusion during the operation.

Exposure of the heart. Rapid and effective exposure are necessary. The following methods have been employed: of these the first and third would seem to be the most satisfactory.

One of the dangers to be anticipated is an extensive pneumothorax

[1] In the series of cases collected by Dr. Peck there were 69 of the right ventricle with 48 deaths (69·6 per cent); 74 of the left ventricle with 45 deaths (60·8 per cent.); 5 of the left auricle with 2 deaths (40 per cent.); 6 of the right auricle with 2 deaths (33·3 per cent.); and 7 miscellaneous cases with 5 deaths (71·5 per cent.); a total of 102 deaths and 58 recoveries (63·7 per cent.). Dr. G. W. Brewster and Dr. S. Robinson have published a paper (*Ann. Surg.*, 1911, vol. liii), on "The Operative Treatment of Wounds of the Heart." A large number of cases have been collected, and there will also be found much useful information about the diagnosis, indications for operation and operative technique.

with collapse of the lung, since the pleura may have been damaged by the original injury, or may be more or less extensively opened in the course of the operation. On this account the intratracheal method of inducing anæsthesia should, if possible, be employed, or one of the other methods mentioned at pp. 780, 781.

(1) *A quadrilateral flap with the hinge external* (Figs. 322, 325). The flap is marked out by horizontal incisions along the second and fifth intercostal spaces. These are joined at their inner ends by a vertical incision just internal to the margin of the sternum. The third, fourth, fifth, and sixth costal cartilages are divided at their sternal attachments, and the flap composed of soft parts and costal cartilages is carefully raised. If the pleura is uninjured it is carefully pushed outwards away from the deep surface of the flap. The cartilages are partly cut through with bone-forceps near the costo-chondral junction and the flap is then turned outwards. The pericardium can then be freely incised and the heart exposed. This method has the advantage of affording a good and rapid exposure of the heart. Injury to the pleura is easily avoided.

(2) *A quadrilateral flap with the hinge internal.* Here two horizontal incisions, similar to those described above, are made, and their outer extremities are joined by a vertical cut. The costal cartilages are then divided with bone-forceps and the flap of costal cartilages and soft parts is turned inwards. The pleura will probably be extensively torn and the exposure of the heart is not as good as in the first method. In a few cases the sternum has been transversely divided at the level of the upper and lower horizontal incisions and has been included in the flap. Though this gives a good view it adds to the length and severity of the operation and there is a danger of also wounding the right pleura.

(3) *By a long incision along the fourth or fifth intercostal spaces with division of one or more costal cartilages at their sternal attachment* (Fig. 324). Ample room may be obtained by strong retraction of the divided costal cartilages. This method has the advantages of rapidity and simplicity, though in all probability the pleura will be widely opened.

When the pericardium is opened the effused blood, which is under considerable tension, will escape, and in some cases this has been followed by an immediate improvement in the pulse. Clots are gently wiped away with gauze wrung out of sterile saline solution. Bleeding may be temporarily checked by the introduction of one or more fingers into the wound in the heart: in some cases the introduction of two or three fingers of the left hand, or that of an assistant, behind the heart will help to steady it and draw it forward into the wound. Dr. Peck recommends that one or two sutures should be quickly placed to co-apt the edges of the wound, to partly check the hæmorrhage, while others are subsequently added more deliberately to complete the control. He also advises that the end of the first suture should be left long to steady the heart for the placing of others. A small curved intestinal needle should be used, and though the stitch should pass deeply into the cardiac muscle the endocardium should not be included. Either fine catgut or silk may be used: interrupted, continuous, or mattress sutures may be employed.

Some irregularity of the heart has usually been noticed during the manipulation and the passage of the sutures, but it soon disappears. Should the heart-beat cease in the course of the operation direct massage should be employed.

Closure of the Wound and Drainage. The desirability of drainage in these cases is still an open question. Dr. Peck says, "unquestionably the use of drainage has in some instances favoured the development of secondary infection of pleura or pericardium, and I believe that closure of both without drainage, in conjunction with systematic careful preparation, is as a rule the best proceeding."

If the pleura contain much blood and has been widely opened, drainage of the pleura alone may be indicated and should preferably be made posteriorly by separate rib resection as in empyema.

Dr. Peck records the following case on which he himself operated. A coloured girl, 24 years of age, was brought to hospital, having been stabbed in the chest with a pocket-knife about thirty minutes before. There was no radial pulse, but a weak pulse could be felt high in the brachial artery and the carotids. The heart sounds could not be heard. Respiration was faint and shallow, extremities cold, and the patient in a condition of profound shock. There was a stab wound at the left border of the sternum over the third costal cartilage, which bled very little. Chloroform and ether were at once administered, and a quadrangular flap with its base external, including the third, fourth and fifth cartilages, was rapidly cut. The internal mammary vessels were ligatured above and below. The pleura was pushed away from its deep surface with gauze pads without being injured. There was a stab wound in the pericardium so close to the edge of the sternum that removal of a portion of that bone was necessary. Intrapericardial tension was so great that the heart-beat could not be felt even with the finger directly on the stab. The pericardium was opened by a three-inch longitudinal incision, one inch to the left of the stab wound, and about 300 cc. of dark blood escaped with a gush, the anæsthetist noticing immediate return of the radial pulse. The pericardium was more freely opened by a transverse cut and the heart lifted forward and slightly rotated to the left with the left hand. A wound of the right auricle about 1 cm. long and 2 cm. above the auriculo ventricular groove was thus brought into view. A suture of fine catgut was passed on a curved intestinal needle and tied, the ends left long, helping to steady the heart while three similar sutures were inserted, completely controlling the bleeding. An effort was made to avoid piercing the endocardium, but whether successful or not, in the thin auricular wall, is doubtful. The pericardium was emptied of blood and the wound closed without drainage. For the first six or seven days there were signs of a mild pleurisy, but at the end of the second week the signs had nearly disappeared, and pulse and temperature were approaching the normal. The wound healed by primary union and she was discharged twenty-four days after the operation. The heart sounds were normal and the signs of pleurisy had disappeared.

The following account of a successful case of a stab-wound dealt with by Parrozzani, is given by Hill [1]: "Parrozzani, in 1897, operated upon a young man who had been stabbed. Five hours after the injury he was carried to the hospital, where it was found that the dagger had entered the seventh left intercostal space in the mid-axillary line. His general condition was extremely grave, heart-beats and pulse almost imperceptible, and respiration rapid and superficial. Immediate intervention without an anæsthetic was decided upon. An incision through the soft parts, an inch and a quarter from the margin of the sternum, in the fourth intercostal space, was carried for a distance of five inches and a half, then it descended vertically in the mid-axillary line as far as the superior margin of the ninth rib. The fifth, sixth, seventh and eighth ribs were cut through in the mid-axillary line with the pleura. The musculo-osseous flap was raised, with the cartilages of the ribs acting as the hinges. The pleural cavity was filled with blood, and an opening one inch in length was found in the pericardium, which was subsequently enlarged to two inches and a half. There was very little blood in the pericardium, because the injury was in the most dependent part, and the blood readily escaped into the pleural cavity. A wound in the apex was observed, three quarters of an inch in length, through which the little finger was passed into the left ventricle. This served the double purpose of checking the hæmorrhage and steadying the organ for the introduction of the sutures. Four deep silk stitches were used, not touching the endocardium. Passing the needle caused violent throbbing of the heart. The pleura and pericardium were thoroughly cleansed, and the flap was sutured in position. Stimulating hypodermic injections

[1] *Loc. supra cit.*

were used, and hypodermoclysis and auto-transfusion practised. The operation lasted one hour and a quarter. Recovery resulted."

Hill, of Montgomery, Alaska, records[1] a successful case of suture of a stab wound of the left ventricle in a negro, æt. 13. The operation was performed eight hours after the injury, under chloroform, the wound being closed with one catgut suture. The patient made a good recovery.

The following are the conclusions drawn by Hill, together with others from the different published cases: (1) As the operation has reduced the mortality from over 90 per cent. to about 63 per cent., every wound of the heart should be operated upon immediately. (2) Unless the patient is unconscious, and corneal reflex abolished, an anæsthetic, preferably chloroform, should be given. Struggling is liable to cause detachment of clot, and fresh hæmorrhage. (3) The wound should never be probed, for fear of injury to the myocardium. (4) Rotter's flap-operation (p. 800) renders access to the heart extremely easy, and should usually be adopted. (5) Before sutures are introduced the heart should be steadied either by lifting up with the hand, or if the wound be large enough, by introducing the little finger into it, which serves the further purpose of stopping the bleeding. (6) The sutures should be of reliable catgut or fine silk, always interrupted and introduced with the smallest possible needle. They should not involve the endocardium, and as few as possible should be used consistent with safety, as they cause a degeneration of the muscle, with a tendency to dilatation and rupture. (7) Suturing or any other part of the technique should not be discontinued because the heart has ceased to pulsate, especially if respiration continues. (8) Forcible divulsion of the sphincter and squeezing the heart have been recommended as means of resuscitation; how far they are beneficial is another matter. (9) The pericardium should be cleansed by sponging out, no fluid being poured into the sac. (10) The advice to close the pericardium does not seem judicious.

In the majority of cases the wound was situated in front, and the pericardium was usually found to be distended with blood. The length of time between the injury and the operation has varied considerably: in a successful case by Rehn it was more than twenty-four hours; in a case of Giordano's, in which the left auricle was sutured, the operation was performed within half an hour of the receipt of the injury. In the majority of cases some hours elapsed before the operation.

Bullet Wounds of the Heart. These are probably less frequently suitable for operation than stab wounds, owing to the likelihood of co-existent injury to large blood-vessels or to other important thoracic or abdominal viscera. That many are, however, in a state to recover after operative treatment is shown by a reference to Dr Keck's list of cases. This contains twenty bullet wounds treated by operation, of which no fewer than nine recovered. In all cases the ventricles were injured.

Major Holt[2] says: "Wounds of the heart and the pericardium were so seldom met with in the hospitals that the inference is inevitable that such injuries caused immediate or very early death upon the field; but fatal wounds of the pericardium were not all immediately lethal. . . . In not a few instances the heart, from the absence of symptoms, must be presumed to have escaped injury, though from the anatomical tract of the bullet one would infer that a lesion must have occurred, unless it be admitted that the heart may be wounded without any obvious ill effects."

The following striking case of double gunshot wound of the heart was operated upon by M. Launay, and reported by M. Peyrot.[3]

The operation took place about three hours after the injury. The pulse was now uncountable, but the patient was able to give an account of the injury. The external wound was at the nipple, and from it hæmorrhage was small and intermittent. The heart sounds were indistinct, a splashing sound could be heard, and there was evidence of blood in the pleura. Chloroform having been administered, an osteoplastic flap was turned back with parts of the fourth, fifth, and sixth ribs. Complete

[1] *New York Med. Rec.*, 1900, vol. lviii. p. 921.
[2] *Surgical Cases Noted in the South African War.*
[3] *Bull. de l'Acad. de Med.*, January 29, 1902.

pneumothorax was present, with a large amount of blood in the pleural sac. The thin edge of the lung was perforated by the bullet. From a small wound in the pericardium the blood flowed slowly and persistently. The wound being enlarged, one was found in the left ventricle, 2 cm. from the apex. From this bleeding took place, only in diastole. The wound was easily closed with a catgut suture. Examination of the back of the heart was somewhat difficult, but the wound of the exit was found when the finger was placed under the apex, and the heart tilted up. It was situated near the base of the left ventricle. A traction-suture was placed in the heart muscle in order to give access to this wound, which was closed with two catgut sutures. The pericardium was cleared of clots and partially closed. The pleura was treated in the same way. During the operation two litres of salt solution were injected into the subcutaneous tissue. The operation lasted about thirty-five minutes. The pulse was uncountable throughout, but the heart had never ceased to beat. The next day the patient was in good condition. P. 100 to 120, of good volume. The drains were removed forty-eight hours after the operation. The patient made an excellent recovery.

CARDIOLYSIS[1]

This operation, which was first suggested by Brauer in 1902, is performed in certain cases of adherent pericardium where the action of the heart is embarrassed by fixation to the surrounding parts. No extensive separation of adhesions is attempted, but by removal of the covering ribs and costal cartilages the precordial part of the chest wall is made more flexible and yielding in the hope that by this means the strain on the heart may be lessened.

Indications for Operation. Needless to say the cases must be carefully selected, and the operation only performed after consultation with a physician after watching thoroughly the effect of rest and medical treatment. In the words of Dr. Poynton and Mr. Trotter, "Clearly, if relief of the overloading of the heart is to be obtained by mobilisation of the precordium, the capacity of the heart to recover must be demonstrable when the overloading is relieved by rest. It would seem, then, that the most suitable cases are those in which the heart is just inadequate for active life."

Operation. This is simple and can be rapidly carried out. A horseshoe-shaped flap is cut by an incision commencing just internal to the left margin of the sternum opposite the third costal cartilage. This is continued downwards to the level of the seventh costal, curving outwards along this, and then upwards to terminate at the third costal cartilage in the region of the nipple line. All soft parts superficial to the costal cartilages are included in the flap which is turned upwards. Three or four inches of the fourth and fifth costal arches and, if necessary, of the third and sixth as well, are then removed in the manner already described (p. 766). No attempt should be made to remove the internal periosteum, as there is little if any tendency for this to form new bone, and any endeavour to do so may result in damage to the pleura or to the cardiac muscle: the external periosteum should not, however, be preserved. After all hæmorrhage has been stopped the wound is closed without drainage. The results of the operation appear to have been satisfactory, though a large number of cases have not been recorded. Dr. Poynton and Mr. Trotter mention a paper by Ernst Venus[2] in which seventeen cases are described: no death is recorded as the result of the operation

[1] "*See* The Operation of Cardiolysis illustrated by a Case," by Dr. F. J. Poynton and Mr. Wilfred Trotter (*Proc. Roy. Soc. Med.*, Clin. *Sec.*, June 1909, p. 243).

[2] *Centralbl. f. die Grenzgebiete*, 1908, xi, p. 401.

and the results appear on the whole to have been very good. The following is an account of Dr. Poynton and Mr. Trotter's case.

A male patient, aged 16 years, was admitted under Sir Thomas Barlow in 1908 for œdema of the legs and face of three months duration. He had steadily got worse and was unable to follow his occupation. On admission there was some cyanosis and the evening temperature usually rose to 99 deg. The pulse, as was of low tension and small calibre, although regular. The veins in the neck were full and pulsated visibly. The impulse was diffuse extending from the third to the sixth intercostal space. Change of posture made no alteration in the position of the impulse. There was great systolic retraction over this area with a powerful ventricular beat. On auscultation there was a triple rhythm but no murmur was audible. The liver and spleen were slightly enlarged and the urine was free from albumin. A diagnosis of adherent pericardium with mediastinitis, left pleurisy and perihepatitis was made. He rapidly improved, and the œdema had disappeared in three weeks. After leaving the hospital the symptoms at once returned, and two weeks later he was re-admitted under Dr. Poynton, his condition being then worse than when first admitted. He again rapidly improved with rest, but the symptoms immediately reappeared after any exertion. Mr. Trotter operated on October 5. A semicircular flap was marked out in the precordial region and was reflected upwards. It included all structures anterior to the ribs. The fourth and fifth ribs were those which seemed to move most with the movements of the heart and three or four inches of each were removed subperiosteally. The pericardium was much thickened and adherent to the chest wall over the region exposed. After removal of the ribs the structures over the heart accommodated themselves far more easily to the cardiac movements. The flap was replaced and the wound completely closed. No exercise of any sort except massage was allowed for three months, and since then it has been graduated. "At the present time we believe that the operation has been justified by the result even if the improvement goes no further; for the patient can now go for a walk extending over half an hour, and in the evening there is only slight pitting over the ankles. He looks more healthy and is less breathless. His pulse has more power and is not so small in size. The size of the heart is somewhat diminished; the liver and spleen are smaller, and the veins in the neck are greatly reduced in size." The writers point out the difficulty in estimating the condition of the myocardium and the importance of this in the prognosis.

Precordial thoracostomy has also been performed in cases of valvular disease of the heart resulting in cardiac hypertrophy, with much heaving of the ribs and costal cartilages, with the object of relieving the enlarged heart of the labour of raising the chest wall. Dr. Alexander Morison has recorded such a case which was attended with a certain degree of success.[1]

[1] *Proc. Roy. Soc., Med.*, Clin. Sec., January 1915, p. 21.

PART IV

OPERATIONS ON THE LOWER EXTREMITY

CHAPTER XXXVIII

OPERATIONS ON THE HIP-JOINT

AMPUTATION AT THE HIP-JOINT. EXCISION OF THE HIP-JOINT. OPERATIVE TREATMENT OF HIP-DISEASE. INCISION OF THE JOINT

AMPUTATION AT THE HIP-JOINT

THE numerous methods which have been described are easily simplified. The indications for this operation are tuberculous disease, and, occasionally, osteo-myelitis, gross injury. For tuberculous and other infective disease the method of Furneaux Jordan, performed in two stages as advised by Sir H. Howse, for gross injury either the methods of Wyeth or Lyman Thomas, or, where these are not available, some modification of lateral skin-flaps, with division of the muscles high up should be adopted. While a few others will be described, the above will suffice for all practical purposes.

METHODS. I. **Furneaux Jordan's, performed in two stages (Sir H. Howse).** II. **Lateral Flaps.** III. **Modified Lateral—viz. Antero-internal and Postero-external Flaps.**

Methods of Controlling Hæmorrhage during Amputation at the Hip-Joint. (1) *Elastic Compression.* This may be applied at the junction of the limb and trunk without interfering with the operator, by the following method: While the patient is passing under the anæsthetic, the limb is emptied of blood by elevation; the patient is then rolled over on to his sound side and a strong flat rubber tourniquet, with slotted metal grips, is applied round the thigh and trunk, passing between the anus and the ischium on a narrow pad of gauze. A sterilised white roller bandage, of appropriate size, is then laid over the termination of the external iliac artery. The ends of the tourniquet are firmly and steadily drawn in direction downwards and outwards, one in front of the groin and the other behind the buttock, to a point above the centre of the iliac crest, sufficient pressure being employed to stop all pulsation in the femorals when the tourniquet is locked. The front part of the band passing over the bandage occludes the external iliac and runs parallel to and below Poupart's ligament. The posterior part runs across the great sciatic notch and controls the branches of the internal iliac.

To prevent the bands slipping down in the way of the surgeon, two loops of tape or bandage may be thus employed: each, about two feet in length, is placed longitudinally, before the elastic band is applied, the one over the groin, the other well behind the great trochanter, the centre of each being where the elastic band will go. When the band has been applied, these form loops by means of which the band is kept well out of the operator's way, both at Poupart's ligament and behind the great trochanter.[1]

(2) *Wyeth's Bloodless Method of Amputation at the Hip-Joint.* I have mentioned this in the account of amputation at the shoulder-joint already (p. 201). It has been largely used by American surgeons, and has given excellent results. Amongst these Dr. Hancock, of Georgia, records [2] a successful amputation at the hip-joint, and one at the shoulder and hip-joints, for railway accidents. Primary shock was absent in each

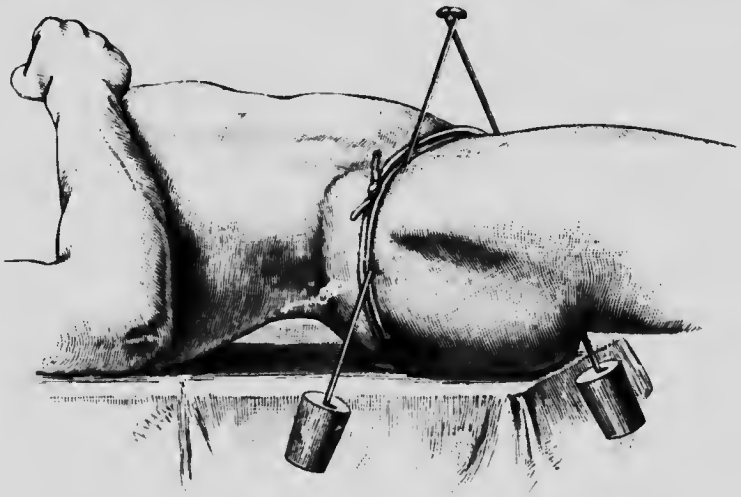


Fig. 326. Wyeth's bloodless method of amputation at the hip-joint.

case to a very unusual degree. The pins must be passed with exactness, and, unless of sufficient strength, will certainly bend under the strain of the cord above. Their use is thus described:[3] "The limb to be amputated should be emptied of blood by elevation of the foot, and by the application of the Esmarch bandage, commencing at the toes. Under certain conditions, the bandage can be only partially applied. When a growth exists, or when septic infiltration is present, pressure should be exercised only to within five inches of the diseased portion, for fear of driving diseased material into the vessels. After injuries with great destruction, crushing or pulpefaction, one must generally trust to elevation, as the Esmarch bandage cannot always be applied. While the member is elevated, and before the Esmarch bandage is removed, the rubber-tubing constrictor is applied. The object of this constriction is the occlusion of every vessel above the level of the hip-joint, permitting the disarticulation to be completed, and the vessels secured without hæmorrhage and before the tourniquet is removed. To prevent any

[1] Jordan Lloyd, *Lancet*, 1883, vol. i, p. 897.
[2] *Ann. of Surg.*, July 1906, p. 98.
[3] *Ann. of Surg.*, 1897, vol. i, p. 132.

possibility of the tourniquet slipping, I employ two large steel needles or skewers, three-sixteenths of an inch in diameter and ten inches long, one of which is introduced one-fourth of an inch below the anterior superior spine of the ilium and slightly to the inner side of this prominence, and is made to traverse superficially for about three inches the muscles and fascia on the outer side of the hip, emerging on a level with the point of entrance (Fig. 326). The point of the second needle is thrust through the skin and tendon of origin of the adductor longus muscle half an inch below the crotch, the point emerging an inch below the tuber ischii. The points should be shielded at once with cork to prevent injury to the hands of the operator. No vessels are endangered by these skewers. A mat or compress of sterile gauze, about two inches thick and four inches square, is laid over the femoral artery and vein as they cross the brim of the pelvis; over this a piece of strong white rubber tubing, half an inch in diameter when unstretched, and long enough when in position to go five or six times around the thigh, is now wound very tightly around and above the fixation-needles and tied. Except the small quantity of blood between the limit of the Esmarch bandage and the constricting tube, the extremity is bloodless and will remain so."

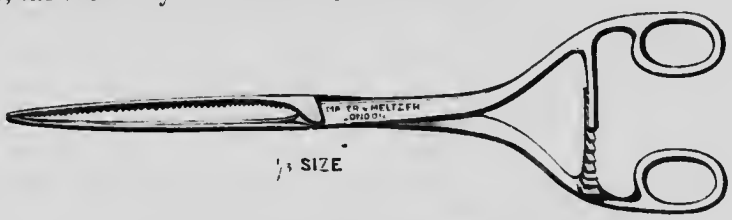


FIG. 327. Lynn Thomas's forceps-tourniquet.[1]

The Esmarch bandage is now removed and a circular incision is made six inches below the tourniquet joined by a longitudinal incision commencing at the tourniquet and passing over the trochanter major. A cuff including the subcutaneous tissue down to the deep fascia is dissected off to the level of the trochanter minor. About this level the remaining soft parts are divided down to the bone with a circular cut and are rapidly dissected from the femur. The vessels should now be searched for and both arteries and veins securely tied. It is advisable to tie all the vessels that can be seen at this stage, *i.e.* before disarticulation, to prevent their retraction. The muscular attachments are separated so that the capsular ligament may be exposed and divided. The limb being used as a lever, the thigh is forcibly elevated, abducted and adducted, letting in air and rupturing the ligamentum teres.[2] The tourniquet may now be carefully loosened and all bleeding-points at once seized. In cases of great exhaustion Dr. Wyeth would do the operation in two stages, securing the vessels, dividing the femur below the lesser trochanter, closing the wound and turning out the head of the femur about two weeks later. While the 633 cases of amputation at the hip-joint collected by Ashurst showed a mortality of 61·1 per cent., of 69 cases performed in this manner only 11 died—a mortality of 15·9.

[1] The most recent form of his forceps-tourniquet, and the method of carrying it in field-service are figured by Mr. Lynn Thomas (*Brit. Med. Journ.*, October 1, 1904).

[2] Where in cases of disease, the femur gives way high up, or where it is extensively crushed, the required traction and leverage will be afforded by tying a piece of sterile gauze round the neck (Hancock, *loc supra cit.*), if no appropriate forceps are at hand.

(3) Forceps-tourniquet of Lynn Thomas (Figs. 327 and 328).[1] An account of this instrument, with its advantages, will be found in the *Lancet*, April 23, 1898, *Brit. Med. Journ.*, April 20, 1901, and Oct. 1, 1904. Fig. 328 shows the method of applying the forceps in disarticulation at the hip, or in any amputation of the lower extremity. A small skin incision is made in the front of the thigh, one to three inches below the anterior superior spine according to the size of the limb. The smooth probe-pointed blade is pushed forcibly through the skin incision well down towards the neck of the femur, and in a transverse direction towards the spine of the pubes, the serrated blade of the forceps being outside, and when the tourniquet is driven well beyond the line of the common femoral vessels, it is clamped like an ordinary catch-forceps. Mr. Griffiths, of Cardiff, gives the following additional details as to the employment of this instrument in a successful case of amputation at the hip-joint for a

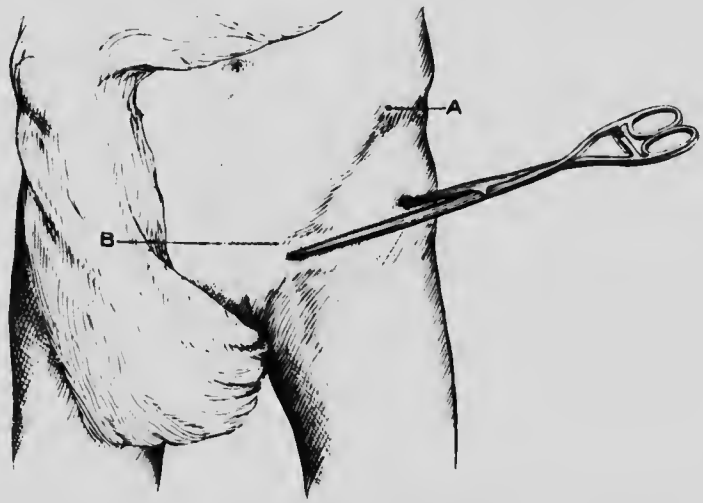


FIG. 328. The forceps-tourniquet applied for amputation of the hip-joint. A, Anterior superior spine of ilium. B, Spine of pubes.

periosteal sarcoma.[2] The vertical limb of a racket-shaped incision was commenced about two inches above the great trochanter, and into this incision, at its upper part, was inserted the smooth blade of Lynn-Thomas's tourniquet-forceps. This having been pushed on in the direction described above, and the forceps clamped, the vessels in the anterior flap were secured. To control the circulation in the posterior flap, another pair of forceps was used, the deep blade passing this time behind the neck of the femur. The oval part of the incision was next marked out, and the skin retracted a little way all round. The muscles attached to the great trochanter and in front of the hip-joint were now divided, the joint opened, and the limb disarticulated, the only spouting vessel seen at this stage being a tiny artery in the capsule. All the vessels which could be seen were next picked up and tied, and then the value of the tourniquet-forceps was demonstrated in the search for the smaller vessels which were

[1] The use of this instrument is also figured under the account of Syme's amputation.
[2] *Brit. Med. Journ.*, December 19, 1903, p. 1583.

found by loosening the forceps and immediately closing them when a bleeding-point showed the position of a vessel.

Mr. Lynn Thomas gives the following additional proofs of the simplicity and efficiency of his instrument. In a case which was believed to be one of central sarcoma of the lower end of the femur, he had amputated through the lower third of the thigh, controlling the hæmorrhage by the method given above. As after the ligature of all visible blood-vessels and loosening the forceps, unusually free oozing took place along the linea aspera, close inspection showed that the growth had extended here. The forceps were reclamped in a second, and after the upper limit of the growth had been defined, the limb was amputated in the upper third of the thigh. Primary union followed. "Though the tourniquet compressed the common femoral vessels and the accompanying nerves for fifty minutes, the only evidence of vaso-motor paresis was confided absolutely to the skin under the outer blade of the forceps-tourniquet."

The following are amongst the cases in which the forceps-tourniquet has been successfully used by Mr. Lynn Thomas.[1] Three amputations through the hip-joint, with three recoveries; three interscapulo-thoracic amputations with three recoveries. The application of the instrument in this operation is well shown. One arterio-venous aneurysm in Hunter's canal, which recovered. Here Mr. Lynn Thomas used two pairs, one to control the vessels at the upper end of the skin incision, and the other at the lower end. "In this operation I made the skin incision down to the fascia lata, but not injuring it, as it formed the outer barrier to the traumatic aneurysm; the probe-shaped blade was pushed boldly through in the direction of the inner aspect of the femur, and driven in as far as it would go, and then clamped (the flat blade being, of course, outside the skin), and the other forceps-tourniquet was applied in a similar manner at the lower border of the skin incision. The fascia lata was then divided and the clots turned out, the partially divided artery and veins were easily found, divided and ligatured. Control of hæmorrhage was as complete as if one had the vessels divided between two ordinary pairs of hæmostatic forceps."

Mr. Lynn Thomas further points out that his instrument will be found especially valuable in injuries to the femoral vessels, by gunshot or other wounds, and especially so where the injury lies close to Poupart's ligament, as here prompt treatment is especially called for, and the control of hæmorrhage is a matter of much difficulty. Any wound present would, of course, be enlarged, as needed. The following are the advantages of the forceps-tourniquet over other instruments, especially Esmarch's bandage: (1) It is not affected by climate; (2) it is easily sterilised; (3) it is most useful in major operations; (4) it does not require an assistant to look after it; (5) in no case has Mr. Lynn Thomas seen its use followed by that oozing which is so common after the employment of an Esmarch bandage.

(4) *Macewen's Method of Compression of the Abdominal Aorta.*[2] Prof. Macewen has used the following for many years, and has found it simple, always ready, easily applied and efficient. No injury has followed to the small intestines. If the patient vomits or coughs violently, the pressure must be temporarily increased. As the patient lies on his back on the table, the assistant, facing the patient's feet, stands on a stool at the left side of the table in a line with the umbilicus. He then places his

[1] *Brit. Med. Journ.*, October 1, 1904.

[2] *Ann. of Surg.*, 1894, vol. i, p. 1.

closed right hand upon the abdomen, a little to the left of the middle line, the knuckles of the index finger first touching the upper border of the umbilicus so that the whole shut hand will embrace about three inches of the aorta above its bifurcation. The assistant then standing upon his left foot, his right foot crossing his left, leans upon his right hand, and thereby exercises the necessary amount of pressure. With the index finger resting upon the common femoral at the brim of the pelvis, the assistant can easily estimate the weight necessary for the purpose. In this way an efficient assistant can control the circulation for half an hour without fatigue.

(5) *Compressing the Common Femoral or the Termination of the External Iliac* by the fingers or hands, aided, if need be, by a weight. This is only possible in the case of a child, and the assistant thus employed is liable to be in the way of the operator.

(6) *Ligature of the Common Femoral Artery.* The incision is utilised afterwards in shaping lateral or some modification of lateral flaps. The surgeon must be prepared for the hæmorrhage from the gluteal and other branches of the internal iliac artery (Fig. 330).

(7) *Commanding the Main Artery* during the operation by seizing it in the flap.

Furneaux Jordan's Method (Fig. 329). By amputating through the thigh as low down as possible, and shelling out and disarticulating the femur, it is now possible to avoid, in large measure, those dangers which were formerly inseparable from the operation, viz.: (1) Shock, the limb being removed much farther from the trunk. (2) Hæmorrhage. (*a*) Abundant room is afforded for compression of the common femoral, and the vessels behind. (*b*) The large vessels can easily be secured on the face of the stump, low down. (*c*) The gluteal and sciatic arteries remain untouched, the hæmorrhage from these, in the older operations, being a source of serious danger. (3) Infection. By the other methods, the copious discharge of bloody serum from the large wound,[1] being poured out close to the anus and genitals, was very liable to infection. By this operation, both the end of the stump and the wound on the outer side can be more easily drained and kept aseptic. In making use of this amputation, especially for hip disease or failed excision, the surgeon should not attempt too much to secure primary union. (4) The stump is a better one. It is longer, more mobile, and occasionally, as in amputation for acute periostitis or necrosis, it is possible to preserve much of the periosteum from the upper half of the femur, and a cord [2] will be left which will render the stump movable.

I. **Furneaux Jordan's Operation** (Fig. 329).[3] The modification of Sir H. Howse in two stages is given at p. 812. Every provision must

[1] While the wound in a Furneaux-Jordan amputation is also a large one, it is much more happily placed for drainage.

[2] The committee of the Clinical Society appointed to examine Mr. Shuter's case of subperiosteal amputation of the hip-joint reported (*Trans.*, vol. xvi, p. 89), (1) that, though there was a firm, resisting cord of considerable size in the centre, which afforded the muscles a common point of attachment, there was not sufficient evidence to enable them to state that this cord contained bone; (2) that the muscles were in a high state of nutrition, the patient not only powerfully flexing, extending, abducting, and adducting his stump, but being able to communicate all these movements to the artificial limb.

[3] Dr. W. E. Arnold, assistant-surgeon U.S. Navy, has kindly drawn my attention to the fact that an amputation, in all essentials the same as Furneaux Jordan's, was performed as long ago as 1806 by Dr. W. Brashear in Bardstown, Kentucky. The following account taken from a letter by Dr. Brashear will be found in Dr. Mott's edition of Velpeau's *Surgery*, in a summary of hip-joint amputations by Dr. Eve, of Tennessee. The patient was a lad, aged 17. An operation on the thigh in the ordinary manner was determined upon, as remote from the hip-joint as circumstances might justify (in this case, about mid-thigh). The amputation was performed and the arteries secured. The next step was to make an incision to and from the lower end of the bone externally over

be taken against shock. The limbs should be bandaged in cotton-wool, the body well wrapped up on a hot-water table, the head kept low, ether given, saline infusion employed intravenously or into the cellular tissue, or by both means. In many cases spinal anæsthesia is strongly indicated as it reduces shock to a minimum.

Before commencing the circular amputation, I have the limb elevated, an Esmarch bandage applied up to the knee, the thigh emptied of venous blood by firm stroking, and the flat rubber tourniquet is applied over the groin and above the crest of the ilium (p. 805), while the femur is shelled out or, perhaps, disarticulated, if the whole operation is performed in one stage.

FIG. 329. Furneaux Jordan's amputation; Above is shown the means of controlling hæmorrhage described at p. 805. Lower down is seen the method of shelling out the femur, after a circular amputation has been performed, and the large vessels secured.

The patient's pelvis is brought to the edge of the table and the body rolled a little on to the sound side, the surgeon standing usually to the right of the diseased limb—*i.e.* inside on the left and outside on the right side—draws up the soft parts forcibly with his left hand, and makes a circular incision through the lower third of the thigh, using his knife as at p. 849, the assistant who is in charge of the limb rotating it so as to make the tissues meet the knife. A circular cuff-like flap of skin and fasciæ is then quickly raised for about two inches and a half, an assistant, who stands opposite the surgeon, giving much help here, by seizing and everting the cut edge of the flap as the surgeon raises it. The

the great trochanter, to the head of the bone and upper part of the socket. The dissection of the bone from the surrounding muscles was simple and safe, by keeping the edge of the knife resting against it. The bone being disengaged from its integuments at its lower extremity, was then turned out at a right angle from the body, so as to give every facility in the operation to separate the capsular ligament and remove the head from its socket. The patient made a good recovery. Judging from a letter from Prof. Ollier to Mr. Shuter (*loc. supra cit.*) the former surgeon had recommended this method in 1859, and performed such an operation once.

flap being drawn upwards out of the way, the soft parts are severed by one or two vigorous circular sweeps down to the bone, and the large vessels and any others that can be seen are next secured. Pressure is now made with sterilised pads on the still oozing wound, the upper india-rubber bandage (Fig. 329) is tightened, and the patient being rolled well over on to his sound side, the surgeon cuts along the outer side of the thigh, starting from the circular wound and ending about midway between the iliac crest and top of the great trochanter. This incision goes straight down to the bone and runs into any excision wound or sinuses which may exist over the joint. The soft parts are then rapidly stripped off the femur, partly with the knife, partly with the finger, the only difficulty met with being along the linea aspera. If an excision has been performed, the operation is rapidly completed, but if the head and neck remain intact, the final steps will be rendered more difficult, and the joint must be opened from the outside by cutting strongly on the neck of the bone, this being facilitated by the assistant moving the limb, in accordance with the surgeon's directions as different parts require to be put on the stretch, strong outward rotation of the femur and dragging of the head away from the acetabulum being required at the last.

Free drainage must be provided, for it must be remembered that the wound left by this method is a very large one, though it has the advantage of being farther removed from sources of infection. Thus, especially if the tissues are riddled with sinuses, too much of the wound must not be closed, and, if shock is present, the surgeon must not wait to insert many sutures, but, trusting to firm bandages over an aseptic dressing, get his patient quickly back to bed. If disease of the acetabulum be present the surgeon will, if the patient's condition admit of it, attend to this, the use of a sharp spoon and the insertion of a drainage-tube through this bone being specially required if pelvic suppuration be present.

Sir H. Howse's Two-stage Modification of the Above. As in spite of its advantages the Furneaux-Jordan method must always be accompanied by shock, and as in spite of strenuous use of elastic compression the loss of blood, especially in adults, may be too much for the patients when their usual exhausted vitality is remembered, I strongly advise my readers to follow Sir H. Howse, and to remove the limb in two stages whenever this is possible, as in cases of tuberculous disease. My own experience is based upon four cases, in which I superintended its performance by my house-surgeons. Two of the patients were in a most unfavourable condition; all recovered. The limb is first removed by a circular amputation through the lower third of the thigh, and, about a fortnight later, the rest of the femur is taken away. By the adoption of this course, the shock is greatly diminished. The blood which would have been circulating in the rest of the limb is returned into the trunk before the first operation. By the removal of the limb the length of leverage which exerts a disturbing influence on the diseased joint and the need of a splint are done away with. The patient rapidly recovers lost ground, and is, at the close of the second operation, in a much better condition for the curetting of sinuses, now usually needful. These advantages, in my experience, outweigh the disadvantage of two operations, and the double anæsthetic.

Amputation by Different Flap Methods. The following will be given here, it being understood that in no case can any of them be recommended if the above method is available. In all, shock should be diminished by

spinal anæsthesia or by the injection of eucaine into the chief nerve trunks preliminary to their division, by the method of Crile and Cushing. Whenever available, the method of Lynn Thomas or Wyeth for arresting hæmorrhage (pp. 806 and 808) should always be employed.

II. **Lateral Flaps.** The methods of Larry and Lisfranc need not be more than alluded to here. In both, the flaps were cut by transfixion, and were about four inches long. Larry tied the common femoral as a preliminary step. Flaps made by either method are so bulky as not to be recommended.

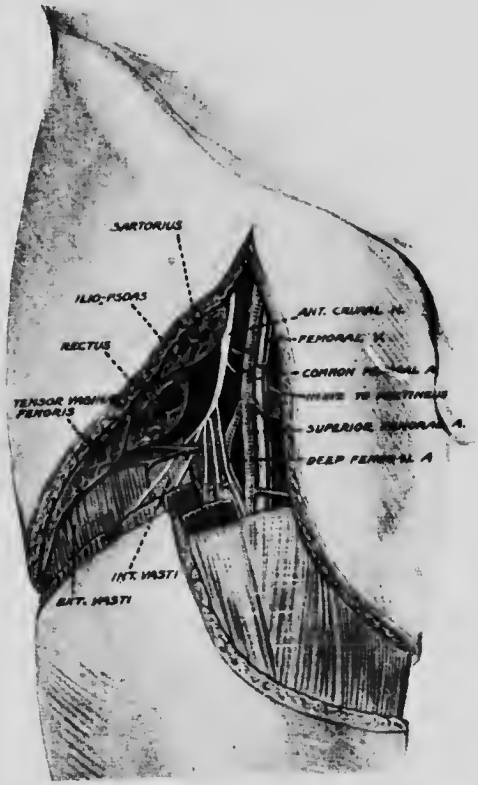


FIG. 330. Amputation at the hip-joint by modified lateral flaps (anterior racket-shaped incision). A double ligature has been placed upon the common femoral vessels.

If the surgeon wishes to use lateral flaps, as in a case involved by growth in front, he may make them, thus, from without inwards: Standing on the right side of either limb, he, *e.g.* in the case of the right limb, marks out an inner flap by means of an incision starting from below the tuber ischii, carried downwards along the inner aspect of the thigh for about four inches and then curving upwards to the centre of the groin and ending a little below Poupart's ligament, to the outer side of the femoral vessels; next, without taking off his knife, he marks out an outer flap by cutting between the same points, but in the reverse direction. This incision, as it passes downwards, outwards, and backwards, should leave the front of the limb about a hand's-breadth below the great trochanter. The flaps having been dissected up, the soft parts are cut through from without inwards, the femoral vessels being secured before they are cut, and disarticulation performed last.

III. **Antero-internal and Postero-external Flaps** (Figs. 330, 331). This is a modification of the last method, and will be useful in cases

of growth extending high up, where it is impossible to perform a Furneaux-Jordan amputation. Some such flaps as the above may be the only ones obtainable. They may be made as follows: The precautions as to shock given at p. 811 having been taken, hæmorrhage will be best met by the details given at p. 808, if Mr. Lynn Thomas's forceps-tourniquet is available. The patient's pelvis is then brought well down to the edge of the table, and the opposite limb being held aside but not tied, the surgeon, standing to the right of either limb, reaches

Fig. 331. The same operation as in the last figure, in a more advanced stage. The capsule has been opened and its outer lip drawn aside by a retractor. The other retractor draws inwards and protects the vessels.

somewhat over and marks out (in the case of the right limb) an antero-internal flap, but cutting from a point close to the tuber ischii to one a little below and internal to the anterior superior iliac spine. The skin and fasciæ having been dissected up, the muscles are cut through till the femoral vessels are reached and secured. Sterilised gauze is now packed into this wound, and, the patient having been rolled a little over, a postero-external flap is marked out and dissected up from the gluteal region, passing between the above points, but in the reverse order. The gluteal vessels are next cut through, the chief vessels

being secured by Spencer-Wells forceps; the capsule is then opened, the round ligament severed, and the limb removed.

EXCISION OF THE HIP. OPERATIVE TREATMENT OF HIP-JOINT DISEASE. INCISION OF THE JOINT

Indications. A. Disease, chiefly tuberculous. B. Injury, especially gunshot.

A. Disease. Few will deny that the progress in the treatment of hip disease has not made, of late years, advances in accordance with the advantages of modern surgery, and the progress made in operations on other parts of the body. While the immediate mortality after operative interference here has been lessened, the results as to real cures are still very poor and compare very unfavourably with the results of careful and prolonged conservative treatment.

This is very simple but tedious. The patient must be kept under observation for at least a year or eighteen months, in an apparatus such as a single or double Thomas's splint, designed to keep the joint at rest and prevent deformity. For about six months the recumbent position is essential. Later the patient can walk about on crutches with hand supports, the opposite boot being elevated to keep the diseased limb off the ground. Later still a modified Hessing's apparatus allows the patient to walk, without transmitting his weight through the diseased hip. This always guards against deformity. An open-air life and good food, and cod-liver oil and malt are valuable aids. As a rule, tuberculin injections are unnecessary and undesirable. The results of careful treatment along these lines are extremely good.

As regards excision of the joint it is obvious that it is almost impossible to remove all the diseased tissues, and that once the head of the femur is removed a normal hip joint is impossible, and is replaced by an unstable or fixed joint with permanent shortening, more or less flexion, adduction and eversion. In many cases sinuses persist.

When excision is performed later and abscesses are present, satisfactory dealing with these is usually rendered extremely difficult by their devious tracks, the risk of leaving a tuberculous sinus, and of this becoming, later, the seat of mixed infection. Then follow one or more curettings, and the child is sent out in a Thomas's splint, or perhaps to a convalescent home, or otherwise lost sight of; the dislike to having even mild cases of suppuration in the wards of a general hospital playing a large part in the interruption in the treatment.

The truth is that the only satisfactory treatment of hip-joint disease is the conservative one by strict adequately prolonged rest. This will not be perfectly obtained while these cases are treated in general hospitals. Institutions on a large scale, especially adapted to this class of case, are what is needed.

The unsatisfactory results met with after excision of the hip have led surgeons to be more chary in its performance, and to the employment of other, more conservative, steps.

Abscesses are extremely rare under conservative treatment commenced as soon as the diagnosis is made, but when an abscess does appear it may be aspirated if it does not absorb under complete rest in the recumbent position.

Iodoform emulsion may be injected into abscesses and the joint itself,

as advocated by the late v. Mickulicz of Breslau and other authorities. The weak points of this treatment are obvious. In the case of abscesses thickness of the pus may prevent anything like complete evacuation. The method makes no attempt to eradicate the bone lesions usually present, but with rest the tendency to heal is strong.

In dealing with an abscess strict asepsis as to the skin, &c., is needful. A syringe holding two to three ounces should be employed, so as to allow of aspiration of the pus. The emulsion is then injected, the syringe being resterilised. A spray of ethyl-chloride may be used. The aspiration is repeated according to the rate at which the abscess re-fills. Where the process has to be repeated, fresh spots should be selected. If the re-collection takes place slowly and is found to contain only blood-stained or brownish-green fluid the outlook is good. I need not enforce the necessity of watching these cases. Where the abscess is multiple, this method rarely succeeds, in my experience.

The joint itself may be injected by taking the line for opening the joint anteriorly (p. 820), and introducing the needle two to three inches below the anterior superior spine, in a direction backwards, upwards, and inwards, so that it enters the joint just above the anterior inter-trochanteric line. From 4 to 30 c.c. of the emulsion are injected at intervals of from one to two weeks, according to the reaction produced. Any pyrexia and pain are, usually, quite temporary.

Reference may here be made to an important contribution to the study of the treatment of hip disease by Drs. Gibney, Waterman, and Reynolds, of New York.[1] An analysis is given of 150 cases treated at the New York Hospital for the Ruptured and Crippled. Of these 25 were still under treatment, and need not be further considered; 7 were advised readmission for deformity, 11 died, and 107 were cured. The 107 cured cases were finally examined at an interval of five to twenty years after leaving the hospital. The excellence of the final result in the cured cases, all of which recovered with sound useful limbs, will be gathered from the following facts. As regards motion, this was perfect in 15, good in 22, limited in 41, and absent in only 9 cases. Shortening averaged an inch and three-fifths in all the cases, but was absent in 21 cases; under one inch in 71, and over one inch in 36. The record as regards flexion is also extremely satisfactory, as 47 cases had none at all, and in 77 it was under 10°; in the remaining 30 cases it was under 30°. The treatment employed consisted essentially in rest and extension; abscesses being either aspirated, or opened and curetted. Osteotomy of the femur was performed 19 times to correct deformity, but excision was done in 4 cases only.

Briefly stated, of 114 cases examined five years and upwards after leaving the hospital, 107 "were cured and able to follow an occupation without the slightest trouble," and the remaining 7 cases were cured but suffering from considerable deformity. As excision was performed in only 4 of these cases, it must be admitted that these excellent results constitute very strong evidence in favour of treatment other than that by actual excision. My experience at a large children's hospital and for years in charge of the Orthopædic Department at Guy's Hospital, where I watched a large number of these cases for many years, makes me strongly advocate conservative treatment. Even under the unfavourable circumstances of South London the patients did very well, and only a few excep-

[1] *Ann. of Surg.*, vol. ii, 1897, p. 435.

tions developed an abscess. I have not excised a tuberculous hip during the last ten years.

Prof. Marsh is strongly against excision, for these reasons: He considers the results obtained by continued rest to be such as to render excision totally uncalled for. "The estimate that I have been led to form is, (*a*) that, in the early stage of the disease, although matter is developed, the operation is as unjustifiable as it is to remove a testis, an eye, or a tooth for incipient but still curable disease; (*b*) that the operation is generally uncalled for, even when sinuses have formed; (*c*) that if hip disease has been allowed to reach the stage in which the bones have become extensively carious, in which matter has burrowed widely, and in which the general health has become seriously affected, excision will be of very doubtful benefit.

The following are the conditions given by a committee of the Clinical Society as calling for excision, viz.:

(i) "Necrosis, and separation of the entire head of the femur, and its conversion into a loose sequestrum."[1]

(ii) "The presence of firm sequestra either in the head or neck of the femur, or in the acetabulum." This question is a most important one, for, as Prof. Marsh (p. 318) writes, "much difference of opinion exists as to the frequency with which hard sequestra of any material size are present in suppurative hip disease." He himself thinks that, when present, sequestra usually consist of porous, friable bone. Their structure is such that, should excision not be performed, they will crumble away and disappear, and will not prevent repair.[2] A distinctly different opinion is held by Mr. Wright[3]: "Here opening of abscesses, and, still less, expectant treatment, can hardly be considered a satisfactory mode of getting rid of sequestra, yet in no less than in 39 (out of 100) were there actual loose sequestra, while in many others there were patches of bone which was practically dead, though not loose. The possibility of removing sequestra without a formal excision is worth trying in some cases, but it is often impossible to discover the presence of the sequestra until the end of the bone has been removed,[4] or to extract them if found. Moreover, even after the removal of sequestra, others may exist and not be found, and in other instances the disease progresses in the surrounding bone and necessitates subsequent excision. There are often, too, other foci of disease in the medulla, which are as great bars to recovery as the sequestra themselves." Careful radiographic examination are very valuable here.

(iii) "Extensive caries of the femur, or the pelvis, leading to prolonged suppuration and the formation of sinuses."

(iv) "Intrapelvic abscess following disease of the acetabulum."

[1] Prof. Marsh (*loc. supra cit.*, Fig. 50, p. 383) thinks that these cases are not rare. Mr. Hilton (*Rest and Pain*, Fig. 63, p. 341) shows a similar specimen. I should have thought the condition a very uncommon one.

[2] "This seems to be proved by the fact that in numerous cases in which profuse suppuration has been going on, so that there can be no reasonable doubt that extensive bone disease has been present, all the sinuses will close, although either no bone has worked out or been extracted. In these instances we must conclude either that no sequestra were present, and in that case it would appear that sequestra are not so common as some believe, or that they often crumble away and are discharged, so that operative interference is by no means essential for their removal" (Marsh, *loc. supra cit.*, p. 319).

[3] *Loc. supra cit.*, p. 118.

[4] For the word "removed" I should substitute "displaced," a step which I consider quite justifiable at the present day, to prevent the need of a complete excision and the flail-like limb which usually follows.

(v) "Extensive and old-standing synovial disease and ulceration of the articular cartilages, with persistent suppuration." This condition is rarely seen in the hip-joint, where the disease, as usually met with, starts not in the synovial membrane, as in the knee-joint, but as a chronic osteo-myelitis in the neighbourhood of the epiphyses, especially the upper one.

(vi) "Displacement of the head of the femur on the dorsum ilii, with chronic sinuses and deformity."

Mr. Jacobson performed excision seven times for such cases; of these six recovered with sound and useful limbs. These patients seem to bear excision well, this being probably due to their having good vitality, as shown by their survival, and the amount of repair. Further, in running successfully the gauntlet of the disease, they have escaped the dangers of lardaceous and general tuberculous trouble. But as a rule, especially if the sinuses are few or closed, osteotomy, either cuneiform of the neck or by Gant's method, together with division of the contracted sartorius, tensor fasciæ, and adductor longus is much to be preferred. Excision does away with much of the stability of the limb, already secured. The surgeon here must, if he excise, be prepared for a good deal of trouble in dislodging the displaced head, after sawing through its neck, owing to its being firmly matted down by old adhesions.

The Condition of the Limb. Is this a better one after Excision or after a Cure by Rest? Prof. Marsh[1] is of opinion that "the limb after excision of either the hip or the knee is usually very inferior to the average limb that is obtained after recovery has followed the treatment by rest." The Clinical Society's Committee reported on this subject that, after excision, "movement is more frequently present, and is also more extensive, but that patients often walk more insecurely and with a considerable limp, while the limb, after treatment by rest and extension though frequently more or less fixed, is more firm and useful for the purposes of progression." In a very large proportion complete recovery results from careful conservative treatment, in many cases not treated from the first or continuously. Limitation of movement with flexion and adduction develop; but even these results are better than those of excision, where much shortening, instability, and chronic sinuses are common.

Conditions of Success in Excision of the Hip. Amongst these are: (1) Age. I consider the best six to fourteen. After fifteen the results have not been so good. (2) Absence of lardaceous disease. Excision should be performed, in my opinion, only before the appearance of lardaceous disease. When there is evidence of this condition having set in, especially in the kidneys or intestine, amputation is to be preferred. (3) Absence of advancing mischief in other joints, or of tuberculous lesions in the viscera, *e.g.* the lungs. (4) The disease must be removed as entirely as possible. Thus, in the femur at least, the section must pass below all foci of disease (p. 823). All sinuses should also be scraped out. (5) Adequate drainage. (6) Careful after-treatment, the wound, including the adjacent skin, being kept aseptic. The patient must not be kept too long on his back in ordinary hospital air but must lead an open-air life. These words must not be taken to encourage getting the patient up, and allowing him to bear any weight on the limb, even if primary union has been secured, eight weeks or so after the operation. After this time the patient may get about on

[1] *Loc. supra cit.*, p. 308.

crutches with hand supports, the opposite boot being elevated at least an inch. The weight of the limb is beneficial and limits shortening. Later a calliper or Hessing splint enables the patient to walk without detriment.

B. Gunshot Injuries.

Excision of the Hip-joint for Gunshot Injuries, contrasted with Conservative Treatment, and Amputation at the Hip-joint. For the sake of convenience it will be well to take the above three plans of treatment of gunshot injuries of the hip together. As before, I shall avail myself of the laborious researches and the unrivalled authority on this subject of Dr. Otis. He writes[1] that the evidence collected during the American War shows that "expectant treatment is to be condemned in all cases in which the diagnosis of direct injury to the articulation can be clearly established"; that "primary excisions of the head or upper extremity of the femur should be performed in all uncomplicated cases of shot fracture of the head or neck"; that "intermediary excisions are indicated in similar cases where the diagnosis is not made out till late"; that "secondary excisions are demanded by caries of the head of the femur or secondary involvement of the joint"; that amputation should be performed: "(1) When the thigh is torn off, the upper extremity of the femur comminuted with great laceration of the soft tissues, or such proximity to the trunk that amputation in continuity is impracticable. (2) When a fracture of the head, neck, or trochanters of the femur is complicated with laceration of the femoral vessels. It may be possible to restore the circulation by vascular suture or anastomosis. (3) When a gunshot fracture involving the [illegible] complicated by a severe compound fracture of the limb lower down, or [illegible] of the knee-joint."

Other authorities have differed from Dr. Otis's opinion as to the uselessness of expectant treatment in gunshot injuries of the hip-joint. Prof. Langenbeck,[2] from his experience in the Franco-German War, considered that the expectant treatment gave a larger proportion of recoveries than excision, and still more than amputation, and advised that the expectant method should always be resorted to save when disarticulation is rendered inevitable by the destruction and shattering of the limb. Sir T. Longmore,[3] thought that this question must be held to be still "*sub judice*, and surgeons must wait for still more extended experience under modern improved methods of treatment, before any rule can be accepted as having yet been established on this grave question."

Dr. Otis shows that "intermediary operations offer the least chance of recovery."

The experience of the Boer campaign, one where the proportion of shell wounds was very small, was widely different.

Mr. G. H. Makins, C.B.,[4] saw no case of perforation of the head or neck of the femur, nor of injury to the hip-joint. Occasionally excision of the head of the femur is indicated in poor patients suffering severe pain from intracapsular fracture.

Operation. Two will be described here: A. **By Anterior Incision**; B. **By Posterior Incision.**

A. Mr. A. E. Barker,[5] in his Hunterian Lectures,[6] advocated the use of **the anterior method** in the early stage of hip disease. In later papers[7] he published some cases thus treated in later stages, where other means had failed, and abscesses were threatening to burst. The following are the chief advantages: (1) the interference with the muscles is practically *nil*;

[1] *Med. and Surg. Hist. of the War of the Rebellion*, pt. iii, p. 165.

[2] *Arch. f. Klin. Chir.*, 1874, Bd. xvi, S. 309-316. The recoveries seem to have been twenty-five out of eighty-eight cases so treated.

[3] *Syst. of Surg.*, vol. i, p. 561.

[4] *Loc. supra cit.*, pp. 193 and 238.

[5] Mr. R. W. Parker (*Clin. Soc. Trans.*, vol. viii, p. 108) recommended this method as interfering less with the muscles and the blood-supply of the joint. Hüter was, I believe, really the first to use this incision, draining the joint by a counter-puncture at the back.

[6] *Brit. Med. Journ.*, 1888, vol. i, p. 1326.

[7] *Ibid.*, 1888, vol. ii, p. 1337, and 1890, vol. ii, p. 1009.

(2) the patient can thus be treated and his wound dressed much more conveniently, *e.g.* with a Thomas's splint; (3) primary union will follow if the following most essential points can be secured: (*a*) the whole of the diseased structures must be removed; (*b*) perfect asepsis must be secured; (*c*) all oozing must be checked, and the wound kept dry by well-applied dressings; (*d*) absolute rest must be maintained during healing. With regard to the objection which has usually been considered to be fatal to the anterior incision, viz. the insufficient drainage which it gives, Mr. Barker replies that the incision, though anterior, is perfectly adequate for drainage, (1) because the discharges are, if the above given precautions are duly followed, very small in quantity, "little more than odourless serum, which ought never to become truly purulent"; (2) "if all the tubercular tissue is removed, a clean-walled cavity is left, most of which is quite capable of healing by first intention, when its different surfaces are brought into close contact by firm pressure. And, in these cases, the head of the bone being removed, and the acetabulum quite clean, the cut surface of the neck of the femur can be brought close up to the latter, so that although there is potentially a large space in the field of operation, there ought to be actually little or no cavity left if pressure has been properly applied from the first."

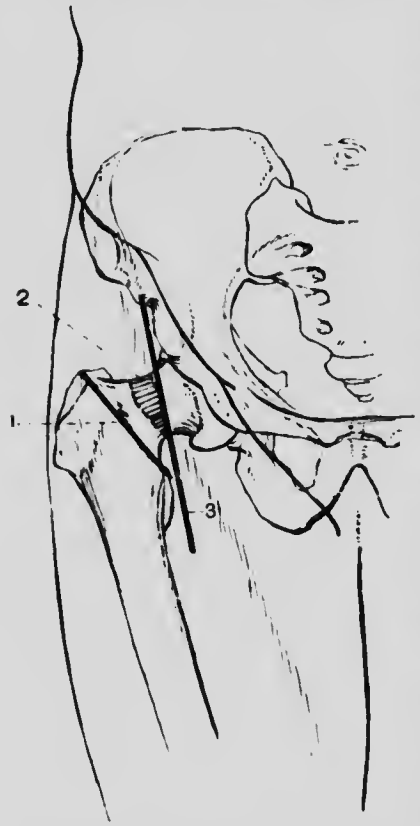


FIG. 332. (1) R. Jones's line of section through trochanter. By this trans-trochanteric osteotomy, followed by traction and abduction, Mr. R. Jones has been able to obliterate or very greatly lessen the shortening in a very large number of cases of bony ankylosis. (2) Cuneiform osteotomy for coxa vara. (3) Anterior incision for excision of the hip (MacCormac.)

G. A. Wright,[1] speaking at the discussion on one of Mr. Barker's papers, said that he had found the entire removal of the morbid tissues practically impossible either by the anterior incision which he used occasionally, or by the posterior. Only little foci of disease might be left, but they were apt to suppurate when some fall or accident gave them the opportunity. And this will be the experience of most, particularly with regard to the acetabulum, and synovial membrane at the back of the capsule.

Operation. The patient being on his back, with the limb extended, and the parts duly sterilised, the surgeon makes an incision three to four inches long, starting half an inch below the anterior superior spine, downwards and slightly inwards, between the tensor vaginae and gluteci externally and the sartorius and rectus internally. The upper part of this

[1] *Brit. Med. Journ.*, 1888, vol. ii, p. 1338.

incision should pass down to the capsule at once, the lower third should divide skin only. The interval between the above-named muscles is next thoroughly opened up and the wound retracted, so that the anterior surface of the capsule is exposed. A branch of the external circumflex artery will now, probably, be divided. The capsule now being freely opened, and the limb flexed, the left index finger is passed into the joint. As the difficulty which is sometimes experienced in removing the head is usually due to an insufficient division of the capsule, this is now further incised with scissors, the left index finger being used as a guide. An aseptic finger now examines the condition of the joint. The wound being opened by retractors, a narrow-bladed saw, guided by a finger, is introduced into the upper part of the wound in the direction of this, and with as little damage to the soft parts as possible, and the femur sawn through the neck, or across the top of the great trochanter.

The advantages and disadvantages of these sections are given below at p. 823. In a case at all advanced there will always be a risk that a section through the neck will expose diseased bone. The head of the femur is now extracted and the acetabulum treated by the means given at p. 823. Owing to the depth at which it lies there is usually difficulty in dislodging the head of the femur. Its direction must be remembered, and the narrow interval between its articular surface and the acetabulum detected. A free opening in the capsule will facilitate its extraction. In the use of elevator or forceps care must be taken not to damage the sawn edge of the femur (p. 823). Every atom of diseased structure, including all the synovial membrane that is accessible, must now be removed, especial care being taken to clear out any caseating abscesses communicating with the joint. All this should be done with as little violence as possible to the surrounding tissues, the lowered vitality of these being remembered, so that none of the tuberculous debris be forced into the fresh-cut surfaces. The best instrument for removing the disease thoroughly is Mr. Barker's "flushing gouge." This has a cutting scooplike edge, is perforated, and to its belt is attached tubing which communicates with an irrigating can. By this means boiled water (F. 105) is kept flowing through the area of operation, carrying away the debris of disease whether from abscess cavities, the joint, or the surface of the acetabulum, if diseased, and with it all blood, while at the same time it arrests hæmorrhage. When every part of the field of operation has been gouged and scraped clear of all tuberculous material, and the water runs clear, the cavity is dried out with sterilised pads, and the wound closed with interrupted salmon-gut sutures. Graduated even pressure is then applied by the dressing and bandages, so that the walls of the cavity are brought into apposition, and the remainder of the neck of the femur secured in the acetabulum. The patient is then placed in a double Thomas's splint. If sinuses are present, and the joint infected, the wound must not be closed, but drainage must be provided. All sinuses, having been thoroughly opened up and curetted, must be plugged by means of strips of iodoform gauze passing down to the bottom.

With regard to the after-treatment I would urge that cases of hip excision should be got up as early as possible, *i.e.* at the end of six or eight weeks. A double Thomas's splint should be applied immediately after the operation, and worn for a period of from six to eight months. After this the child should get about on a patten and crutches, swinging

the affected limb. He should not be allowed to bear any weight on this for a year after the operation. If weight is borne on the limb earlier, the end of the femur is pushed upwards on to the dorsum ilii, and much shortening is the result. A modified Hessing's splint or, in poor patients, a Thomas's calliper splint, designed to take the weight from the tuber ischii, enables the patient to walk earlier and with less fear of shortening, adduction or flexion. Mr. Barker has allowed some of his cases to get up and dispense with a splint at a much earlier period. I think the above-given dates better suited to these cases of excision of the hip, when we remember the risks to which they are exposed by their rough-and-tumble life when they leave the hospital.

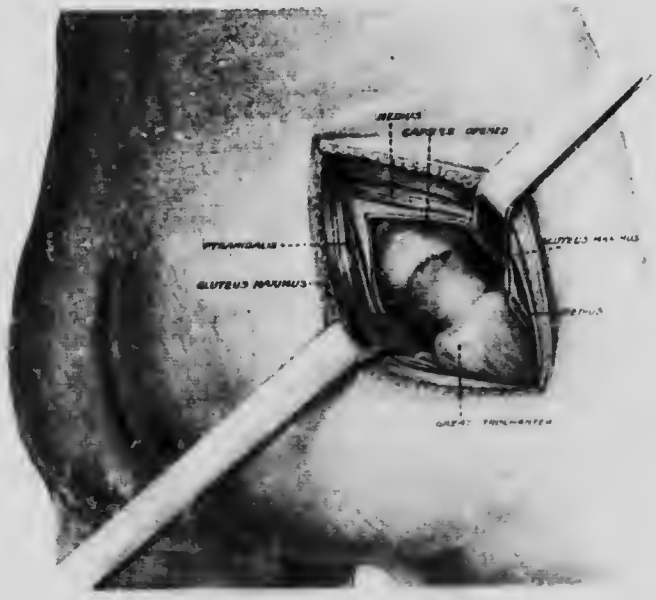


FIG. 333.—Resection of the head of the femur by the posterior incision. The thigh is flexed to an angle of 45°.

B. **Posterior Incision** (Fig. 333). The chief advantage of this is its better drainage, a point which is of less importance nowadays, and which no longer outweighs, in my opinion, the smaller interference with muscles entailed by the incision in front (p. 819).

While the patient is being brought under ether, a stirrup is applied if weight-extension is to be made. The child being rolled over on to the sound side, and the parts thoroughly cleansed, the surgeon stands usually outside the limb, the patient's body being in either case placed conveniently at the edge of the table, one assistant supporting the limb, while another is opposite to the surgeon. An incision, about three and a half inches long,[1] is now made over the middle[2] of the great trochanter, commencing about midway between the top of this bone and the posterior superior spine, and ending over the shaft, just below the trochanter. The incision should curve slightly forwards and pass down to bone or cartilage, as the case may be, at

[1] It must be always remembered that a small wound, by giving insufficient room, leads to bruising and difficulty.

[2] The advantage of going so far forward as this is, that the fleshy and vascular parts of the muscles attached to the great trochanter are better avoided.

ones. Any bleeding vessels having been secured, the exact position of the head and neck is now made out by the finger, aided by an assistant rotating the limb. A second incision opens the capsule freely. With a periosteal elevator, aided by a knife, the muscles attached to the great trochanter are detached, the cartilage in young subjects peeling off with them in one or more pieces. The finger is now passed round the neck of the femur and the soft parts, including the periosteum, detached as much as possible on the inner side. The finger now feeling that the upper part of the trochanter and the neck of the bone are free, and protecting the soft parts on the inner side, the bone is sawn through just below the top of the trochanter with an osteotomy, metacarpal, or keyhole saw.[1] This division should be thoroughly and cleanly effected without splintering. If it be preferred, in addition to the protection of the finger on the inner side, a blunt dissector may be passed behind the bone, but this is not essential: retraction will protect the lips of the wound from the saw. With the aid of the finger and an elevator, or with a lion-forceps, the head and neck of the bone are levered out of the acetabulum, this being often attended with difficulty. Free opening of the capsule will aid this step. But great care is now needed to avoid infliction of damage on the sawn femur. Such damage is very likely indeed to lead to tuberculous infection of the bony section. This *must* be left clean cut and uninjured. Any instrument used must be directed to the head itself. The ligamentum teres is probably destroyed; if not, it must be divided. The acetabulum is then examined, and, if merely roughened, left alone; if pitting or erosion be present, gouging must be resorted to. Any sequestra present must be removed. If the acetabulum is perforated, and pus present on its pelvic aspect, free exit must be provided by means of a gouge or small trephine, and a drainage-tube passed through.

The inner surface of the capsule and all abscess cavities must now be thoroughly curetted and irrigated by means of a flushing spoon, as described above, until all granulation tissue and caseous debris have been removed. If sinuses are present, these must be carefully curetted and treated with pure carbolic acid. Hæmorrhage is usually very slight, and with the exception of a few vessels, which may be caught with forceps, usually consists of general oozing. This will usually be stopped by the hot irrigating fluid; if, however, it is troublesome, the cavity may be packed with gauze.

Drainage, either by means of iodoform gauze or a tube, will be necessary in nearly all cases. In a very few, however, where no sinuses exist, where all disease in bone and soft parts alike has been removed, and where all oozing has been arrested, a little sterilised iodoform emulsion may be rubbed in and the wound partially closed with sutures. The dressings must be carefully applied and firm pressure used to prevent oozing.

Site of Section of the Femur. Section through the root of the neck of the femur has the great *advantages* of disturbing and damaging the attachments of muscles much less, and thus leads to more rapid healing and far greater mobility of the limb. These, however, are outweighed by the *disadvantage* which leaving such a large piece of bone as the trochanter entails, viz. that, after healing, this process gets drawn up against the scar and may constantly fret it. It is also said to check the escape of discharges, and to render the patient liable to persistence or recurrence of the disease. I am doubtful as to the last two, but the first is absolutely certain, unless prolonged rest is enforced. Where the section is made through the neck, the surface must be carefully scrutinised.

Usual Causes of Failure after Excision of the Hip. (1) Persistent pelvic disease. (2) Chronic osteomyelitis of sawn end of femur (*vide*

[1] It is usually advised that the section of the femur be made while the bone is *in situ*, owing to the risks of fracturing a wasted shaft, inflicting damage on weak epiphyseal lines and stripping off the periosteum. To these accidents will be very exceptional if careful hands and eyes are used. There is no doubt that displacement of the head (by adducting the limb) facilitates complete removal of the synovial membrane, especially its posterior and less accessible portion. Further, careful dislocation of the head does away with the difficulty, often present, of turning it out of its socket after the bone section has been made *in situ*, and the resulting drainage sinus usually inflicted on the upper end of the shaft of the femur (*vide infra*).

supra). (3) Suppuration and hectic. (4) Lardaceous disease. (5) Tuberculous conditions elsewhere. General outbreak of tuberculosis. (6) Disease of the opposite femur.

Operations for Rectifying Deformities in the Later Stages of Hip-Joint Disease, such as a cuneiform osteotomy of the neck, or Gant's subtrochanteric operation, are described below in the chapter on Osteotomy.

The anterior incision should be used to open the joint in *cases of infective arthritis and epiphysitis* occasionally met with here. Owing to the gravity of these cases, and the difficulty of flushing out the joint and establishing drainage, the capsule should be very freely opened and drainage should, in every case, be provided behind by a counter-puncture in the buttock, made with a pair of stout forceps thrust through the back of the capsule from the wound in front.

I only mention the subject of excision in *osteoarthritis* to condemn it, owing to its severity in patients of the usual age at which this disease appears, and the impossibility of preventing re-appearance of osteophytes. I can imagine the operation being justified in patients who are crippled at an unusually early age, in whom both joints are affected, the operation being performed in the hope of enabling them to bend one hip-joint. Handley's operation for the removal of osteophytes from the acetabular rim and the neck of the femur is to be preferred.

In some cases when only one hip-joint is affected with painful osteoarthritis a partial arthrectomy with the object of securing painless bony ankylosis is desirable.

SACRO-ILIAC JOINT

ARTHRECTOMY

It has been shown that the prognosis in tuberculous disease of this joint, usually looked upon as so grave, is much better if the same radical methods of treatment, which have proved so satisfactory in other joints, are applied to the sacro-iliac synchondrosis after conservative treatment has failed.

Mr. Collier first drew attention to the above fact with a case successfully treated by trephining,[1] and Sir George Makins and Mr. Golding Bird followed, each surgeon publishing three successful cases.[2] The following points are taken from these papers:

Operation. The joint is exposed by a crucial incision (Makins), or by a flap (Collier, Golding Bird). In the words of the last-named surgeon, "a semicircular flap of skin and subcutaneous tissue over the iliac area of the joint, and having its convexity corresponding to the posterior edge of the ilium, is dissected upwards and forwards, and the underlying glutei are detached. The bone being thus freely exposed, a large trephine is applied at the root of the posterior inferior iliac spine, and in a line drawn from the top of that spine to the junction of the anterior with the middle third of the iliac crest. . . . The ilium at the seat of the operation is very thick, but the disc of bone removed should reach quite down to the joint." The trephine-opening is then sufficiently enlarged, the articular

[1] *Lancet*, 1889, vol. ii, p. 787.
[2] *Clin. Soc. Trans.*, vol. xxvi, p. 127, and vol. xxviii, p. 186.

surfaces cut away with a gouge or forceps sufficiently to enable the surgeon to explore the pelvic surface of the joint, and to liberate any pus lying on this aspect. The sharp spoon, or Barker's flushing gouge, is then thoroughly used, all fragments of bone, granulation tissue, or loosened cartilage removed, and any sinuses present laid open. Sterilised iodoform having been next applied the wound is closed, a drainage-tube being left in for twenty-four hours only. Rest for some weeks in the supine position, to be followed by a Thomas's hip-splint with crutches and elevation of the opposite boot for many months, are essential in the after-treatment.

CHAPTER XXXIX

OPERATIVE INTERFERENCE IN DISLOCATION OF THE HIP. COXA VARA

HERE three varieties of cases have to be considered: I. **Traumatic Dislocations.** II. **Dislocation from Disease** (this is rather a partial dislocation, or a subluxation). III. **Congenital Dislocations.**

I. **Traumatic Dislocation.** The great deformity, permanent crippling, and often great suffering resulting occasionally from old unreduced dislocations of the hip, abundantly justify resort to operation, nowadays, as long as it is understood that the operation will be a severe one, and the after-treatment one requiring great vigilance on the part of the surgeon.

In an excellent paper [1] Dr. M. L. Harris, of Chicago, publishes an instructive case of his own and twenty-four others which he has collected. From these he draws the following conclusions: (1) Owing to the danger of fracturing the neck of the femur; [2] of laceration of the great vessels of the thigh [3] here, in an attempt to reduce by manipulation an obturator dislocation of thirteen weeks' duration in an adult, a fatal tear was produced at the junction of the superficial and deep femoral veins; or of shock and death, [4] the application of great force to reduce old dislocations of the hip should be discontinued in favour of freely opening the joint and reducing the head of the bone, after the method used by Dr. Harris (*vide infra*). (2) Subcutaneous operations in old dislocations are without benefit. (3) As osteotomy below the great trochanter leaves the head in its abnormal position, and thus fails to relieve the pain which so frequently accompanies these old dislocations, and as it cannot improve the limited mobility which is always present, it is not to be considered in any way an operation of choice. (4) Resection is only to be thought of when reduction after free arthrotomy fails.

The following are the steps of the **operation** performed by Dr. Harris in his case of dorsal dislocation of nearly four months' standing, in which repeated and prolonged attempts at reduction had been made:

A free incision was made between the tensor vaginæ femoris and the gluteus medius, thus leading directly down to the acetabulum and anterior surface of the head and neck of the femur. As was expected, the acetabulum was found filled with a tough, adherent connective tissue proliferation [5] from the anterior portion of the capsular ligament, which, in falling over the cavity, completely closed it. On cutting through the capsular ligament, the head of the bone was found resting on the posterior and superior edge of the acetabulum in a shallow depression, the lining of which had a smooth cartilaginous feel. Immediately in front of the head and helping to fill the cotyloid cavity was a small piece of bone, curved in shape, which had been detached from the posterior wall of the acetabulum. This may have been an obstacle to the early reduction of the case. The head of the bone was still covered with smooth cartilage, while the neck had acquired new firm adhesion to all the surrounding parts, thus producing a new capsular ligament.

[1] *Ann. of Surg.*, September 1894, p. 349.
[2] *Arch. f. Klin. Chir.*, 1885, Bd. xxxii, S. 440.
[3] *Ann. of Surg.*, June 1892, p. 425.
[4] *Rev. d'Orthop.*, September 1890.
[5] In a case of traumatic dorsal dislocation in a boy, aged 7, reduced after five months by the open method, and brought by Mr. Spencer before the Clinical Society, February 8 1895, a long anterior incision showed the acetabulum to be filled with dense fibrous tissue. It is stated that the acetabulum could not have been reached by a posterior incision without resecting the head of the bone.

Only a small portion of the ligamentum teres was present in the depression in the head when this was turned out of its new joint. The adhesions to the neck were divided, and all the muscular attachments to the great trochanter and shaft as far down as the lesser trochanter were separated subperiosteally from the bone, thus liberating the entire upper end of the femur. Attention was then directed to the acetabulum, which, by means of the gouge and sharp spoon, was freed of capsular ligament and the new connective-tissue formation. The cartilage lining the bottom of the cavity was found to be still smooth. The head of the bone, however, could not be made to enter the acetabulum, which seemed too small. The cavity was consequently enlarged somewhat posteriorly with the gouge and mallet, after which, by considerable exertion and manipulation, the head was finally returned to its place, and the leg assumed its normal position. The wound was partly stitched, and the rest packed with iodoform gauze. The limb was placed in the extended position, plaster of Paris put on, and extension applied. The operation was a very severe one, occupying fully two hours. The patient suffered considerably from shock, although the loss of blood was not great. Reaction came on promptly, and the progress of the case was favourable from the start. There was considerable serous drainage from the wound during the first few days, necessitating rather frequent renewals of the dressings. In three weeks the wound was closed, but in another week a small collection of sero-pus required evacuation by a counter-puncture. The extension was continued three weeks. Six weeks from the time of the operation the patient was allowed up on crutches. In three months he could walk with a cane without pain in the hip. Active motion was possible in all directions—flexion, abduction, adduction, and rotation; these, though limited, were daily increasing.

II. **Dislocation from Disease.** This has been referred to at p. 818.

III. **Congenital Dislocations.** *Lorenz's Manipulative Method.* There is no doubt that Lorenz's bloodless method gives very satisfactory results in the majority of children under eight years of age. The younger the child the more easy the replacement, the less the danger, and the better the result. Even when the head of the femur cannot be reduced or maintained in the acetabulum, a posterior dislocation is converted into a subspinous one, and the functional result, although not perfect, is much improved. The gliding is much diminished and the balance is improved. The pelvis and the thighs are thoroughly washed, dried, and then powdered with boracic acid and zinc oxide, and the hands of the surgeon are treated in a similar way. While an assistant thoroughly fixes the opposite side of the pelvis and the opposite thigh, the surgeon grasps the knee with one hand and flexes and abducts the thigh, while with the ulnar border of the other hand he presses against and tears the tight adductors just below the pelvis. The muscles gradually yield to the firm pressure combined with traction, and when they no longer offer any appreciable resistance the hip is gradually hyperextended in order to stretch the shortened structures, if any, in front and to the outer side of the hip, especially the tensor fasciæ femoris and the fascia lata. Then the surgeon places one fist with its ulnar border on the table and the child's trochanter lying in the hollow between the index finger and the thumb. The fist thus placed acts as a splendid fulcrum, while with the other hand the thigh is flexed, abducted, and rotated until the head of the femur can be felt to enter the acetabulum with a distinct thud or click. When the head has been reduced an effort is made to stretch the anterior part of the capsule by rotation of the femur, but care must be taken to avoid external rotation, which may possibly produce a subspinous dislocation. The pelvis and the thigh are surrounded with gamgee tissue and several plaster bandages are applied, while the hip is maintained in the corrected position, abducted at right angles to the pelvis, and with the knee farther back than the plane of the symphysis pubis. The plaster spica extends to the lower third of the thigh, the knee being left free. Great care is taken to avoid

undue pressure upon any part, and especially by the edges of the spica. This can be avoided by making the plaster less extensive than the gamgee protection. No plaster is applied directly in front of the reduced head of the femur, for it is a great advantage to be able to prove that the correction is maintained, by feeling the head of the femur and by means of an X-ray examination, while the plaster is still on. When the displacement is double, both hips are reduced at the same sitting, and then fixed in a double plaster spica. The plaster is changed at once if the correction is not maintained, as shown by repeated examinations; but, as a rule, it is not necessary to change it for about three months, and then the flexion and abduction may be slightly diminished in most cases. At the end of six months the limb is brought still farther down so that the child can walk upon the foot with the aid of a high boot.

If carefully carried out, Lorenz's bloodless method gives very satisfactory results in the majority of cases. In about 80 per cent. the head of the femur can be reduced into the acetabulum; and though in a few redislocation may occur from failure of after-treatment, it may be estimated that in at least 60 per cent. of cases a good permanent anatomical reduction can be obtained, and that in another 30 per cent. anterior transposition with improved function may result.

There are certain dangers associated with the method, and these should never be overlooked. The anæsthetic mortality has been high, probably owing to the severity of the manipulation and consequent shock. The neck of the femur and even the pelvis have been fractured. Paralysis of the external popliteal the sciatic, or the anterior crural nerve has also occurred. The femoral artery has been ruptured, and gangrene of the leg has occurred. Suppuration or sloughing of the skin in the soft parts about the pelvis has also taken place. But with care and early operation there is very little risk of these complications at the present time.

Indications for Operation. Operative interference in this condition should not be undertaken unless the bloodless method of reposition by manipulation has been given a fair trial, and has failed. Even then the advisability of operative interference here is still much disputed. When we consider the condition of the parts affected, especially the shallow, ill-developed acetabulum and the altered flattened head, we can easily understand the difficulty which has been met with in getting the head into, and retaining it in, a satisfactory position.

Mr. Jackson Clarke, whose book on "Congenital Dislocation of the Hip," 2nd ed., 1905, contains the clearest account of Lorenz's manipulative method with which I am acquainted, and one based on much personal experience, goes farther than the above statement and sums up the position of the open operation as follows (p. x.): "It should not be performed in any case in which manipulative reposition is impossible, and, where the latter can be done, it is safer, and alone gives far better functional results than the open operation. Therefore the open operation is no longer a legitimate surgical procedure." Later in his work Mr. J. Clarke is inclined to allow a little more latitude, implying that there may be a few cases in which an open operation is justificable. Thus he writes at p. 21: "Lorenz's manipulative method in a considerable proportion of cases gives a perfect anatomical and physiological result (*i.e.* it cures a condition hitherto deemed incurable); in a still greater number of cases it affords a permanent functional im-

provement that relieves the patient of the grievous disabilities which the deformity entails if untreated. In the remaining cases in which this method fails to give a firm articulation placed anteriorly, the manipulative operation of Lorenz is a necessary preliminary to any subsequent treatment by open operation that may be undertaken."

No one who studies the results which have been progressively attained will feel any doubt that with increasing experience and careful attention to the details of Lorenz's technique, not only at the time, but during the nine or twelve months which follow, the number of perfect results will increase.[1] Where a perfect result, *i.e.* an actual replacement of the head within the acetabulum and its retention there, as proved by skiagraphy, six months after the removal of all casing, is not secured, but merely an improved position, *e.g.* an anterior transposition, not a true reposition, if this transposition has brought the head of the femur near the acetabulum, and if this new resting-place is made secure by attention to the after-treatment insisted upon by Lorenz so as to secure sound healing of the torn structures and to prevent a relapse, either anterior or supracotyloid, or still more a posterior or dorsal one, the result will be a great improvement.[2] Thus many of the chief deformities characteristic of congenital dislocation, viz. the shortening, the lordosis, and the insecurity will be largely removed, and a good functional result will be secured.

Operation. In those cases where it has been found impossible to secure or to maintain a sufficiently improved position, where the child is over five or six years and therefore more easily kept clean, but not of such an age that the structures have become so rigid that the head cannot be brought near the acetabulum, the following method may be employed: the chief changes in the structures and the difficulties that may be met with will be manifest. If the adductors and hamstrings are very rigid these must be dealt with at a preliminary stage. By extension the head is drawn down to the level of the hip-joint. The incision given at p. 820 is made and its upper part prolonged along the crest of the ilium in order to detach the origin of the tensor fasciæ and the deep fascia.[3] The tensor is retracted and the extended limb rotated outwards. The capsule is next freely incised parallel with the anterior inter-trochanteric line and the head protruded. If the ligamentum teres interfere with this, it should be divided. With a sterile finger the condition of the acetabulum is investigated. I shall suppose that one exists though small, and I would here point out that the safety of the operation largely turns on the degree to which the acetabulum and head of the femur are developed; the difficulties and dangers of the operation increase greatly when this is not the case. The obstacles to the reentrance of the head may now be found to require division of the iliopsoas at its insertion (Burghard), the straight head of the rectus at its origin,[4] or to be due to resistance of the capsule and a narrow slit-like

[1] Mr. J. Clarke is of opinion that those who speak of the perfect results attained by Lorenz's method being few and isolated have not really mastered the details of his technique.

[2] The different results which may be attained short of a perfect one and the necessary treatment, exercises, &c., to secure further improvement are given in detail by Mr. J. Clarke (*loc. supra cit.*). On this subject my readers should also refer to a paper by Dr. J. Ridlon, of Chicago (*Journ. Amer. Med. Assoc.*, 1904, pp. 1011 and 1063). The paper is a very helpful one from its straightforward candour, and from the fact that Dr. Ridlon, like Mr. Clarke, has been associated with Lorenz.

[3] Burghard, *Brit. Med. Journ.*, October 19, 1901, p. 1157.

[4] Keetley, *Orthopædic Surgery*, p. 297.

condition of the cotyloid ligament. With regard to the capsule, any unnecessary division must be avoided, as it is one of the chief means of restraining and steadying the head later, and the introduction of sutures is a possible source of infection. If it be a slit-like condition of the cotyloid ligament which cannot be sufficiently dilated by the pressure of the head, this structure, with the anterior attachment of the capsule to the acetabulum, together with the straight head of the rectus, must be carefully detached with a periosteal elevator. The head can usually now be placed in its proper position by the manipulations of Lorenz. It remains to replace the separated capsule and to tighten this by sutures of sterilised catgut or silk. The question of drainage must depend upon the extent to which the parts have been disturbed, and the dryness of the wound. The limb is then put up in plaster of Paris in the abducted, outwardly rotated, and slightly flexed position. To provide inspection of the wound, Mr. Burghard employs a form of Croft's splint, consisting of a posterior portion embracing the posterior two thirds of the buttocks, pelvis, thigh, and leg; the other half embraces the anterior portions, and can be taken off for inspection of the wound. The knee, in the flexed position, is included in the plaster. At the end of a month a large plaster spica is substituted, and the abduction slightly diminished. An X-ray photograph is taken at the same time.

Up to this point the conditions met with have been comparatively simple and easy to deal with. But there are other cases which present an entirely different aspect. To take those where the acetabulum and head of the femur are totally inadequate. With regard to the first, and deepening or making a new acetabulum, it should be superfluous to point out how the difficulties and dangers of the operation, especially shock, hæmorrhage, and infection, are increased. And if these are satisfactorily met, the ultimate after-result is liable to be very disappointing. On this point Mr. Burghard's opinion on the results of Sir Arbuthnot Lane's operation, the object of which is to make a secure joint below the anterior inferior spine, deserves careful attention. "I have tried it in five cases and have been invariably disappointed with the results. The space available for the formation of a new acetabulum is extremely small, and in order to get a stable joint it is necessary so to whittle down the head of the bone that it becomes a mere point and firm ankylosis as likely to result. If not, the joint becomes gradually unstable, and the final condition is no better than before operation." Every surgeon of experience will confirm Mr. Burghard's opinion. Hoffa himself, in his article in v. Bergmann's Surgery,[1] dismisses the formation of a new acetabulum in four and a half lines, as if it were a simple and easy matter. It is a matter of great difficulty to ensure that "the new cavity be deep and broad and the walls fairly steep, especially above, to give good support to the head." It requires most careful and arduous work with gouge and burrs to form a new cavity even large enough to bury the last joint of an adult thumb. One operator has been candid enough to record a case in which perforation of the bone took place at this stage with fatal peritonitis. When the head and neck of the femur are faulty in direction rather than in development, *i.e.* directed forwards instead of inwards, this may be first corrected and the dislocation reduced later. When the head and neck are practically absent it is extremely doubtful if any operation will be of real permanent value. Our experience

[1] *Amer. Trans.*, vol. iii, p. 413.

up to the present time justifies the following conclusions. Between the ages of about two and six I repeat that the amount of rigidity present is a more important factor than the number of years one or more attempts should always be made to secure a perfect or much improved result by the manipulative method perfected by Lorenz. If the details insisted upon by this authority are followed at the time and during the needful after-treatment, good results will be increasingly secured. If the surgeon fail, and also in the case of rather older children, *i.e.* from the ages of six to about eight, it will be justifiable to operate on the lines given above. When the acetabulum and upper extremity of the femur are sufficiently developed and normal in direction and position to admit of their being retitted, the result will often be good. In other cases, it is very doubtful if the results ultimately attained are worth the risks which are necessarily run.

Risks and Causes of Failure. The chief of these are: (1) Shock. (2) Hæmorrhage. (3 and 4) In children the effects of a prolonged anæsthetic and of iodoform intoxication must also be remembered. (5) Infection. (6) Prolonged suppuration increasing the risk of (7) ankylosis. (8) Relapse into a faulty position. Other rarer but possible accidents, such as that of peritonitis, have been already mentioned. Finally, in cases where much difficulty is present, it is obvious that the dangers which have been met with in the manipulative method must be remembered here also. I refer, especially, to injury to the delicate epiphyses and shaft and neck of the femur. These, and many others, are mentioned by Dr. Ridlon and Mr. J. Clarke, especially the former.[1]

CURVATURES OF THE NECK OF THE FEMUR. COXA VARA[2]

Indications for Operation. These are, chiefly, a degree of deformity in which such shortening, fatigue after walking, stiffness in stooping and sitting are present that rest will not permanently relieve the pain, or exercises, active and passive, increase the range of movement. No operation should be undertaken in children or adolescents while there is any reason to believe that the bones are still soft,[3] and if the patient operated on be rapidly growing with poor development of muscles and joints, prolonged rest and general treatment will be required if a satisfactory result is to be attained. An occupation involving hard work, or carrying heavy weights is, in my opinion, an indication for operation, if the above-mentioned condition can be secured.

Operation. Two groups may be made here: A. **On the neck.** B. **Subtrochanteric.** Owing to the healthy condition of the joint, excision may be set aside, though still highly thought of by some German authorities.[4] Contrasting these two methods briefly, I consider that the

[1] *Loc. supra cit.*

[2] This term is convenient, but only correct when one curve is spoken of. More than one curve may be met with.

[3] Mr. Keetley, to whom belongs the credit of first performing osteotomy (subtrochanteric), in a case due to rachitis adolescentium, and proving this by examination of the wedge removed (*Illus. Med. News*, September 29, 1888) gives the following important hint (*Orthopædic Surgery*, p. 312): "Adolescents attacked with rickets do not present the same clinical picture as infants. . . . The older a person is when attacked with rickets the more limited and localised are his deformities likely to be."

[4] Prof. Hoffa (v. Bergmann's Surgery, *Amer. Trans.*, vol. iii. p. 517) writes: "Resection of the joint is best for the severe cases. The improvement in the gait and general condition in the majority of cases of resection verify its value (Muller, Hoffa, Kocher, Maydl, Sprenger, and others). In the case which the author resected the shortening was reduced

younger the patient the more is a subtrochanteric operation indicated. In children the parts are too small to admit of easily meeting the necessity of so arranging the wedge that when the gap is brought together the proper position of the femur is restored. In older patients, where the parts are larger and the elongation of the upper margin of the neck more pronounced, it is easier to secure the above object, but in these patients opening the joint, which it is difficult to avoid, is more likely to be followed by stiffness. In my opinion a subtrochanteric operation is always to be preferred. Certainly osteotomy of the neck should never be employed unless a skiagram shows that the lengthening of the neck is enough pronounced to render removal of a wedge likely to be sufficient. Linear osteotomy alone is not likely to be satisfactory in cases of sufficient severity to call for operation.

A. **Cuneiform osteotomy of the neck** (Fig. 332). The parts are exposed by the anterior incision already described (p. 820). The upper margin of the neck is the spot to which attention must be directed, and in separation of the periosteum and other structures care must be taken not to inflict needless damage on the epiphysial structures or the joint. It will be remembered that the epiphyses here are late in joining, and that rachitic changes may be more or less active up to certainly as late as eighteen years. The base of the wedge should be upwards and usually forwards; according to the degree of the deformity it will measure from one to two inches. The wedge must be cut cleanly with a chisel, and through to the inner border, which is always short. In removing it the above given precautions as to injury to adjacent parts must be remembered.

Before the necessary correction into the abducted, everted and rotated inwards position can be satisfactorily secured, division of the adductors and hamstrings may be needful, now, or as a preliminary measure.

B. **Subtrochanteric osteotomy** (Fig. 334). Here the osteotomy has been linear, transverse, oblique from without inwards, or cuneiform. Theoretically, as the neck is the part primarily affected, interference here is the more scientific course, but on account of its greater simplicity, and for the reasons given above, I recommend subtrochanteric osteotomy. I shall mention two methods, both of which give good results. I prefer the first as rather the simpler.

I. *Cuneiform Subtrochanteric Osteotomy.* Here a wedge is removed below the great trochanter, the apex being inwards and forming a hinge; on this, when the cut surfaces of the bone are brought into contact by abducting the limb, not only is the position of the limb rectified but the restoration of a more normal angle and direction of the neck is commenced, the after-treatment continuing this object.

R. Whitman's method [1] will be found comparatively easy and efficient

from 2¾ to 1⅝ inches. The importance of gymnastics and massage after the extension is removed is self-understood." It is difficult to understand the above statement with regard to the shortening if the case had been watched for any length of time. With regard to the adoption of this step, Mr. Keetley writes in his usual terse and vigorous style: "What is to be thought of reports like the following (reference to one of Schneider's cases): 'Patient limps, but has no pain. Treatment: Resection of the hip-joint. The patient was discharged cured.' Cured! What of? Not of the limp, we may be sure; not of the adduction either, unless bony ankylosis ensued; nor of the shortening. Increased mobility may have been obtained, but at the expense of increased weakness and diminished length."

[1] *Ann. of Surg.*, 1900, vol. i, p. 145, and *Med. Rec.*, March 19, 1904.

(Fig. 334). It is especially indicated in adolescents (about twelve to seventeen years of age).[1] In Dr. Whitman's words: "The base of the wedge should be about three-quarters of an inch in breadth, directly opposite to the trochanter minor; the upper section should be practically at a right angle with the shaft, the lower one being more oblique. The cortical substance on the inner aspect of the bone should not be divided, but, reinforced by the cartilaginous trochanter minor, should serve as a hinge on which the shaft of the femur is gently forced out until the opening is closed by the apposition of the fragments after the upper segment has been fixed by contact with the margin of the acetabulum; thus

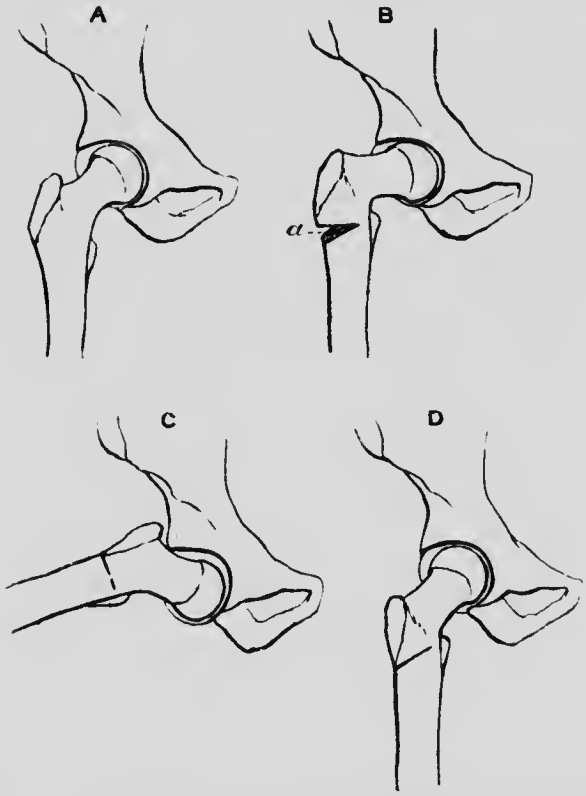


Fig. 334. A. A normal femur. B. A femur with coxa vara. *a*. A subtrochanteric wedge has been removed. C. Abduction first fixes the upper segment by contact with the acetabulum, and then closes the opening in the bone. D. Replacement of the limb, after union is completed, elevates the neck to its former position. (Whitman.)

the continuity of the bone is preserved. The leg is then held in the attitude of extreme abduction by a plaster spica bandage, which should include the foot also, until the union is firm."

Here also any contracted adductors or hamstrings must be rectified, either at the time, or beforehand by manipulation or tenotomy.

[1] In children Mr. Barnard finds it possible to produce a subcutaneous rectification of the neck of the femur by simply abducting the femur under an anæsthetic, to a similar degree to the normal side and then putting the limb up in plaster (*Clin. Journ.*, January 6, 1904).

H. Mr. Watson Cheyne, C.B., divides the femur below the trochanters, and, having rotated the limb inwards until in the position of extreme internal rotation, holds the fragments together by perforated aluminium plates secured with tin-tacks.

When both limbs require operation, they should, if possible, be dealt with at the same time. In a young adult the time required for adequate rest and after exercises, if the result is to be satisfactory, is considerable. Mr. Watson Cheyne gives another reason which affects younger patients. In a case seen some years after the operation, the limb operated on was found to be a good deal longer than its fellow, which, not rectified and still incapacitated, had not grown so well.

CHAPTER XL

LIGATURE OF ARTERIES IN THE BUTTOCK AND THIGH

LIGATURE OF THE GLUTEAL ARTERY

Indications. (1) Stab. (2) Aneurysm. (3) Hæmorrhage after opening an abscess. All are rare, especially the last.

(1) *Stab.* The source of the bleeding from a stab in the buttock may be very difficult to tell exactly. The surgeon may be guided by the position of the exit of the gluteal and sciatic vessels (Fig. 335); he will remember the outline of the gluteus maximus, the lower border of this muscle forming the fold of the buttock, the upper starting from the crest about two inches in front of the posterior superior spine, and running downwards and forwards to the greater trochanter. Hæmorrhage from a stab in the upper part of this muscle will probably come from the gluteal; if from the lower part, from the gluteal or sciatic.

(2) *Aneurysm.* When it is entirely outside the pelvis. When this point is uncertain it is better to tie the internal iliac.

Surgical Anatomy of the Gluteal Artery. A short, thick branch from the posterior division of the internal iliac, this leaves the pelvis above the pyriformis, through the sacro-sciatic notch. Immediately after its exit it divides into a superficial and a deep portion. The superficial is mainly distributed to the gluteus maximus; the deep lies between the gluteus medius and minimus, and divides into two, the upper branch running along the origin of the gluteus minimus, and the lower running obliquely across this muscle towards the trochanter major. The superior gluteal nerve emerges just below the artery, and sends branches with the deeper portion.

Line and Guide. "If a line be drawn from the posterior superior spine to the great trochanter, the limb being slightly flexed and rotated inwards, the point of emergence of the gluteal artery from the upper part of the sciatic notch will correspond with the junction of the upper with the middle third of this line."[1]

Operation (Fig. 335). The patient being rolled two-thirds over on to his face, the part well exposed and cleansed, the limb hanging over the edge of the table, an incision, five inches long, is made in a line running from the posterior superior spine to the upper and inner part of the great trochanter. The incision should run almost parallel with the gluteus maximus. The fibres of this muscle being separated, between adjacent fasciculi, with a director, a muscular branch should be found and traced down to the exit of the artery. The gluteus maximus having been relaxed, and the contiguous margins of the gluteus medius and pyriformis separated with retractors, the surgeon, taking as his guide

[1] MacCormac, *Lig. of Arts.*, p. 126, Figs. 10, 11.

the above line and the aperture of the great sacro-sciatic notch, clears the artery as high up as possible, avoiding the nerve and the veins, and dividing the adjacent muscles if needful. The ligature should be applied as far within the notch as possible, almost within the pelvis, as the artery divides immediately after its exit If in the case of a stab, bleeding continues after the ligature has been carefully applied, and the gluteal has evidently been punctured within the pelvis, the internal iliac must be tied after the wound in the buttock has been firmly plugged with sterilised gauze.

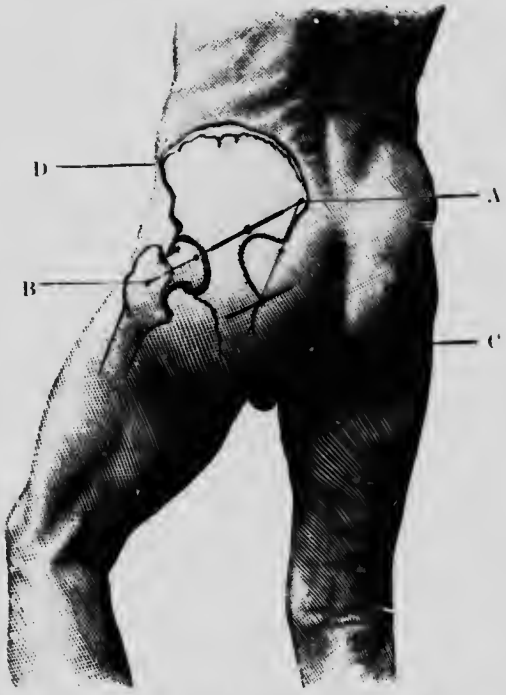


Fig 335. Position and direction of the superficial incisions which must be made to secure the gluteal, sciatic, or pudic arteries.

A. Posterior superior iliac spine. C. Tuberosity of ischium.
B. Great trochanter. D. Anterior superior iliac spine.

AB. Ilio-trochanteric line, divided into thirds. This line corresponds in direction with the line of the fibres of the gluteus maximus. The incision to reach the gluteal artery is indicated by the darker portion of the line. Its centre is at the junction of the upper and middle thirds of the ilio-trochanteric line, and exactly corresponds with the point of emergence of the gluteal artery from the great sciatic notch.

AC. Ilio-ischiatic line. The incision to reach the sciatic or internal pudic arteries is indicated by the lower dark line. It is also to be made in the direction of the fibres of the gluteus maximus. The centre of the wound corresponds to the junction of the lower and middle thirds of the ilio ischiatic line. (MacCormac.)

LIGATURE OF THE SCIATIC ARTERY

Indications. *Stab.* This operation is so rarely required that it may be very briefly described here.

Surgical Anatomy. The sciatic artery emerges, together with the sciatic nerve and the pudic artery, from the lower part of the great sacro-sciatic notch below the pyriformis.

Guide and Line. The limb being rotated inwards, a line is drawn from the posterior superior spine to the ischial tuberosity. The exit of the sciatic and pudic arteries corresponds to the junction of the middle and lower thirds of this line.

Operation (Fig. 335). The sciatic artery may be found by one of two incisions- (*a*) by a horizontal one, about five inches long, made about an inch and a half below that for the gluteal artery, and, like that, parallel with the fibres of the gluteus maximus; (*b*) by one made vertically in the above given line.

LIGATURE OF THE COMMON FEMORAL

Though this operation is not regarded with much favour, especially for aneurysm, it will be described here, as the question of tying it arises from time to time, and as it should always be performed, for the sake of practice, on the dead body.

Indications. (1) *Wounds.* These are rare, here, compared with those affecting the vessels lower down. The wound must always be explored and the bleeding-point sought, for several reasons: (*a*) Ligature of the external iliac will usually fail to arrest bleeding from the common femoral. (*b*) The source of the bleeding may easily be mistaken here; thus, Mr. Liston,[1] in a case of pistol-shot wound of the groin, tied the external iliac for what was proved, at the necropsy, to be a wound of "one of the superficial branches of the common femoral, about half an inch below Poupart's ligament." (*c*) Vascular suture may be practicable and wise, so that the continuity of the artery or vein is maintained or restored.

The very important subject of **ligature of the femoral artery or vein, or both, in cases of wounds,** will be referred to here, though briefly. Such cases will arise most frequently in removal of growths—*e.g.* epitheliomata, lymphomata, sarcomata—less often in cases of stabs.

(2) *Ulceration into the Artery by Growths.* From the frequency of growths here this indication will occasionally arise. I have met with one case. A man was admitted under my care who had been operated on elsewhere for the removal of sarcomatous glands in the groin. The application of zinc chloride paste had led to detachment of sloughs and exposure of the common femoral, which gave way, leading to profuse hæmorrhage. I tied the common femoral immediately above the bleeding-point; this was slowly followed by typical dry gangrene, necessitating amputation through the lower third of the thigh.

(3) *Ulceration of the Femoral Vessels in Inguinal Bubo.* Mr. Shield has drawn attention to this most dangerous condition.[2] Though in his case ulceration occurred in the *superficial* femoral vessels, I have alluded to it here, in association with the previous two headings. Owing to hæmorrhage from sloughing sinuses in Scarpa's triangle, Mr. Shield was obliged to tie both artery and vein, using two ligatures in each case. There was no return of hæmorrhage, and gangrene did not occur, but the patient sank exhausted on the eleventh day with a large pyæmic abscess in the opposite hip-joint. When once bleeding has occurred and recurred, as pressure, owing to the condition of the soft parts, is likely to fail, a free incision and ligature of the vessels above and below the point of ulceration is the wisest course.

(4) *Aneurysm.* There has been much difference of opinion as to whether it is wiser, when dealing with an aneurysm of the superficial

[1] *Med.-Chir. Trans.*, vol. xxix, p. 107. The flow of the blood here is said to have been "most impetuous and profuse." In Mr. Liston's words: "The division of even a small branch close to the principal vessel, it is well known, pours out blood furiously, as much so, in fact as if an opening in the coats of the artery itself were, so to say, punched out, corresponding in size to the area of the branch."

[2] *Med. Soc. Proc.*, vol. x, p. 261.

femoral high up, to tie the common femoral or the external iliac. English surgeons have rejected ligature of the common femoral for these reasons: (1) The risk of gangrene, as the ligature is placed above both the great nutrient arteries of the limb. (2) The probability of firm clotting taking place after the ligature is rendered doubtful, owing to the number of small vessels given off here, viz. the superficial epigastric, and circumflex iliac, the superior and inferior external pudic, and very commonly one of the circumflex arteries, and also by the proximity of the profunda. (3) The uncertainty of the origin of the profunda, and thus of the length of the common femoral. (4) I would add to the above that ligature of the common femoral for aneurysm approximates the treatment to that of Anel rather than to that of Hunter. Sir J. E. Erichsen[1] went so far as to say, "It may be laid down as a rule in surgery, that in all those cases of aneurysm which are situated above the middle of the thigh, in which compression has failed and sufficient space does not intervene between the origin of the deep femoral and the upper part of the sac for the application of a ligature to the superficial femoral, the external iliac should be tied."

(5) *As a Preparatory Step to Amputation at the Hip-joint.* The need of this has been largely done away with by the adoption of other preferable steps (p. 805).

Line and Guide. From a point midway between the anterior superior spine of the ilium and symphysis pubis to the adductor tubercle, and the inner margin of the internal condyle.

Relations:

In Front

Skin; fasciæ; lymphatic glands.
Crural branch of genito-crural. Sheath.

Outside		*Inside*
Anterior crural.	Common femoral.	Septum of sheath. Femoral vein.

Behind

Sheath.
Psoas.

It is important to note that the common femoral is usually only an inch and a half long, and that from it come off not only the superficial epigastric, circumflex iliac, and superior and inferior external pudic but occasionally one of the circumflex arteries as well.

Collateral Circulation (Fig. 336).

Above		*Below*
Gluteal and sciatic,	with	Superior perforating and circumflex arteries.
Superficial circumflex iliac,	with	Ascending branch of external circumflex.
Obturator,	with	Internal circumflex.
Comes nervi ischiadici,	with	Perforating of profunda and articular of popliteal.

Operation. The groin having been shaved and cleansed, the hip and knee semiflexed, and the limb abducted and rotated somewhat

[1] *Surgery*, vol. ii, p. 244.

outwards, an incision about two and a half inches long is made in the line of the artery, commencing just above Poupart's ligament. The skin and superficial fascia having been divided, and any overlying glands displaced or removed, any veins which may be met with descending to join the internal saphena are either drawn aside or tied between double ligatures. The fascia lata having been opened just below Poupart's ligament, the artery or its pulsation is felt for, the vessel exposed here, and the needle passed from within outwards, care being taken to avoid the crural branch of the genito-crural nerve, which lies superficial to the artery. The neighbourhood of any branch is, if possible, avoided. The ligature of strong catgut is tied and the wound closed.

LIGATURE OF THE SUPERFICIAL FEMORAL IN SCARPA'S TRIANGLE

Indications. (1) *Certain Cases of Aneurysm of the Popliteal Artery Femoral low down.* Thus the ligature will probably be indicated: (*a*) where a popliteal aneurysm is rapidly growing, especially when (*b*) it [illegible] anterior aspect of the artery instead of behind or at one side of it, [illegible] the former case the knee-joint may become involved after very [illegible] severe symptoms; (*c*) when the aneurysm is fusiform rather than sacular; (*d*) when it has very thin walls; (*e*) when it threatens to burst, or when this has already happened, unless other symptoms *e.g.* gangrene—call for amputation; (*f*) if visceral disease—cardiac, renal, hepatic—or an atheromatous condition of the vessels is present, the surgeon must weigh carefully the question of operative interference: I should prefer in most cases a trial of the ligature as likely, with the aid of antiseptic precautions, a modern ligature and primary union, to entail less taxing of the patient's powers. On this point, so difficult of wise decision, I may say that of the seven cases in which I have ligatured the superficial femoral for popliteal aneurysm the only one that ended in failure was that of a man æt. 65, with diseased arteries and interstitial nephritis. Owing to the restlessness and want of amenability of the patient I decided against a trial of pressure. The greatest difficulty was met with in keeping the patient still, and gangrene followed, fatal on the fifth day; (*g*) where a trial of pressure has failed, or is certain to fail from the irritability of the patient. Matas's operation is given at p. 839.

(2) *Wounds.*

(3) *For Hæmorrhage low down, e.g.* after amputation in the middle of the thigh, when other means fail and the wound is nearly united. Two other instances are given by Mr. Bryant.[1]

One was "a case of Mr. Bransby Cooper's in which a compound fracture of the leg was complicated with a laceration of the femoral artery. The artery was secured at the seat of injury, and repair went on well in all respects. Mr. Bransby Cooper has also recorded in his *Surgical Essays* a case of fracture of the femur in which the femoral artery was ligatured for a ruptured popliteal artery, and in which recovery took place in six weeks."

Each of such cases must be considered on its own merits, but the above shows what ligature of the femoral artery will do in appropriate cases.

[1] *Surgery*, vol. ii, p. 417.

(4) *For Elephantiasis.* Cases in which the superficial femoral has been tied will be found in the *Lancet* for 1879, vol. i, p. 44; and Ranking's *Abstract* for 1860, vol. ii, p. 193. The subject of ligature of the main artery of the limb for this affection is considered at p. 893, vol. ii.

Line. That above given, p. 838.

Guide. The above line and the inner border of the sartorius at the apex of the triangle.

Relations:

In Front

Skin; superficial fascia; glands; crural branch of genito-crural nerve; middle cutaneous and branch of internal cutaneous; fascia lata; sartorius.

Outside	*Inside*
Femoral vein (below). Anterior crural nerve, and some of its branches, viz. the nerve to the vastus internus, and long saphenous nerve.	Femoral vein (above).

Behind

Psoas; pectineus; adductor longus; femoral vein (below); profunda artery and vein; nerves to pectineus.

Collateral Circulation.

Above		*Below*
Perforating of profunda,	with	Lower muscular and anastomotic of femoral, articular of popliteal, and anterior tibial recurrent.
External circumflex of profunda,	with	Ditto ditto.
Comes nervi ischiadici,	with	Perforating of profunda and articular of popliteal.

Operation. The parts having been sterilised, the knee and hip slightly flexed, the thigh abducted and somewhat everted, and the leg resting on a pillow, the surgeon, seated or standing to the right of the affected limb, makes an incision three inches long in the line of the artery (p. 838). This should begin about two inches and a half below Poupart's ligament, and run down to, and somewhat below, the apex of Scarpa's triangle, which lies usually four to five inches below Poupart's ligament. The skin and superficial fascia having been divided, any small vessels are secured, and branches of the saphena vein drawn aside with a strabismus hook or secured with double ligatures. The deep fascia is now slit up for the whole length of the wound, and the inner margin of the sartorius, which crosses the lower part of the incision, identified. This is then held outwards, while the artery or its pulsation is felt for. The wound being now well opened out with retractors and carefully wiped out, the sheath is opened to the outer side, care being taken to avoid the nerves in contact with it, viz. the long saphenous, and the nerve

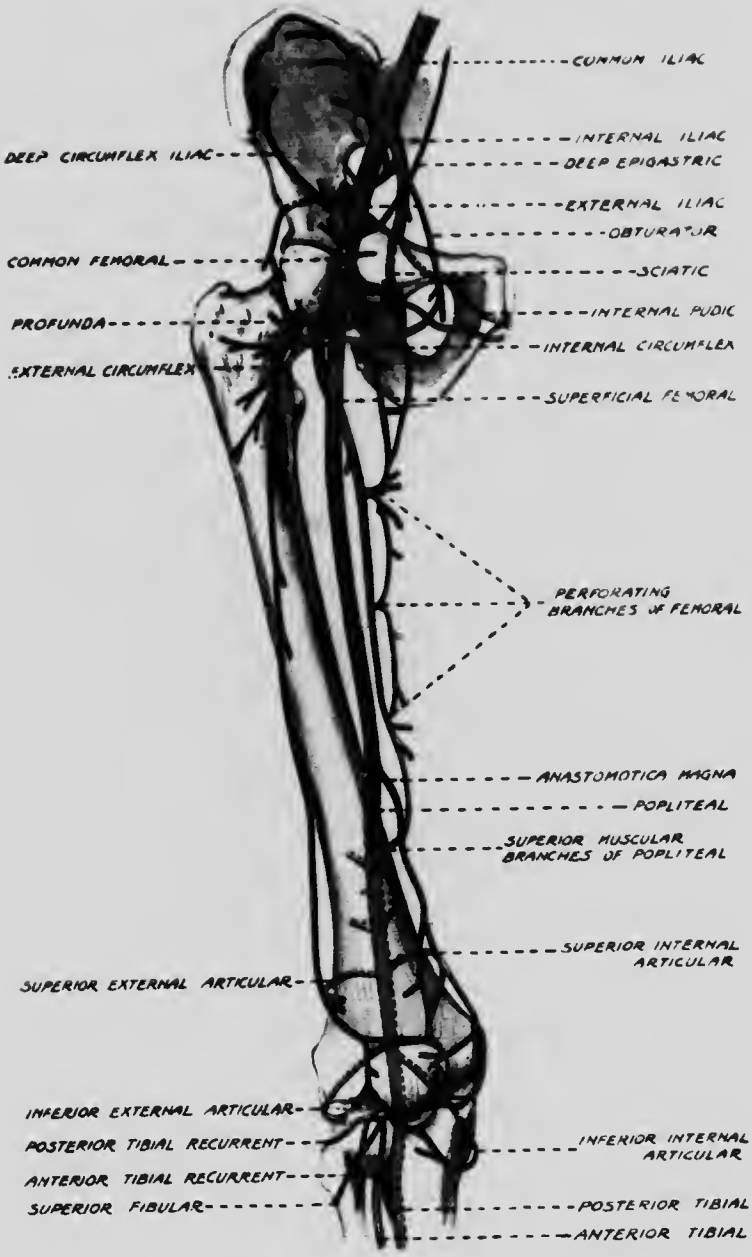


FIG. 336. Anastomotic circulation of the iliac and femoral arteries.

to the vastus internus (*see* Fig. 337). The artery having been cleaned, thoroughly but most carefully, on either side and behind, the needle is passed from within outwards, being kept very close to the vessel so as to avoid the vein which lies behind and internally.[1] The artery having been tied, the ligature is cut short, drainage provided according to the amount of disturbance of the parts, &c., and the wound closed. The precautions given in vol. ii. p. 896 for the prevention of gangrene must be taken.

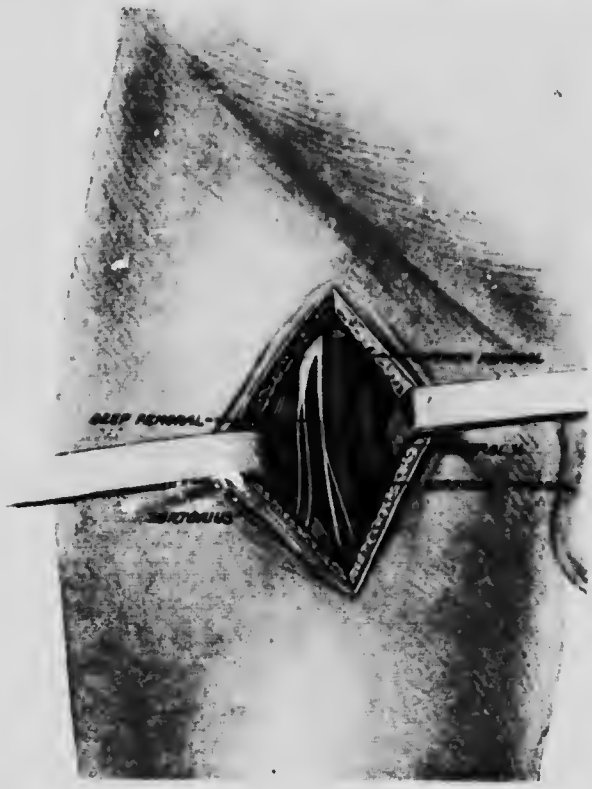


FIG. 337. Ligature of the superficial femoral artery.

Difficulties and Mistakes. (1) *Wounding the Saphena Vein.* This may occur if the incision is made too internal. It is always to be avoided if possible, owing to the troublesome œdema which may follow. (2) A very broad sartorius. (3) *Injury to the Femoral Vein.* This may easily

[1] The vein is so frequently damaged here especially on the dead subject, that a few precautions may be given as to the best way of avoiding it. First, the sheath must be identified exactly, and sufficiently opened at its outer part. It will be found of much help in clearing the vessel if one edge of the cut sheath is held by an assistant, while the surgeon has hold of the other; the opening in the sheath is thus made sure of and retained. There must be no needless disturbance, or lifting up of the vessel upon the needle, which, with the director, must be used with the utmost carefulness. As soon as the eye (and this should be at the very end of the needle) is seen to have passed round the vessel the ligature should be at once seized, and the needle withdrawn. On the dead body the apparent thickness due to the solid thrombosis in the vein, in subjects prepared with formalin, must not lead, here or elsewhere, to this vessel being mistaken for the artery.

take place if force is used in pushing the needle round an imperfectly cleaned artery, or if the needle is not kept close to the vessel. If the accident occur, the surgeon must not persist in his attempt to tie the artery at this spot, a course which will only end in his inflicting more injury in the vein, but firm pressure being made in the lower angle of the wound, the artery is tied either above or below the spot where the vein has been injured. As soon as the artery is secured, no further hæmorrhage will take place, but pressure may be kept up by means of sterilised dressings over the wound for a day or two.[1] The patient will do well to wear a Martin's bandage or an elastic stocking for some time after getting up. (4) Including one of the nerves. (5) A matted condition of the parts due to a previous trial of compression.

Abnormalities of the Femoral Artery. (1) A double superficial femoral, the two trunks uniting below to form the popliteal. More than one case of this kind is recorded. The persistence of pulsation in the aneurysm after the first ligature would lead to a suspicion of this condition. (2) The vessel may run down at the back of the limb.

LIGATURE OF THE FEMORAL ARTERY IN HUNTER'S CANAL TREATMENT OF A STAB IN MID-THIGH

Indications for Ligature of the Femoral Artery in Hunter's Canal. (1) *Wounds* These may be (*a*) incised; (*b*) punctured.

(*a*) The artery above is controlled by a tourniquet or the hands of an assistant or provisionally secured by a loop of silk immediately above the wound in it, or clamps, if these are at hand. The wound is then enlarged and the vessel dealt with according to the directions given at p. 53, if possible. Only if the conditions do not admit of this is the artery to be tied above and below the wound in it. If the vein is injured also, suture is still more strongly indicated; if ligatures are applied, the patient or the friends must be prepared for the possibility of imminent need of amputation. The limb should be secured on a splint and the foot of the bed raised.

(*b*) If a punctured wound lies in the line of the artery, and if much blood has been lost, the main trunk is probably injured, and the question will arise, if the bleeding has ceased, whether to cut down upon the artery or to trust to pressure. Mr. Cripps[2] advises that, if the wound be in the upper part of the thigh, "the surgeon may enlarge the wound with a good prospect of finding the wounded vessel without an extensive or prolonged operation. If the wound be in the lower half of the thigh, owing to the greater depth of the artery and the possibility of its being the popliteal which is wounded, the search is rendered far more severe and hazardous, and it should not be taken until a thorough trial of pressure has proved ineffectual."

The following mode of applying pressure is taken from Mr. Cripps.[3] I would also refer my readers to the account of punctured wound of the palm given in vol. i of this work.

[1] If venous hæmorrhage persist, the opening in the vessel should be secured by suture

[2] *Dict. of Surg.*, vol. i, p. 525.

[3] *Loc supra cit.* Mr. Cripps draws attention to the instructiveness of the literature of this subject, as it proves not only that many cases have been successfully treated by pressure from the first, but that both life and limb have been saved by pressure after the surgeon has failed to find the artery in the wound, or after the iliac has been tied in vain.

The main vessel having been controlled above, the foot and leg should be carefully strapped from the toes to the knee, and a bandage then carried from the toes up to the wound, and then, avoiding this, up to the groin, where it is secured, spica-fashion, over a pad on the main artery. The limb is then laid on a long back splint with a foot-piece and secured to this in an elevated position. The wound having been sterilised, a graduated gauze compress is then fastened over it. Two sterilised rectal bougies are then applied in the course of the artery, above and below the wound, outside the bandage which surrounds the limb, so as to keep these segments of vessel empty. Two well-padded lateral splints are then secured with straps and buckles to the thigh. The toes should be left exposed that their condition may be watched. Morphia must be given as freely as is judicious.

Fig. 338. Ligature of the femoral artery in Hunter's canal.

(2) *Hæmorrhage from a Stump after Amputation in the Lower Third of Thigh or Knee.* If clearing away the clots, followed by well-adjusted pressure, and, this failing, trying to find the bleeding-point in the flaps, do not suffice, the artery must be tied above.

Line and Guide (p. 838).
Relations:

In Front

Saphena vein.
Skin; fasciæ; sartorius; aponeurosis between vastus internus and adductors; internal saphenous nerve.

Outside — *Inside*

Vastus internus; vein (slightly). — Adductor longus and magnus.

Femoral artery in Hunter's canal.

Behind

Femoral vein (especially above)

Operation (Fig. 338). The knee and hip having been flexed, and the limb abducted and rotated outwards, the surgeon, seated comfortably on the inner side of the limb, makes an incision three inches and a half long in the line of the artery in the middle third of the thigh. The skin, superficial and deep fasciæ, having been divided, and the saphena vein, if seen, drawn to one side with a strabismus hook, or any of its branches divided between double ligatures, the sartorius is identified by the direction of its fibres and drawn to the inner side. The canal is next opened by dividing the aponeurotic roof, and the artery or its pulsation felt for. The vessel will be found closely connected to its vein, which lies behind it, while the saphenous nerve crosses it from without inwards. The artery having been most carefully cleaned all round, the ligature may be passed from either side, as is found most convenient.[1]

Causes of Failure after Ligature of the Femoral. (1) Gangrene. (2) *Secondary Hæmorrhage.* If pressure fail, an attempt must be made to re-tie the vessel, and this not succeeding, the limb must be amputated. (3) *Suppuration of the Sac of an Aneurysm.* This is very rare. (4) *Recurrent Pulsation in the Aneurysm.* The premature softening of the ligature, especially in an infected wound, must always be remembered as a possible cause of this. Pressure failing, the artery may be tied lower down. (5) A very rare complication is the formation of an aneurysm at the seat of ligature.

[1] Much difficulty will be met with in tying the femoral artery in Hunter's canal unless the line of the artery is strictly followed. A common mistake is to make the incision too far out, thus exposing the fibres of the vastus internus, which run downwards and outwards, instead of those of the sartorius, which run downwards and inwards (Smith and Walsham, *Man. of Oper. Surg.*, p. 83). Sir J. E. Erichsen (*Surgery*, vol. ii. p. 250), who gives as the line of the artery, one drawn from a point exactly midway between the anterior superior spine and the symphysis pubis to the most prominent part of the internal condyle, insists on the need of making the incision a finger's-breadth internal to this. The line which I have given above will be found sufficiently internal.

CHAPTER XLI

AMPUTATION THROUGH THE THIGH. REMOVAL OF EXOSTOSIS. FRACTURES OF THE FEMUR

AMPUTATION THROUGH THE THIGH

Practical Points in Amputation of the Thigh. The operation should always be performed as low down as possible, not only to avoid shock and to secure as long a stump as possible for the artificial limb, but also to secure as much as possible of the rectus femoris. This muscle is a most important agent by which the thigh is put forward in stepping. Its division does not preclude the retention of its office, as it acquires a sufficient adhesion to the material of the stump to answer every useful purpose, as an agent in the flexion of the thigh on the pelvis, though that of extension of the leg be destroyed.

Different Methods. The following five, which will give ample choice, will alone be described here: the first is especially recommended:

I. **Mixed Antero-posterior Flaps and Circular Division of the Muscles.** II. **Antero-posterior Flaps by Transfixion.** III. **The Circular Method.** IV. **Rectangular Flaps.** V. **Lateral Flaps.**

I. **Mixed Antero-posterior Flaps and Circular Division of the Muscles** (Fig. 339). By the term mixed is meant an anterior flap of skin and fasciæ raised from without, and a posterior one made by transfixion. The anterior is, wherever practicable, made the longer of the two.

This method has the following great *advantages*: (1) The longer anterior flap falls well over the bone, and thus keeps the scar behind; (2) being raised from without inwards, it can be taken from the neighbourhood of the knee-joint and patella; (3) it is a most expeditious method,[1] almost as quick as that by double transfixion-flaps; (4) it is suited to all cases, save perhaps those of very muscular thighs, where the surgeon should be careful to take only part of the muscles behind as he transfixes, or else should raise his posterior flap also from without inwards; (5) it gives good drainage.

While amputation by anterior and posterior flaps is given in detail, the surgeon will not tie himself to this method, but use such modifications as that by antero-external and postero-internal flaps. Save in cases of malignant disease, the chief object is to save as much of the femur as possible and also of the adductors. The length of the leverage on the artificial limb is thus increased, and the action of the abductors better counter-balanced.

Operation. The femoral artery having been controlled with a tourniquet, the limb, a sterile towel having been first bandaged on, being brought over the edge of the table, and supported by an assistant; the

[1] As in railway and other accidents.

opposite ankle being tied to the table, and the parts duly cleansed, the surgeon standing to the right side of the limb to be removed, places his left index finger and thumb on either side of the limb, at the level where he intends to saw the bone,[1] and sinking the point of his knife through the skin just below the former and rather below the centre of the outer or inner aspect of the limb, as the case may be, carries it rapidly down for about four and a half inches, and then sweeps it across the limb with a broad, not pointed, convexity, and carries it up along the side nearest to him as far as his thumb. A flap of skin and fasciæ, muscle being taken up increasingly towards its base, is then quickly dissected up, and the knife, being sent across the limb, behind the bone, cuts a posterior flap, the knife being used with a rapid sawing movement, and driven at first straight down parallel with the bone, and then sharply brought out through the skin.

The flaps, covered with gauze, being held out of the way by the surgeon's left hand,[2] the soft parts around the femur are next severed

Fig. 339. Amputation through the thigh. The posterior flap may be cut by transfixion if desired.

with circular sweeps[3] till the bone is exposed, when one more firm sweep divides the periosteum.[4]

The saw is now placed with its heel on the bone and drawn towards the operator once or twice with firm pressure so as to make one groove, and one only. With a few sharp sweeps the bone is next severed, care being taken to use the saw lightly for fear of splintering the linea aspera, and to use the whole length of the instrument. At this time the limb must be kept steady and straight, the assistant neither raising it, which will lock the saw, nor depressing it, which will splinter the femur when this is partly divided.

If the surgeon decide to make his posterior flap also of skin and fasciæ, he must have the limb raised, and first looking over and then stooping down, he marks out a skin flap, about two-thirds the length of

[1] The finger and thumb should not be shifted till the anterior flap is marked out.

[2] And also pressed firmly upwards, so as to enable the saw to be appli as high up as possible. If the limb is bulky an assistant must help here.

[3] This requires really forcible use of the knife, the muscles behind the bone tending to be pushed before the knife rather than divided by it.

[4] This final cut should be a little above the base of the flaps, in order that the sawn femur may lie well buried in soft parts.

the anterior; this is then dissected up, and the operation completed as before.

In addition to the femoral vessels, the anastomotica, and descending branch of the external circumflex, some muscular branches will require attention; and one of these last may give some trouble from its position close to the bone, in contact with the linea aspera.

The following points deserve attention in tying the femoral vessels: (1) Not to include the saphenous nerve; (2) the tendency of the vessels to slip up if the point of their division passes through Hunter's canal; (3) if the vessels are atheromatous, they must not be tied too tightly. A catgut ligature, not too fine, should be employed now, and care should be taken to include a little of the soft parts so as to prevent the ligature cutting through. The muscles are brought together over the bone end with catgut sutures. The cavity in the stump is thus obliterated and oozing prevented, so that clots and serum do not accumulate.

In amputations of the thigh accompanied by grave shock (p. 811), no time should be lost in looking for vessels, save the femoral and any other large branch which can be seen. Firm bandaging and raising the stump will suffice. It is well partially to relieve the tightness of the bandages in a few hours by nicking them. Very few sutures should be used in these cases of shock, or in those where the soft parts are sinus-riddled.

II. **Transfixion Flaps.** *Advantage.* Great rapidity. *Disadvantages.* Those given at p. 138, on a large scale. This method may be used where much speed is needed, as in a double amputation after a railway accident, or where many wounded require attention, as after a great battle. It is also adapted to the wasted muscles of a patient who has long suffered from some chronic disease of knee or leg, but even here it is inferior to the mixed method.

Operation. The surgeon, standing to the right side of either limb, with his left index and thumb marking the site of his intended bone-section, raises with his hand the soft parts on the front and sides of the thigh, and sends his knife across the limb in front of the femur. The knife should be entered well below, so as to get as large an anterior flap as possible, and at its entry should be pushed a little upwards so as to go easily over the bone. An anterior flap is then cut four to four and a half inches long, with a broadly curving, almost square extremity, and not too thin at its edge. This being raised by the surgeon or an assistant, the knife is now passed behind the bone, and a posterior flap cut of the same length as the anterior, the making of this flap being somewhat facilitated by drawing the soft parts on the back of the limb away from the bone.

If the limb be very bulky, the knife should be kept well away from the bone, especially behind it; thus the more superficial muscles only will be included in the posterior flap.

Both flaps having been retracted, the remaining soft parts are severed with circular sweeps, and the rest of the operation completed, as at p. 847, but with this difference, that here there will be more need of trimming some of the soft parts clean and square.[1]

III. **The Circular Method.** I may here state briefly why this method is, nowadays, considered inferior, both in the thigh and elsewhere, to

[1] While dresser to the late Mr. Poland, I once saw the femoral vessels split for about three and a half inches by his rapid hands. This amputation of the thigh by transfixion was his last operation at Guy's Hospital. He was even then facing with quiet braveness the bronchitis which, a very few days later, ended his life.

that by flaps. In saying this, it is not denied that in many cases stumps by the circular method are fully equal to those by flaps; indeed, in many it is impossible to tell, in later years, which method has been employed. On the whole, however, the *flap-method* has the following *advantages:* (1) It is most generally applicable, *e.g.* in most parts not circular and at the joints. (2) By it the surgeon can better adapt his skin covering to his needs, *e.g.* when the skin is less available on one aspect of the limb than on another. (3) There is less risk of a conical stump; and (4) of a cicatrix adherent to the bone. The great advantage of the circular method, viz. that the vessels and nerves are cut square, and that, thus, the former retracting more easily, fewer need securing, while there is less risk of bulbous ends forming on the latter.

One more advantage of the flap-method is the greater rapidity, especially when transfixion is employed, though this, in these days of anæsthetics, is only of importance in a few cases.

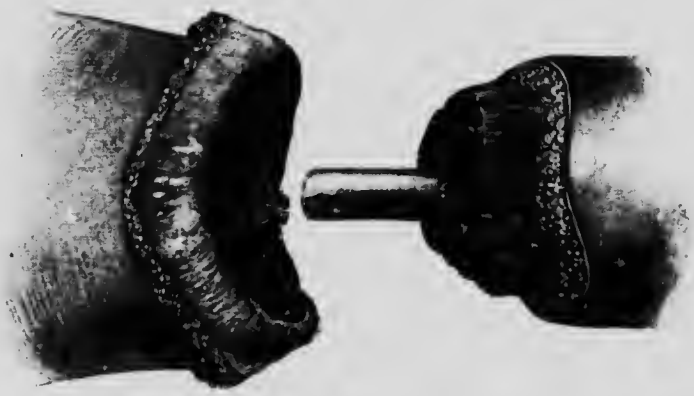


Fig. 340. Circular amputation through the thigh. The skin and fascia lata may be difficult to retract without a vertical slit on the outer side. The muscles are sewn over the bone with catgut sutures.

The circular method is only to be adopted here in the case of the lower third of wasted thighs, or in those of young subjects. Even here the greater tendency of the posterior muscles to retract must be met by cutting them about three-quarters of an inch longer than those in front.

While this operation is for the above reasons not recommended in practice, it may be made use of in the lower third of the thigh in the cases mentioned above. On the dead subject, the student who has not had a chance of performing it upon the arm, may make use of it here.

Operation. As this method has been described in detail under amputation of the arm, it will be only briefly given here. The preliminaries are those already given. The surgeon standing to the right of the limb, the assistant, who stands on the opposite side to him, but nearer the trunk, draws up the skin with both hands. The surgeon, stooping a little, passes his knife first under the limb then above, across, and so around it till by dropping the knife vertically the back of the instrument looks towards him, while its heel rests on that side nearest to him. He then makes a circular sweep around the thigh, this being aided by the assistant who has charge of the limb rotating it so as to make the soft parts meet

the knife. The surgeon then taking hold of the edge of the incision, dissects up a cuff-like flap of skin and deep fascia about two inches in length, cutting it of even thickness all round the limb. The flap is then folded back, and the remaining soft parts divided with circular sweeps of the knife. In doing this the greater contraction of the hamstring muscles must be remembered, and these muscles cut rather longer than those in front. All the muscles are cut obliquely from below upwards towards the bone at the point selected for section, which is generally about four and a half inches above the skin incision. Care must be taken, if it is thought needful, after making the circular sweeps, to free the bone higher up, and so to secure its being well buried in the soft parts, but not to prick the already divided femoral vessels which lie in close proximity to the femur in the lower third. The muscles are carefully sewn together.

IV. **Rectangular Flaps of Mr. Teale.** This method is fully described later. It is not recommended here, as it is expensive, involving division of the bone nearer to the trunk than other methods. (1) Owing to the bulkiness of the long anterior flap, it is, here, especially difficult to fold and adjust it at the conclusion of the operation, and still more so to keep it adjusted if primary union fails. (2) Its chief advantages—keeping the end of the bone well buried, and cutting the vessels and nerves clean and square—are also sufficiently attained by the other flap methods already given, especially the mixed method (p. 846).

V. **Lateral Flaps.** This method has certain grave objections here. (1) The sawn femur, tilted upwards by the ilio-psoas, is very liable to press against the upper angle of the flaps, and to come through at this spot, and necrose. (2) If this does not take place, the bone often adheres to the cicatrix here, while the flaps hang down and away from it.

It should only be made use of when no other method is available, as in a case where, owing to the condition of the soft parts, flaps can only be got by making one long external and a short internal, or *vice versa*.

Operation. This method will be found fully described at p. 905.

This will be a convenient place for making a few remarks which may be useful to my juniors on certain grave conditions in which amputation through the thigh may be called for. I refer to A. **Amputation during shock**; B. **Multiple amputations**; and C. **Amputation for gangrene.**

I take first A, **the question of the advisability of primary amputation in severe injuries, while shock is present.** Each case must be studied by itself according to the conditions present, both as regards the injury and the patient. If a general rule can be formulated it would be to run the risk, inevitably great, and operate as soon as possible. Delay, say for six or twelve hours, will not remove the factor of shock altogether, while it exposes the patient to other dangers. H. Cushing[1] strongly advocates early amputation. "Here a state of shock may already be present, and the attendant ordinarily is advised to wait for some hours, during which time a readjustment of conditions is expected to take place, and the severity of shock to diminish. As a matter of fact, the very conditions are present which tend to perpetuate or to increase the already existent degree of shock. Such an increase is brought about by a continuation of afferent sensory impulses. The tourniquet itself, which has been applied at the time of the accident, although controlling the loss of blood, constantly adds, from pain, to the shock of the original injury. The dragging of the mangled limb on the great sensory nerve trunks, which are rarely severed, gives impulses of pain with every movement of

[1] *Ann of Surg.*, September 1902.

the often restless patient, impulses which in such a state cause reflexly a further lowering of blood pressure. Strychnia, intravenous infusion, and delay are the usual measures advocated for such states. I believe they are, if not actually harmful, certainly not helpful. The real indication is to rid the patient of the centripetal impulses, originating in the crushed member, by cocainisation and division of the large nerves, so often exposed in a mangled limb, by ligation of vessels, and the earliest possible removal of the painful tourniquet. Under proper management, with possible strapping of the abdomen to hold up the blood pressure, with morphia in small amounts to control restlessness, and with a proper avoidance of those conditions which during the operation would increase shock, I believe that it is no heresy to advocate ether anæsthesia (never chloroform) and early operation for most cases of severe traumatism of the extremities." Spinal anæsthesia is a great boon in these cases, and axillary or intravenous infusion before, during, and after the operation are of great value. The earlier the amputation the less the fear of sepsis.

B. **Multiple amputations.** The main points here are: (1) To perform the operations together. Thus when the services of three operators can be secured a triple amputation can be completed in thirty-five minutes. (2) In such a case a large saline infusion should be made into one of the main veins severed during the amputations. (3) As advised by Crile, cocaine should be injected into the main nerve trunks (p. 28). (4) No time should be lost in tying a number of smaller vessels. The main trunks should be secured, and Spencer-Wells forceps applied to other bleeding-points, or the wound packed with gauze and firmly bandaged. Such bandages will need nicking in an hour or two. (5) There should be no close or tight suturing; any attempt to secure primary neatness will only defeat its own end. (6) As sterilisation will probably be incomplete, wet gauze dressings should be applied, to be replaced for the first few days, when the danger of haemorrhage has passed, by boracic acid fomentations. (7) For the first two days the patient should have a room to himself.

C. **Amputation in cases of gangrene.** These may be divided into **acute** and **chronic.** In the **former** a high amputation is the patient's only chance. In the lower extremity the resort, though the only one, is much more desperate. Knott[1] recommends amputation in two stages in acute traumatic cases. A circular amputation is first performed just above the line of apparent demarcation. Later, when the patient's condition is improved, a second operation, which consists in a higher division of the bone and approximation of the soft parts, is done. The reasons for advising this are that the first operation may remove the source of infection, and that the cutting of flaps and introduction of sutures tend to produce gangrene in structures the circulation of which is already bad. Knott has practised the above method four times—once in the upper third of the thigh, once in the middle third of the forearm, and twice in the upper third of the leg with uniformly good results.[2]

[1] *Journ. Amer. Med. Assoc.*, April 11, 1903.

[2] The following case is of some interest, as it shows that sometimes the worst forms of spreading gangrene may be prevented by an amputation, though the surgeon may not be aware of this at the time. Three years ago, a young man who had been run over on the South Eastern Railway was admitted with the lower part of one leg so smashed as to call for amputation through the upper third. This was done by my house surgeon, Dr.

Amputation in Chronic Gangrene. I refer here to cases originating in cardiac disease, frost-bite, typhoid fever, pneumonia, and the more common ones, viz. those simulating the senile form in which, in an elderly patient after an injury, *e.g.* to the leg, thrombosis begins in a large muscular branch, and creeps up into the tibial arteries, and lastly, and more especially, to senile gangrene. And I use the term "chronic" rather than "dry" because senile gangrene, of which I speak more particularly, is only dry while it remains limited to the toes, owing to the small supply of fluid and the readiness of evaporation. While in many of the other cases of chronic gangrene the surgeon will do well to wait because the progress is so slow, and because, owing to the completeness of the dryness, infection and toxæmia are absent, this delay will thus allow of a much less severe amputation and a more useful artificial limb; this is not the case where there is evidence of the gangrene being "mixed." Here evidence of infection may show itself at any moment, and owing to the vitality of the patient, may be rapidly fatal. Sooner or later, senile gangrene reaches the sole, and now becomes moist as well as dry, and the result of infection will speedily follow. For this reason, and because established gangrene of the toes means a bed-ridden patient and a death in life, because the pain and loss of sleep admit of no real alleviation, and, together with the progressive impairment of damaged viscera, will but further lower the depressed vitality to a point unable safely to meet the operation when this, often too late, is consented to—for these reasons I advocate strongly amputation through the lower third of the thigh in senile gangrene as soon as this is established in the toes. I take it for granted that the other factors in the question relating to the patient's general condition are sufficiently favourable. My experience would lead me to look upon diabetes and albuminuria, especially in stout patients with an unstable mental condition, as prohibitive. If a surgeon, early in his experience, be asked about the value of local interference, *e.g.* detachment of gangrenous parts, incisions, or a low amputation, the results are, as a rule, so extremely bad that such questions should not be entertained. Amputation high up in the leg gives results but little better, owing to the condition of the vessels. Thus of thirteen cases recorded by Heidenhain in only two did the flaps heal, two died of reappearing gangrene, nine were reamputated. In amputation through the lower third of the thigh, the results improve owing to the better nutrition of the parts. Thus of sixteen cases amputated through and above the knee-joint eight recovered and eight died (Heidenhain). G. Bellingham Smith and H. E. Durham found that of eighteen cases of amputation through the thigh ten recovered (in four there was some gangrene and infection of the flaps); eight died. While the step will always remain one of great gravity, one in which both sides of the question must be fairly placed before the patients and the decision left to them, and while it too often proves only palliative owing to reappearance,

Norman Tickhurst, now of St. Leonards. When I scrutinised the condition of the ligatured vessels, I happened, by the merest chance, to detect some bubbles of gas in the connective tissue between some of the intermuscular septa. Pointing this out as an instance of the far-reaching effects of a very severe injury, I suggested that the tissue affected should be cut out and forwarded in a sterile tube to the Bacteriological Department, and further directed that a drainage-tube should be inserted and very few sutures employed. The flaps sloughed almost in their entirety, and, in a few days, the report reached us that the bacillus of malignant œdema had been present. The patient recovered, and the stump was, ultimately, most serviceable. The soil at the site of the accident was that of the permanent way between London Bridge and Cannon Street Stations.

ultimately, of gangrene in the opposite limb. I consider it abundantly justified in suitable cases for the reasons already given, and I would lay stress on the amputation being through the lower third of the thigh, and here only. The greater distance from the gangrene, the better nutrition of the parts, the vascular muscular tissues, the single large artery easy to secure, all emphasise this point. The chief details to bear in mind are to see that the Esmarch bandage or its equivalent is put on with great care, to cut the flaps sufficiently long and thick and uniform and here every cutting instrument should be of the sharpest not to insert too many or too tight sutures, and to make use of drainage. It is very difficult to make out the condition of the main artery beforehand. If it be thrombosed, an unusual number of small vessels will probably need securing. Where it is rigid and calcareous, the ligature must not be too small, and some of the sheath, and, if needful, some fascial or muscular tissue as well, must be included in it. In two of my cases in which this condition of the femoral artery was present, uninterrupted healing and recovery followed. In diabetic patients spinal anaesthesia is indicated.

AMPUTATIONS IMMEDIATELY ABOVE THE KNEE-JOINT

While conditions admitting of the performance of these amputations are not common, the surgeon should be familiar with them, especially with that of Carden, owing to the importance of preserving as much as possible of the femur and adductors.

Methods : (i) **Carden's** (Figs. 341 and 342). (ii) **Gritti's Trans-condyloid** (Figs. 343 and 345). (iii) **Stokes's Supracondyloid,** an important modification of the above (Figs. 344, 346, 347, and 348).

All the above, but especially the two latter, possess the following *advantages* (which they share with amputation through the knee-joint over amputation through the thigh), viz. :

(1) The patient can bear his weight in walking on the face of his stump ; thus, he is not compelled to take his bearing from the tuberosity of the ischium, or to walk as if he had an ankylosed hip-joint (Stokes), as is the case after amputation of the thigh. (2) Very good power of adduction over the artificial limb remains. Every surgeon must have noticed how badly off a patient is in this respect after an ordinary amputation through the thigh. By these methods the adductors are left almost intact, even to part of the strong vertical tendon of the adductor magnus, the result being that the balance between the adductors and the abductors of the thigh remains practically undisturbed, and the patient when walking has none of that difficulty (which is seen after thigh amputations) of bringing the limb which he has swung forwards in again under the centre of gravity.[1] (3) The medullary canal is not opened : on this account there is less risk of necrosis and osteo-myelitis if the stump becomes infected. (4) There is less shock, because (*a*) the limb is removed farther from the trunk, (*b*) the muscles are divided not through their vascular bellies, but through their tendons.

(i) Carden's Amputation

Advantages. This valuable amputation has some points in common with Syme's amputation at the ankle-joint. In both the bone-section is made not through a medullary canal, but through vascular, quickly

[1] The importance of the preservation of the quadriceps extensor, given by the Stokes-Gritti method, need only be alluded to.

healing cancellous tissue, in both the skin reserved for the face of the stump has been used to pressure, though not equally so, for the skin preserved in the ankle-amputation is thick and callous, in the other thinner and more sensitive.

Lord Lister[1] thus recommends this amputation: "This operation, when contrasted with amputation in the lower third of the thigh, presents a remarkable combination of advantages. It is less serious in its immediate effects upon the system, because a considerably smaller quantity

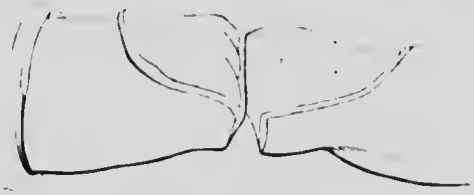


Fig. 341. (Carden.)

of the body is removed, and also because, the limb being divided where it consists of little else than skin, bone, and tendons, fewer blood-vessels are cut than when the knife is carried through the highly vascular muscles of the thigh; the popliteal and one or two articular branches being, as a general rule, all that require attention, so that loss of blood is much diminished. In the further progress of the case the tendency to protrusion of the bone, which often causes inconvenience in an amputation through the thigh, is rendered comparatively slight by the ample extent of the covering provided, and also by the circumstance that the divided hamstrings slip up in their sheaths, so that the posterior muscles have

Fig. 342. (Carden.)

comparatively little power to produce retraction. The superiority of the operation is equally conspicuous as regards the ultimate usefulness of the stump, which, from its great length, has full command of the artificial limb, while its extremity is well calculated for sustaining pressure, both on account of the breadth of the cut surface of the bone divided through the condyles, and from the character of the skin habituated to similar treatment in kneeling. Considering therefore that this procedure can be substituted for amputation of the thigh in the great majority of cases both of injury and disease formerly supposed to demand it, 'Carden's operation' must be regarded as a great advance in surgery."[2]

[1] *System of Surgery*, vol. iii. p. 705.

[2] Other advantages given by Mr. Carden are, the favourable position of the stump for dressing and drainage; its painlessness, the chief nerves being cut high up and slipping upwards out of the way; and the cicatrix being drawn clear of the point of the bone, and out of reach of pressure.

Disadvantages. The chief of these is the sloughing of the long anterior flap which may occur, "in spite of faultless operating," especially if the skin, of which it chiefly consists, has been damaged by injury or disease, or if the patient be old or weakly, thus leading to an adherent, tender scar, and a useless stump. Another very important objection is that the stump is too long to fit on an artificial limb, having its knee-joint on a level with the opposite knee, so that the asymmetry is easily noticed, especially when the patient sits.

Fig. 343. Gritti's transcondyloid section of the femur, leaving a stump too long and a surface too large for the sawn patella to fit.

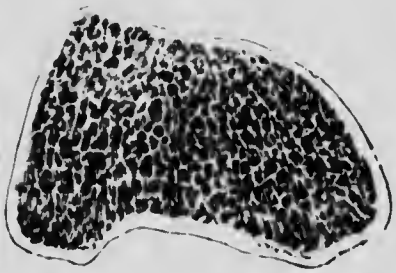


Fig. 344. Stokes' supracondyloid amputation, leaving a shorter stump and a surface much more easily fitted by the sawn patella.

Operation. According to its introducer this amputation consists in raising a rounded flap from the front of the joint (Figs. 341 and 342), dividing everything else straight down to the bone, and sawing this slightly above the plane of the muscles.

The operator, standing on the right side of the limb, takes it, between his left forefinger and thumb, at the spot selected for the base of the flap,[1] and enters the point of his knife close to his finger, bringing it round through the skin and fat below the patella to the spot pressed by his thumb, then turning the edge downwards at a right angle with the line of the limb, he passes it through to the spot where it first entered, cutting outwards through everything behind the bone. The flap is then reflected, and the remainder of the soft parts divided straight down to the bone; the muscles are then slightly cleared upwards, and the saw applied "through the base of the condyles." The projecting part of the femur may be rounded off. Where

Fig. 345. (Farabeuf.)

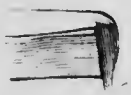


Fig. 346. (Farabeuf.)

there is any doubt about the vitality of the large anterior flap, a short posterior one should be made, the anterior one thus not needing to be so long.

Owing to the risk of sloughing of the long anterior flap, Lord Lister's modification, by which two shorter flaps are employed, is always to be preferred. "The surgeon first cuts transversely across the front of the limb from side to side at the level of the anterior tuberosity of the tibia, and joins the horns of this incision posteriorly by carrying the knife backwards obliquely at an angle of 45 degrees to the axis of the leg through the skin and fat. The limb being elevated, he dissects up the posterior skin flap, and then proceeds to raise the ring of integument as in a circular operation, taking due care to avoid scoring the subcutaneous tissue;

[1] This corresponds with the upper border of the patella, the limb being extended. The lower margin comes down to the tubercle of the tibia, as in Fig. 341. (*See also Brit. Med. Journ.*, 1864, vol. i. p. 416.)

and dividing the hamstrings as soon as they are exposed, and bending the knee, he finds no difficulty in exposing the upper border of the patella. He then sinks his knife through the insertion of the quadriceps, and having cleared the bone immediately above the articular cartilage, and holding the limb horizontal, he applies the saw vertically, and at the same time transversely to the axis of the limb (not of the bone), so as to ensure a horizontal surface for the patient to rest on."

(ii) **Gritti's Transcondyloid** (Figs. 343 and 345). (iii) **Stokes's Supra-condyloid Amputation** (Figs. 344, 346, 347 and 348).

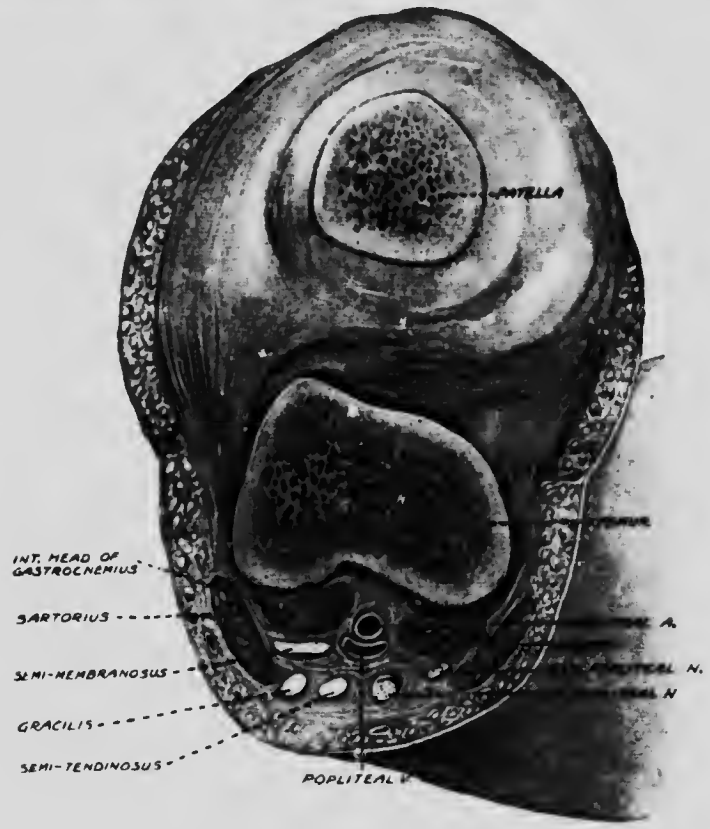


FIG. 347. Stokes-Gritti amputation.

For fuller information on the above amputations I would refer my readers to a paper I contributed to the *Guy's Hosp. Reports*, vol. xxiii, p. 211, 1878.

But while this osteo-plastic method shares with that of Carden the advantages given above (p. 854), the difficulty of securing a satisfactory section of a small mobile bone like the patella, and, later, of retaining it accurately *in situ*, is usually very considerable. From an extended experience of this operation I much prefer that of Stephen Smith when the conditions admit of it.

The two methods are often confused. Between them there is this all-important difference: in Gritti's the section of the femur is made *through* the condyles; in Stokes's, at least half an inch *above* them. In other words, the one operation is *trans-*, the other *supra-condyloid*.

On this point great stress has been laid, and very rightly, by Sir W. Stokes, and a comparison of the two operations will convince every one that he was correct. If the section of the femur be made through the condyles (Fig. 343), the sawn patella will not fit down into place. It will either be drawn up altogether on to the front of the femur, or else will project forwards, somewhat like the half-open lid of a box (Fig. 345), at an angle to the broad sawn surface, which is also too large for it to cover, and across, and off which it is liable to be shifted by the contraction of the quadriceps, if it has been found possible to get it into place. To effect this, an amount of force will be required which is almost certain to result in bruising of the cut periosteum on the edge of the femur, and consequent necrosis. If, on the other hand, the saw is made to pass a full inch *above* the condyles (Fig. 344), the patella will fall readily into place (Fig. 346), it will cover more completely the now smaller surface of the femur, and will remain easily *in situ* here, the flaps when brought together presenting the appearance shown in Fig. 348.

Operation. An Esmarch's bandage having been applied, the limb brought over the edge of the table and supported, and the opposite one secured out of the way, the surgeon, standing to the right of the limb, with his left index finger and thumb marking the base of the flap, makes an incision commencing (on the left side) an inch above and rather behind the external condyle, carried vertically downwards to a point opposite to the tibial tubercle, then broadly curved across the leg and carried upwards to a point opposite to that from which it started. The flap having been

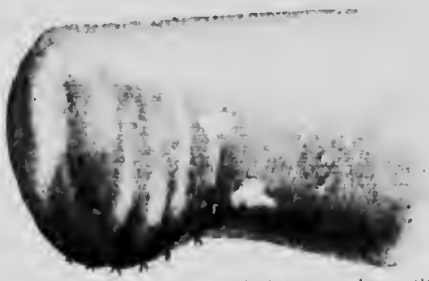


Fig. 348. Stokes-Gritti amputation. Stump.

dissected upwards, together with the patella (after section of the ligamentum patellæ), a posterior flap is cut nearly as long as the anterior. This may be effected in one of two ways, either by the surgeon looking over and then stooping a little (the limb being now raised), next drawing the knife from without inwards across the popliteal space, thus marking out and then dissecting up a skin flap, or by transfixing and cutting the flap from within outwards. Of the two I prefer the first: the latter is the speedier, but less suited to bulky limbs. The flaps being retracted, the soft parts are cut through with a circular sweep a full inch above the articular surface of the femur; the bone is then sawn through here, and the limb removed. The posterior surface of the patella is next removed with a metacarpal or small Butcher saw. This last step is one of considerable difficulty, owing to the mobility of the bone; it will be facilitated by an assistant with both his hands everting and projecting the under-surface of the anterior flap, so as to make the patella stand out from it.

The vessels—popliteal, one or two articular, and the anastomotic—having been secured, drainage is provided, and the flaps are brought together with numerous points of suture, save at the angles.

Even where the flaps are cut of proper length and the femur is sawn at the proper height, the patella may still not remain accurately *in situ*. If there seem any doubt on this point, or if the patient is very muscular, additional security may be given by passing sutures of sterilised silk between the tissues on the under-surface of the anterior flap, at the edges of the patella, and the soft parts in the posterior flap (avoiding the vicinity of the large vessels). Wiring or pegging the bones or division of the rectus muscle on the under-surface of the anterior flap are unsatisfactory complications.

REMOVAL OF AN EXOSTOSIS FROM NEAR THE ADDUCTOR TUBERCLE[1]

As these growths are by no means uncommon in adolescents, this operation will be briefly described here. Aseptic excision has now replaced any other operation, such as subcutaneous fracture.

Operation. The parts having been thoroughly sterilised, the knee is flexed so as to bring down the synovial membrane, and the limb placed on its outer side. A free incision, about three and a half inches long, is made over the growth, down to the vastus internus, and any superficial vessels attended to. The muscular fibres are then cleanly cut through, and the bluish-grey cartilage which caps the swelling now comes into view.[2] Any muscular branches being now carefully secured, and the wound dried, the cut vastus is pulled aside with retractors, and the base of the growth being thoroughly exposed, it is shaved off with an osteotome or chisel, leaving exposed cancellous tissue. The muscular fibres are then united with catgut, and the wound closed with fishing-gut. The dressings are firmly bandaged to prevent oozing from the bone.

FRACTURES OF THE FEMUR

The following remarks apply, chiefly, to interference for ununited factures: more immediate interference is chiefly called for in injuries to the lower end of the bone.

1. Ununited Fractures about the Neck. Lord Lister recorded as long ago as 1871[3] the case of an ununited extracapsular fracture of the femur in a man, aged 45, where, eighteen months after the injury, he cut down on the fragments, with antiseptic precautions, and gouged them, the fracture being then firmly put up. Recovery was complete, the man walking well.

Indications for this rarely called-for operation would be a patient before, or perhaps at, middle age, with good vitality and much pain or loss of function; there should be no evidence of osteoarthritis. Dr. L. Freeman, of Denver, has recorded one case of his own and collected thirteen others.[4] Dr. G. E. Davis[5] recorded a case of intracapsular fracture successfully treated by a screw. Some years ago one of us (R. P. R.) successfully treated a recent intracapsular fracture in an old lady by exposing the head and neck of the femur and passing a long screw through the great trochanter, and the neck into the head of the femur.

Operation. The incision usually employed will be the anterior one.[6] All fibrous tissue between the fragments must be removed with scissors, gouge, &c. As little bone as possible is to be taken away. Drilling and fixation of the fragments is most difficult, partly from their position, partly from their softened condition. Screws, pegs, long nails, a gimlet left in eight weeks (Sayre), have been employed. They can only be introduced through a separate incision made over the outer aspect of the

[1] This account will serve for the removal of other exostoses, *e.g.* those met with at the deltoid insertion, the spine of the scapula, or the pelvis.

[2] Any synovia-like fluid now escaping comes probably from a bursa over the growth, not from the joint.

[3] *Brit. Med. Journ.*, August 26.

[4] *Ann. of Surg.*, 1904, vol. ii, p. 561. [5] *Ibid.*, August 1905, p. 82

[6] The presence of a skiagram may help the surgeon during the operation.

great trochanter. This bone must be well raised first and kept up by a peg, &c., owing to its tendency to drop backwards. The drill and peg must pass through the trochanter and neck well into the head. This requires much care. Whatever means of fixation is used should be left in until there is evidence of sufficient consolidation. As is the case elsewhere, a sinus often forms at the time that the screw, &c., becomes loose. The patient should be kept in bed for six weeks, and a Hessing or Thomas's splint then applied, so that the patient can get about without transmitting any weight through the affected femur. The results are encouraging, a satisfactory degree of mobility and good use of the limb being recorded in most cases.

Some shortening remains. In a few cases the fragments have again become loose. In another small series of cases the head of the femur has been removed; in spite of the shortening, the result is stated to have been good.

II. **Ununited Fractures of the Shaft.** The risk of failure after operations for this condition is well known. The difficulties which may be present during and after these operations are very considerable; amongst them sufficient exposure of the fragments, keeping the wound aseptic, and the parts in correct apposition afterwards (*vide infra*), are most prominent.

Operation. Resection and fixation of the fragments is indicated here. This is especially so in long-standing cases, where other methods have failed, where there is very little attempt at repair, where an artificial joint exists, or where, after a severe injury, necrosis, atrophy of the fragments, and fibrous union have followed.

The operation of resection should always be performed with strict aseptic precautions, otherwise the risks of suppuration, osteo-myelitis, and pyæmia owing to the very free incision required, the exposure of cancellous tissue, and, perhaps, of the medullary canal, are considerable.

The following most important preliminary points are given by Sir F. Treves:[1] "(1) It will be well in some cases to apply extension for a week or two before the operation; this partly overcomes the shortening produced by contracted muscles, and enables the surgeon to make trial of the splint he proposes to employ afterwards. (2) Before undertaking this operation the surgeon should understand that its success depends more upon the completeness of the arrangements that are made for keeping the bones in position after the operation than upon the operation itself, provided the latter be carried out with due care. . . . Care in the adjusting of the fragments, and infinite and continued care in the after-treatment, are the main elements of success in the present class of case. The success of the operation depends far more upon (1) absolute asepsis, and (2) accurate apposition with careful provision for the maintenance of the same by means of the plates until firm union can take place. The maintenance of apposition should not depend on external splints, but on effective bone carpentry. For asepsis Lane's technique and instruments are invaluable and incomparable. The limb having been rendered bloodless, if practicable, with Esmarch bandages,[2] the fracture is exposed by a

[1] *Oper. Surg.*, vol. i. p. 588.

[2] This step is condemned by some, notably by Sir F. Treves (*loc. supra cit.*, p. 588). I admit that it leads to much oozing from the cut surfaces, but, having tried both ways, I am of opinion that this can be safely met by applying ample well adjusted dressings before the bandage is removed, and that the advantage of a bloodless wound during a most difficult and prolonged operation is almost incalculable.

free incision, five to eight inches long, on the outer side of, and going down to, the bone. The incision should be made along the line of the intermuscular septum between the vastus externus and biceps. If it be needful to expose the inner aspect of the fragments, a second incision must be made through the vastus internus so as to be external to the large vessels. The ends are freed and raised, and a thin layer of bone, about a quarter of an inch in thickness, removed from each. The soft parts must be protected with retractors. Only if it be absolutely needful should the fragments be thrust or dragged out of the wound; any disturbance of the periosteum should be as restricted as possible. When the ends of the bone are cut square a saw is preferable. If they can be made to interlock, by shaping these in part into the form of a $>$, or by stepping them, a chisel will be useful: the ends of the bones are first steadied with forceps. The fragments are now brought into exact apposition, and to facilitate this it may be necessary to divide adhesions or tendons, or to remove any intervening fibrous or fibro-cartilaginous material, or a sequestrum. Lane's plates and screws are the best means of maintaining apposition of the fragments.

A full account of the clamp devised by Dr. C. Parkill and its various uses is given in the *Ann. of Surg.*, May 1898. Here will be found also the reports of fourteen cases in which the clamp had been used. The fact that success was obtained in each of these cases constitutes a strong claim for a more extended trial. Owing to its numerous parts, it is complicated, and the projection of a portion of the instrument calls for constant attention to keeping the skin sterile. In the only case in which I have seen this clamp used it was not successful. The remarks made below on fractures of the leg should also be referred to.

III. **Injuries about the lower end of the Femur.** *E.g.* supra- and inter-condyloid fractures and injuries to the epiphysis. Where, after an attempt under anæsthesia, a skiagram, taken on the second or third day, shows that the position of the fragments is unsatisfactory, it is quite justifiable, especially in a young and healthy patient, to resort to operation if the surroundings and skill of the surgeon are suitable. In the case of the shaft the dangers of the relations increase from below upwards; here, in addition to the importance of the relations, the presence of the knee-joint, the possibility of injury to the popliteal vessels,[1] the bulk and fixity of the lower fragment, have all to be remembered. Adhesions here form so quickly that interference should be resorted to in the first week. The following are the chief points which need attention. (1) The chief incision should be on the outer side along the outer border of the biceps tendon, prolonged upwards along the line of the external intermuscular septum already mentioned; in any extension of the incision below care must be taken of the external popliteal nerve. (2) If the joint be uninjured, the synovial membrane should be avoided by keeping the incision low down.[2] (3) Division of the tendo Achillis, while variable in the aid which it affords, should always be resorted to. (4) The

[1] Œdema of the foot, persisting after alteration in the position of the limb, will be an indication for operation.

[2] The persistent stiffness of the joint which is so liable to follow a successful reduction of the fragments would make one very chary of dividing the extensor, or opening the knee joint so as to insert a finger to aid in the replacement as advised by some. If the joint be infected, it is another matter.

position of the fragments,[1] the aspect of their surfaces, the amount of tilting, rotation, &c., being determined by inspection after adequate exposure, reduction must be effected by manipulations aided by leverage. The wound and its adjacent area being protected with sterile gauze, extension is made on the leg in the extended and flexed positions, while the surgeon and an assistant hold the fragments with long forceps, and lever the ends into apposition, no fingers being placed in the wound throughout the operation. The difficulties now present are the locking of the lower fragment between the closely adjacent femur and tibia; in the case of a separated epiphysis this may have carried with it a portion of the diaphysis which may need careful enucleation, and, this failing, detachment with a chisel, or the upper end of the diaphysis may be held in a buttonhole-like slit by a detached sheath of periosteum, this requiring careful slitting up. If the leverage of a periosteal elevator is required, care must be taken not to inflict needless damage on the delicate and softened epiphysial structures. (5) When replacement has been effected there is not, in my experience, the same difficulty in retaining these fragments in position that is met with in injuries about the elbow-joint. Plates and screws or long screws are used to maintain apposition. (6) It is needless to insist on the need of the most rigid asepsis throughout. (7) The after-position, whether flexed or extended, will mainly depend upon the position in which it has been found easiest to replace and fix the fragments. As I have stated, the amount of mobility of the joint, even where rapid healing has been secured, is often disappointing, and, in separation of the epiphysis especially, in addition to some stiffness of the joint and shortening, some degree of genu valgum or varum is very likely to follow if the limb be used prematurely.

[1] The difference in the displacement in a case of separated epiphysis and supracondyloid fracture will be remembered. In the former case the epiphysis is displaced upwards, and the lower end of the diaphysis will be felt in the popliteal space. In the case of the fracture the lower fragment is drawn backwards, and arrested behind the upper, with its fractured surface looking into the space behind.

CHAPTER XLII

OPERATIONS INVOLVING THE KNEE-JOINT

AMPUTATION THROUGH THE KNEE-JOINT. ERASION OF THE KNEE-JOINT. EXCISION OF THE KNEE-JOINT. ARTHRODESIS.

AMPUTATION THROUGH THE KNEE-JOINT (Fig. 349)

Chief Methods: I. By Lateral Flaps. II. By Long Anterior and Short Posterior Flaps. Of these the first is far the superior. The great objection to the second is, that in order to get sufficient covering to fall readily over the large condyles, a long anterior flap must be cut; as this must reach two inches below the tibial tubercle, a good deal of its blood-supply which comes from below, *e.g.* from the recurrent tibial, must be cut off, and the flap is thus liable to slough. This risk is much diminished, and the blood-supply better equalised, by the method of lateral flaps.

I. **Amputation by Lateral Flaps.** This, the method of Dr. Stephen Smith,[1] was brought before English surgeons by Mr. Bryant.[2] The femoral artery having been controlled, the limb supported over the edge of the table, and slightly flexed, the surgeon, standing on the right side of either limb, marks out two broad lateral flaps as follows: His left thumb and index finger being placed, the former over the centre of the head of the tibia, the latter at the corresponding point behind, opposite the centre of the joint, he marks out (in the case of the right limb) an inner flap by an incision which, commencing close to the index finger, is carried down along the back of the limb for about three inches and a half, and then curves upwards and forwards across the inner aspect of the leg, till it ends in front just below the thumb.[3] The knife not being taken off, a similar flap is then shaped from the outer side, but in the reverse direction. Dr. Stephen Smith calls attention to the following points: In making these flaps, they should be cut broad enough to secure ample covering for the condyles, and the inner one should be made additionally full as the internal condyle is longer than the external. The flaps should be at least three inches and a half long, if of equal length. They consist of skin and fasciæ. When they have been raised as far as the line of the articulation the ligamentum patellæ are severed, allowing the patella to go upwards. The soft parts around the joint are then cut through with a circular

[1] *New York Journ. of Med.*, September 1852; *Amer. Journ. Med. Sci.*, January 1870.

[2] *Med.-Chir. Trans.*, vol. lxix, p. 163.

[3] Dr. S. Smith begins his incision about an inch below the tubercle of the tibia, and carries it up rather higher behind, viz. to the centre of the articulation. It will be found easier to open the joint and to detach the semilunar cartilages from the tibia by making the incision as recommended above.

sweep, and the leg removed. In doing this, the limb being flexed to relax the parts and facilitate opening the joint, the semilunar cartilages will very likely be found closely encircling the condyles of the femur. Mr. Bryant, in the paper already quoted, and Dr. Brinton,[1] as long ago as 1872, have strongly advised that the semilunar cartilages should be left *in situ* by severing the coronary ligaments which tie them to the tibia. They thus, in Dr. Brinton's words, form "a cap, fitted on the end of the femur, which preserves all the fascial relations, effectually prevents retraction, and guards against the projection of the condyles."

FIG. 349. Amputation through the knee-joint by lateral flaps; the internal flap is the longer to cover the more prominent internal condyle. The semilunar cartilages are left in the stump.

This precaution will obviate a serious objection to amputation through the knee-joint. For a time the patient bears his weight well on the end of the stump. But after some months the ends of the condyles (if unprotected by the menisci) begin to fret the thin overlying skin, and within a year or so of the amputation the patient, usually, has to have his artificial limb altered, &c.

11. **By a Long Anterior and a Short Posterior Flap.** The position of the patient and the surgeon being as at p. 862, the latter with his left index finger and thumb on either side of the interval between the femur and tibia, enters his knife (in the case of the right limb) just below the finger and internal condyle, carries it straight down along the inner side of the leg till it reaches a spot two inches below the tibial tubercle; then squarely across the leg till it reaches a corresponding point well back upon the outer side, and thence up to a point just below his thumb, or to the external condyle. This flap is then dissected up, containing the patella, as thickly as possible, and almost rectangular in shape, anything like pointing of its lower end being most carefully avoided as certain to lead to sloughing.

This flap being raised, a posterior flap is made about two-thirds the length of the first, as at p. 847, either by dissection from without inwards, or by transfixion after disarticulation.

[1] *Philad. Med. Times*, December 28, 1872.

ERASION[1] OF THE KNEE-JOINT

Definition. By this operation, which we owe to G. A. Wright,[2] of Manchester, is meant a systematic removal of the tuberculous synovial membrane; the ligaments, as far as these are diseased, are also removed, the bones and cartilage being dealt with by paring with a knife, or by a gouge or sharp spoon. The more advanced the disease the less typical will be the erasion. When sinuses are present, and the joint is the seat of mixed infection, the risks of failure of any attempt to save the limb are hugely increased. Where an abscess is present, G. A. Wright[3] deals with this by stages. The abscess should be thoroughly cleared out first, the wound closed, and erasion performed after healing has taken place. This plan is not applicable to cases where the whole joint is suppurating. Where sinuses exist he has still found it possible in some cases to render the parts aseptic by excision of the walls of the tuberculous tracts, and the use of powerful disinfectants, of which he considers turpentine to be one of the best. Thus while erasion is directed chiefly to the soft structures which are usually the primary seat of the disease, it entails a need of much wider attention to other structures, especially in hospital cases which have passed beyond the desired early stage.

The old excision of former days, with the attention of the operator directed to the bones rather than to the synovial membrane, is an operation of the past. Erasion is, when possible, always to be preferred to excision. With increasing experience the more will a surgeon's operation here partake of an erasion, especially if he has much to do with children. But in my experience, with the advanced cases which are still so frequent, the operation is rarely an erasion alone; in the great majority of cases the ends of the bones are affected. While the gouge is invariably, at any age, to be preferred to the saw, as some surgeons still prefer excision, and as excision may be required after the failure of erasion in tuberculous cases, and in a few which are not tuberculous, *e.g.*, osteo-arthritis, I have described both operations. With proper conservative treatment neither is often required.

Value of Erasion as compared with Excision; Suitable and Unsuitable Cases. Where a knee-joint, the site of tuberculous trouble, resists, in hospital patients, careful conservative treatment continued for a year, where there is but little evidence of caseation in the joint (very difficult to tell, but indicated by chronic obstinacy of the disease, by spots where the feel is distinctly doughy, or becoming bluish in tint)—in other words, where the disease is early, but, owing to the patient's surroundings, will go on from bad to worse, erasion is indicated and far preferable to excision. Its *advantages* are, (1) There is no removal of bone-slices, and still less any interference with the epiphyses. Thus the only shortening which follows is that due to premature synostosis of the epiphysial line (W. Cheyne), and disuse of the limb, too often allowed to become

[1] Arthrectomy was a term introduced by Volkmann (*Cent. f. Chir.*, 1888); it is less accurate, and, etymologically, comes too near to excision.

[2] *Lancet*, 1881, vol. ii, p. 992; *Med. Chron.*, July 1885; and one together with Mr. Haslam, *Brit. Med. Journ.*, vol. ii, 1903, p. 888. See also a paper by Mr. Shield (*Ann. of Surg.*, February 1888), and one by Mr. E. Owen (*Med.-Chir. Trans.*, vol. lxxii, p. 56).

[3] *Loc. supra cit.*

flexed. This advantage will be at once recognised when it is remembered that the increase in length of the femur takes place chiefly at the junction of its shaft with the lower epiphysis, and in the case of the tibia at its upper epiphysis. In one of my cases, a girl of 11, there was not only no shortening, but repeated careful measurements showed half an inch increase of length, perhaps due to the increase of vascularity, about the above-mentioned epiphyses. (2) With regard to the retention of mobility, and the advantage at first claimed for it, this, in my opinion, has been much exaggerated. I have no doubt whatever that a larger number of carefully published cases will show that where movement is sought for, the risk is run of a certain degree of permanent flexion, of attacks of pain and swelling, and of the formation of troublesome sinuses. I should strongly dissuade, from any attempt to secure mobility in the case of the knee and ankle. (3) The ligaments are less interfered with, and thus, the ties of the joint being preserved, firm union is more speedy. This advantage is only true of the desirable early cases, and is not to be expected where the whole of the interior of the joint has been interfered with to allow of eradication of every diseased structure. (4) If performed early, erasion, as excision does, but in a less expensive way, cuts short the disease, and thus gives a considerable saving of time. (5) It is better suited to young children. Thus, as it does not arrest development, it may be used very early. Wright has operated "with perfect success in a child under two years of age."

The *disadvantage* of erasion—I am speaking only from an experience of twenty-six cases, of which two required excision later, and two others amputation—is, I think, chiefly this, that if the operation fail, excision is rendered much more difficult. I cannot here at all agree with the statement of my old friend, the chief authority on this subject, that erasion, if it fail, leaves the limb little, if at all, in worse condition for excision afterwards. This is true of the limb, but not of the joint. In one of my erasions which required excision, I found that the previous operation had entirely obliterated the usual landmarks, and that great difficulty was experienced and much care needed in dealing with such parts as the remains of the posterior ligament. The ultimate result here (*vide infra*) was good. Another minor disadvantage, and one shared by excision, is the after-flexion. In my opinion the liability to this is greater after erasion. After both operations, prolonged fixation, for at least two years after erasion, is to be insisted upon.

To recapitulate, the *cases most suitable for erasion* are those where the disease is limited, or almost limited, to the synovial membrane, with little, if any, caseation; where the cartilage and bones are almost intact as shown by the X rays, where there are no abscesses or sinuses, where there is no evidence of other tuberculous disease, and where the power of repair is satisfactory.

Operation. The preliminaries are the same as for excision (p. 868). A transpatellar incision should be employed. Many other incisions, *e.g.* a flap usually going through the ligament, a median vertical one splitting the quadriceps, patella and ligament, and two lateral incisions, have all been employed. I have used the first, but prefer that through the patella as best combining adequate exposure of the parts and retention of the patella in order to meet the inevitable tendency to flexion. But to ensure thorough exposure of the suprapatellar region, a very dangerous area on account of its numerous nooks

and crannies, which give lurking-places to tuberculous mischief, I always slit this pouch right up to its very top with a sharp-pointed bistoury, thus dividing the upper flap into two. G. A. Wright in his last paper writes: "I now do the transverse transpatellar operation with a vertical upward incision occasionally added to facilitate removal of disease tracking up the suberural sac. I usually divide the aponeurosis on each side of each half of the patella for an inch or more to facilitate exposure." The flaps being then, one by one, thoroughly everted with a sharp hook, taking the upper half of the joint first, I seize the tip of one of the flaps with mouse-tooth forceps, and then, with blunt-pointed scissors curved on the flat, dissect the diseased synovial membrane off the under-surface of the split quadriceps expansion in a continuous strip till the uppermost limit of the suprapatellar pouch is reached. The reflection of the synovial membrane over the front of the femur is then dealt with in the same way, leaving the periosteum on this quite clean. The joint being then well bent, and the tibia being brought forward as directed (p. 871), the crucial ligaments, the semilunar cartilages, the intercondyloid notch, and the synovial reflections behind the crucial ligaments are carefully inspected. To do this thoroughly, it is absolutely needful to divide the lateral ligaments sufficiently. With regard to the other structures, some retain the semilunar cartilages, if healthy; others remove them in any case. For my part, as it is so essential to remove *all* the synovial membrane, and this is impossible unless the semilunar cartilages go, I always remove them. With regard to the crucial ligaments, the anterior nearly always requires removal; as regards the posterior, the whole ligament, or as much of it as possible, should be left, since its removal is extremely liable to be followed by backward displacement of the tibia. The intercondyloid notch, and the reflection behind the crucial ligaments, is then taken in hand, very wide flexion of the joint, and a finger of an assistant in the popliteal space, here facilitating this, the most difficult and important part of the operation. When much disease is present here in the synovial membrane, both crucial ligaments must be unhesitatingly removed, and, if needful, the overhanging posterior part of the condyles must be cut away. In dealing with the synovial membrane in the intercondyloid notch, the surgeon must remember that he will never have a similar chance of dealing with the disease here, and that, if any is left behind, excision, and perhaps amputation, will be called for. The synovial membrane around the lower half of the patella is then removed, and finally the ends of the bones are examined. Any pits and foci are gouged out and more extensive ulceration shaved off with a strong sharp knife. Drainage is rarely required, save of course in infected cases, or where the condition of the parts will certainly give rise to much oozing later. The two ends of the wound should never be closely sutured. The dressings are applied, and not until all is completed is the Esmarch bandage removed.

The after-treatment is the same as after excision. As there is the same long-continued tendency for the limb to become flexed, there is the same urgent need for a rigid apparatus for at least two years.

Causes of Failure after Erasion. These are much the same as those given under excision. The chief of them, persistence of the disease from failure to eradicate it at the first operation, is there dealt with.

EXCISION OF THE KNEE-JOINT

Indications. A. **For Disease.** B. **Injury.**

A. **For Disease.**

(i) *Tuberculous disease.*

On this subject the remarks already made (p. 864) on erasion should be referred to. With careful conservative treatment, the need of this operation has been greatly reduced. The writer never performs it for tubercle except when the bone end is seriously diseased and invaded as shown by the X-rays. The following points require mention as well: One is age. The chief growth of the femur takes place at its lower end. By fifteen, and still more by seventeen, the growth of the bone is largely completed. Thus, in young subjects, especially before ten, as little of the bones as possible should be removed, and gouging should largely replace the saw. While the old-fashioned excision, in which attention was chiefly directed to the ends of the bones, is, as already stated, very largely an operation of the past in tuberculous cases, it may still be called for in the following: where the disease is of long standing; where there is backward displacement of the tibia; where the disease has started as an epiphysial osteitis.

While the subject of tuberculous disease of the knee-joint is being considered, the question of amputation will arise in certain cases. Sir H. Howse,[1] gives the following conditions which call for this step. They are: A. *Constitutional.* (α) Lardaceous disease. (β) Tuberculous disease of the lungs or other viscus. (γ) Great emaciation without any very evident visceral disease. (δ) Multiple joint disease (*see* p. 865). B. *Local.* (α) Osteitis or periostitis extending along the shafts of either femur or tibia, as shown by great thickness or tenderness of the bone.[2] (β) Very great infiltration of tuberculous material into the soft parts, extending far beyond the limits of the joint.

(ii) Some cases of failed erasion in which the mischief is too extensive for curetting, but does not call for amputation.

(iii) Disorganisation of the knee with flexion after pyæmia, and other forms of infective arthritis.

(iv) *Osteo-arthritis.* Where one joint only is affected, and the patient is not past middle life, excision gives good results. The surgeon must be prepared for sawing very dense bones.

(v) *Ankylosis.* Excision can usually be abandoned here for better operations (p. 877), *e.g.* dividing, with aseptic precautions, the union, with an osteotome introduced first on one side and then on the other and worked forwards under the patella and skin, and backwards as far as the popliteal artery allows. If this fail, a double osteotomy of the femur and tibia should be performed rather than excision, an operation which, in the case of true bony ankylosis, is liable to be severe, prolonged, and to leave a large wound, and, in the case of young subjects, to lead to further shortening of a limb already atrophied and weakened from disease. I would strongly urge caution in rapidly and completely straightening a knee-joint which has long been the seat of a

[1] *Guy's Hospital Reports*, 1894.

[2] Sir H. Howse points out that, occasionally, tenderness and thickening may be due to a sequestrum, which may be successfully removed, and later on a useful limb obtained by excision.

bony ankylosis in a bad position and call attention to the case related at p. 877.

(vi) *Old Neglected Infantile Paralysis.* The question of excision here is referred to (p. 878), under the heading of Arthrodesis.

B. **Injury.** Here such injuries as those from gunshot and those from a lacerated wound or a compound fracture must be considered separately.

(1) *Gunshot.* "The results of the excisions of the knee-joint performed during the American civil war, whether the operations were primary, intermediary, or secondary, were not very encouraging, forty-four of the fifty-four cases in which the issues were ascertained having terminated fatally, a mortality of 81·4 per cent., exceeding the mortality of the amputations of the thigh (53·8) by 27·6 per cent."[1] Sir T. Longmore[2] lays down these definite rules: "From all the experience which has been gained regarding gunshot wounds in which the knee-joint has been opened, especially if the surfaces of the bone have escaped damage, as may occasionally happen with modern narrow rifle bullets, and even in other cases where one of the bones has been fissured, or partial fracture has occurred, provided early immobilisation of the injured parts can be secured, antiseptic treatment carried out, and the general surroundings are sufficiently hygienic, it may now be laid down as a rule that conservative treatment ought to be adopted. When, however, the circumstances under which the wounds have been inflicted are such that the precautionary methods and modes of treatment mentioned cannot be put into practice, when the patients are liable to be moved frequently or to long distances hurriedly, and without adequate protection, or when the joint is not only penetrated, but the surrounding coverings are much lacerated, or the bones are comminuted and the fragments completely detached, the sacrifice of the limb by amputation above the joint is the only measure calculated to afford a fair promise of safety of life to the patient."

Mr. Makins, C.B., in his standard work,[3] from which I have already quoted, writes (p. 238), that while the knee-joint was the one most commonly injured, "injuries to the joint gave less anxiety than is the case in civil practice. The old difficulty of deciding on partial as against full excision or amputation was never met with by us. We had merely to do our first dressings with care, fix the joint for a short period, and be careful to commence passive movements as soon as the wounds were properly healed to obtain in the great majority of cases perfect results. If suppuration occurred, the choice between incision and amputation had to be considered. Amputation was sometimes indicated in cases of severe bone-splintering, but was as a rule only performed after an ineffectual trial to cut short general infection of the septicæmic type by incision." Association of popliteal aneurysm with wounds of the knee-joint was comparatively common.

(2) *Injuries other than gunshot.* Excision is rarely indicated here. Occasionally in hospital practice excision is the best treatment of flail knee following violent injuries tearing the crucial and lateral ligaments.

Operation. Before and throughout an excision of the knee, or rather a combination of partial excision with erasion, the operator should bear in mind the following points: (1) to remove every atom of the disease; (2) to secure good drainage; (3) to leave the bones in good position; (4) to ensure absolute immobility afterwards; (5) to watch for and at once attack any relapse. The more I performed this operation, the more did I feel the truth of the words of Prof. Bruns, of Tübingen, that, while formerly its chief object was to remove all affected bone, it should now be considered of chief importance to remove all the tuberculous material that can possibly be got away, and that the surgeon should not content himself with snipping away all he can, leaving the rest to caseate or become scar-tissue if it will, but pursue it with the same earnest aim of extermination as he would in the case of malignant

[1] Otis, *loc. supra cit.*, p. 419.
[2] *Syst. of Surg.*, vol. i, p. 565.
[3] *Surgical Experiences in South Africa*, 1899–1900.

disease. I would not by the above seem to speak slightingly of the value of securing healthy and correctly sawn surfaces of bone, as on these largely depend firm ankylosis and a sound and useful limb, but I would insist on the fact that such surfaces are secured in vain if tuberculous material is allowed to remain, and that other instruments, *e.g.* sharp spoons and scissors curved on the flat, are to the full as useful as the saw.

Before the time of the excision, any flexion of the knee should be corrected as far as possible by careful weight-extension. A knee should rarely be excised while flexed. Such a step will only be liable to lead to removing bone needlessly in order to straighten the limb. The risk of gangrene is alluded to at p. 877.

The parts having been duly sterilised, the foot elevated and a tourniquet [1] applied at the top of the thigh, the limb is brought over the edge of the table, flexed, and held by an assistant.

From the moment of commencing the operation to its very close the surgeon must bear in mind the inveteracy of tuberculous material (malignancy would probably not be too strong a word), and in his endeavours to extirpate the disease completely his operation will combine the operations of erasion and excision rather than follow the typical lines of either.

The following modes of exposing the joint will be given here:

A. **Transverse, removing the Patella.** B. **Transverse, through the Patella.** C. **The Semilunar Flap** (lately recommended by Mr. Barker, and attributed by him to Moreau).

A. **Transverse, removing the Patella.** This, the older method, is still resorted to by those surgeons who, like Sir H. Howse, believe that if the patella is retained, a most serious risk is run of leaving behind tuberculous material which will require removal later on under less favourable circumstances, and this failing, may lead to amputation.

The surgeon, standing on the left [2] side of the diseased knee (the opposite limb being tied to the table), makes an incision right across the joint from the back of one condyle to that of the other.[3] This incision passes over the lower part of the patella and exposes the lateral ligaments at once. The soft parts being then dissected up for two inches above the patella, so as to expose the suprapatellar pouch, deep incisions are made above and below the patella, which is then removed and the joint opened.

If the patella is ankylosed to the condyles, it must be removed by a blunt elevator, aided by a narrow saw, or, better, by an osteotome and mallet. No violence should be used in opening a joint partially ankylosed, or the epiphyses may easily be separated from the shaft, especially in a child.

I invariably, when raising the flap of soft parts in an excision of the

[1] Some object to the tourniquet as needless and as likely to lead to troublesome oozing after the operation. This may be met by firm pressure and even bandaging on of the dressings, before the tourniquet is removed. If a tourniquet bandage is not applied, the bleeding during the operation interferes with the removal of diseased tissues, requires constant pressure to arrest it, and taxes the patient's resources considerably. Its use meets another risk, which is possibly hypothetical, and that is it renders impossible the general diffusion of tuberculous material by the cut veins and lymphatics.

[2] This position renders it much easier for him to saw the femur and tibia.

[3] Beyond this spot the incision should not go, for fear of wounding the internal saphena vein. This would lead to troublesome œdema of the foot and leg, and, if the wound should become infected, might bring about phlebitis and pyæmia.

knee, however performed, slit them up by a vertical incision, going to the upper limit of the suprapatellar pouch, so as to expose fully all its folds and recesses. Unless this is done, tuberculous material is very easily left behind, and, later on breaking down, leads to œdema, persistent sinuses, perforation of the pouch and spread of disease amongst the adductors and into the vicinity of the femoral, and perforating vessels, where it is impossible to eradicate it, amputation being eventually called for.

B. **Transverse, through the Patella.** This method, by preserving the patella and the insertion of the quadriceps, partly counterbalances the flexing action of the ham-strings at the same time. Used by Volkmann many years ago, it was again brought under the notice of English surgeons by Mr. Golding Bird in a case which he brought before the Clinical Society.[1]

For arguments against preserving the patella I must refer my readers to Sir H. Howse's article.[2] I am of opinion, myself, that in young subjects where the union is certain to yield for some time, it is well worth while, in cases where the disease is not too advanced, to preserve the patella, though to ensure the full benefit of this step, fresh osseous surfaces should be prepared on this bone and on the femur and tibia, so as to promote bony union. Another and minor argument in favour of preserving this bone is that the anastomoses about the joint are less interfered with. This method is not adapted to cases where caseation is advanced, and its adoption only lessens, but does not remove, the liability to subsequent flexion.

The transverse incision is made here much as in the first method, only across the middle of the patella; this is sawn through or divided with a stout knife, the fragments turned up and down, and the joint freely opened.

C. **Semilunar Flap** (Moreau, Barker). Here a large U-shaped flap is raised by a semilunar incision, starting above one condyle, descending to the level of the tibial tubercle, crossing the leg here and running up to a corresponding point on the other side. In raising this flap, which includes all the soft parts down to the bone, either the ligamentum patellæ should be severed (suturing of this being resorted to later), or the tuberosity, attached to the ligament, is removed with a chisel, and subsequently wired down (Barker).

The joint having been opened by one of the above incisions, it is well to slit with a sharp bistoury the suprapatellar pouch[3] up to its upper limits (readily reached by a finger), so as to lay bare every crevice and to remove every atom of diseased tissue. The cut margins being held on the stretch by two forceps, the surgeon with mouse-toothed forceps seizes the cut edge of the synovial lining of the capsule, and with curved scissors removes it in one piece, first from under the vasti muscles and then along its reflexion on to the femur down to where it ceases at the margins of the articular cartilage.

Next the lateral and crucial ligaments are examined, and every particle of diseased tissue removed, only bright, glistening, clearly healthy ligamentous tissue being left.[4] But as naked-eye examination in parts

[1] *Trans.*, vol. xvi, p. 82. [2] *Loc supra cit.*

[3] I look on this as one of the most cardinal points of the operation.

[4] Prof. Ollier (*loc. infra cit.* and *Rev. de Chir.*, 1882) drew attention to preserving the lateral ligaments, if possible, together with all healthy periosteum and capsule,

perhaps not absolutely bloodless may easily be fallacious, it is much better in doubtful cases to remove these completely than to run any risk whatever. The assistant who is in charge of the limb now brings the head of the tibia well into view by pulling the calf of the leg well forward with one hand while he further dislocates the bone by pushing up the leg (Fig. 351).

The condition of the semilunar cartilages is next examined, and if

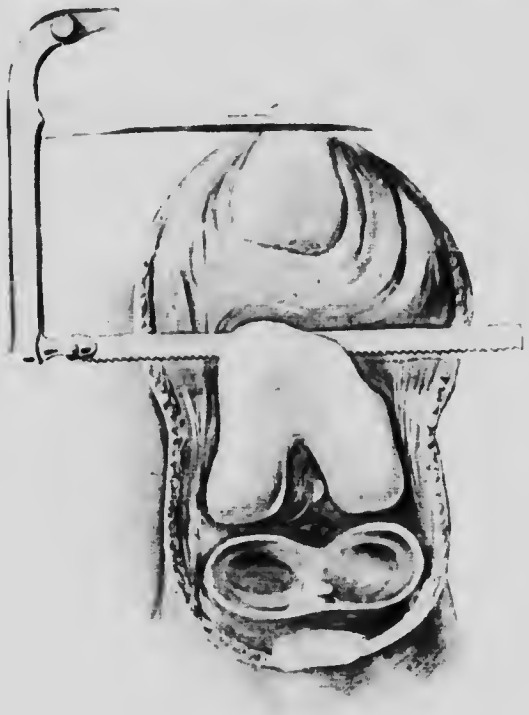


Fig. 350. Excision of the knee. The patella has been reflected in a semilunar flap.

they are invaded by tuberculous tissue, if it is intended to perform a complete excision, they must be cut away entirely.

The back of the joint is next taken in hand. This region can be far more effectively dealt with after removal of the bones. If, owing to the case being an early one, with little or no caries, the surgeon desires to remain content with an erasion, he must still deal thoroughly with the posterior ligament [1] and deeper parts of the sides of the joint with all recesses and folds of the synovial membrane. To expose these parts thoroughly is a matter of some difficulty. The assistant should manipulate the limb as above directed at one time, at another flex the leg

i.e., those tissues which will keep the bones in place and which will tend to produce ossifying material. This will not interfere, if carefully carried out, with extirpating diseased parts, while it will go far to prevent progressive flexion of the joint.

[1] This and the posterior parts of the semilunar fibro-cartilages are liable to be inefficiently treated.

back towards the table, while occasionally a sterilised finger in the popliteal space will keep within reach any altered tissue that it is desired to deal with. Every pains must be taken to use the scissors systematically and thoroughly here as elsewhere until healthy tissues are reached, and not to dread the popliteal artery too much. This should be enforced for two reasons. If any diseased tissue is left here, it will be shut in after the limb is extended and be impossible to deal with, save by a fresh and probably unsuccessful operation. Again, there is always a risk, especially in a surgeon's earlier operations, of his not dealing with disease

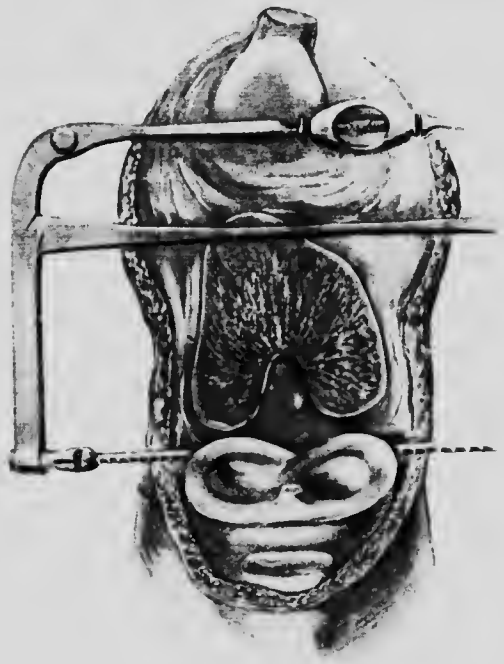


Fig. 351. Excision of the knee. The upper surface of the tibia is sawn from behind forwards.

here with sufficient thoroughness from dread of injuring the popliteal artery. This vessel may be avoided by (1) not dipping the points of the scissors deeply, but using the blades as far as possible parallel with the course of the vessel; (2) remembering that even after the posterior crucial ligament has been removed (a detail often imperfectly carried out) there is still a considerable thickness of tissue in front of the artery.

After all diseased tissues at the back have been thoroughly eradicated, the deeper aspects of the sides of the joint must be examined. Where caseating foci have spread down on the inner side of the joint, the tendons of the sartorius, semi-membranosus, and semi-tendinosus may need exposing.

It remains to describe the removal of the bones in case erasion is not sufficient. Where excision is evidently needed, the bones should be sawn after the suprapatellar pouch is cleared out, and before the

posterior aspect of the joint is taken in hand, as this step will be much facilitated thereby.

The femur, held as steady as possible, is taken first. A groove for the saw is first so marked out with the scalpel as to remove about one-third of the condyles. In severer cases, or where the above section will clearly be insufficient, half, or even two-thirds, of the articular surface may be removed, but no section should be made farther back than this, or the epipyhsis will be trenched upon with serious after-results.[1] Care should be taken, in making the section of the femur, to ensure that the plane of the sawn surface shall be at right angles to the axis of the shaft. Sir H. Howse prefers to saw the femur while this is held vertically.

The tibia is taken next, and a groove marked out with the knife about half an inch below the articular cartilage. A Butcher saw, set horizontally, is used from behind forwards, and on a perfectly level plane. Neither here nor in sawing the femur must the slightest wobbling of the saw be permitted.

About half an inch only of the tibia should be removed, just enough in fact to expose healthy cancellous tissue, and no more. Of the femur no more than an inch and a half should be removed if possible.[2] Any soft, yellow cheesy, fatty patches, any cancellous tissue into which pulpy tissue has dipped after perforating the cartilage, should be carefully removed with a gouge. Where, however, there is much caries, or the above patches are numerous, breaking down readily under the finger-nail, more than one slice of bone had better be removed.

The whole wound is now finally most carefully scrutinised, every outlying angle and recess being examined for tuberculous tissue left behind.

The tourniquet is now by some removed, and while sterile pads wrung out of hot 1 in 2000 hydr. perch. are held firmly over the sawn tibia, any bleeding-points in the upper half of the wound are attended to. The safest way of arresting the bleeding is by underrunning with chromic gut and fine needles all the vessels which spirt,[3] as practised by Sir H. Howse, or as I greatly prefer, by Mr. Barker's plan (*vide infra*). Bleeding from the cancellous tissue will be arrested by placing the bones in contact. If there is any tendency of the edges of the skin to fold in, these must be shortened.

The best means of meeting the hæmorrhage, and one which I have

[1] Dr. Hoffa, of Wurzburg (*Arch. f. klin. Chir.*, Band xxii. Heft 4, 1885; *Annals of Surgery*, March 1886), brings forward cases to show that removal of both epiphyses led, at the end of ten years, to shortening, amounting to 2½ cm. (1 cm. ⅖ inch), while in another case it amounted in two years to 10 cm. Loss of the femoral epiphysis alone showed 17 cm. of shortening in six years, and 7 cm. in a year and a half. Two cases of the like duration affecting the tibial line showed respectively 1½ and 6 cm. It is, however, well known that considerable shortening may occur in cases treated expectantly.

[2] If the surgeon is obliged to trench upon the epiphyses it should be with the gouge, and not with the saw, if possible. In one case of a boy, aged 7, the bones being carious, soft, and fatty, a large patch of cheesy, fatty bone presented itself in the head of the tibia after the first slice had been removed. In removing this, the gouge entered the medullary canal, which was exposed, gaping on the sawn surface. I was doubtful how far union would take place here, but three years later the boy had a most useful limb, probably from a ring of epiphysial tissue being left.

[3] The following vessels will be found to give the chief trouble after a combined erasion and excision: one or two running down in the periosteum over the femur, one or two in the cut periosteum surrounding the sawn margin of the tibia, and one from the azygos articular in the posterior ligament.

followed in all my later cases of excision and erasion, is that advised by Mr. Barker.[1] The tourniquet is here not removed until the dressings in sufficiently thick successive layers, *e.g.* sterilised gauze and wool, are firmly bandaged in position. To admit of sufficient pressure being applied to check the oozing and to distribute it uniformly throughout the dressings, a sterile white bandage should first be applied from the foot to the upper third of the leg. If one of Sir H. Howse's splints is employed the tourniquet must be applied sufficiently high up the thigh not to interfere with the limb being placed in the splint, as this has to be done before the dressings are applied. I have found this plan most satisfactory.

The patella, if sawn, is now drilled and wired, or united with stout catgut. I prefer the first, the wire being cut short and buried in the

A. B.

FIG. 352. A and B show the line of the epiphyses which enter into the knee-joint, seen from the front. That of the fibula is also seen. They are taken from a well-grown subject of about 18. (Farabeuf.)

tendon above the patella in the way described at p. 882. As an additional precaution against the inevitable tendency to flexion, Mr. A. H. Tubby advises[2] that the anterior aspects of the ends of the femur and tibia and the posterior aspects of the patella be removed. The four portions of bone are then united with a silver wire, which is embedded.

The question now arises whether the tibia and femur should be united by wiring or pegging.[3] I am of opinion that if the bones have been so sawn as to bring their faces squarely together, with sufficiently exact closeness to prevent more than a finger-nail being inserted between them, and if they are put up with the security which is given by Sir H. Howse's method, the above aids are not needed.[4] Failure of excision is due not to deficiency of repair in the bones, but, as a rule, to persistence of tuberculous material.

[1] Hunt. Lect., *supra cit.* [2] *Brit. Med. Journ.*, 1903, vol. ii. p. 893.

[3] The bones have been united with different forms of pegs or nails, or by wire, stout carbolised silk, or chromic gut.

[4] I may be speaking with insufficient knowledge, but I am under a strong impression that the advocates of these aids have not made trial of the absolute fixity ensured by a well-applied Howse's splint (*vide infra*). Mr. Morrant Baker's and Mr. Howard Marsh's methods of fixing the bones by steel or bone pins will be found in the *Brit. Med. Journ.*, 1887, vol. xi, pp. 321, 389.

The need of drainage must vary with the experience of the operator. If the bone surfaces are well together, if the angles of the wound are left open, and if aseptic precautions have been taken throughout, drainage is rarely required. Sir H. Howse's splint is now applied. To those who are not familiar with it the following brief account [1] may be useful. The arrangement will be found most simple, and equally efficient in admitting of antiseptic dressing and maintaining the parts in absolute rest. The splint consists of two interrupted tinned-iron troughs for the thigh and leg joined by a posterior bar. This is from four to six inches long, according to the age of the patient; it is convex from side to side to avoid cutting into the popliteal space, and can be lengthened or shortened if any alterations in the interruption are required. At the end of the splint is an adjustable foot-piece.

The limb being laid in the splint, attention must be paid to the posterior bar being in the centre of the popliteal space; the foot must be well dow[illegible]e foot-piece; if the splint grips the thigh or leg too tightly or ric[illegible]sely, it must be bent out or in with iron "crows." The dressing[illegible]w applied as at p. 873. Great care must be taken to bandage from below upwards and from within outwards, the bandage being laid on evenly and firmly so as to distribute the discharges evenly right through the dressings, and to prevent their coming through at one or two spots. The splint is next secured to the limb with "waxed bandages," prepared by passing them through a mixture of ordinary yellow wax and olive oil, in proportions sufficient to make the wax soft and workable. After they are applied to the leg and thigh they are painted over with a little hot wax-mixture, so as to make them weld into one mass.[2] The limb, thus secured, is slung with cord and pulley to Sir H. Howse's modification of Salter's cradle. This occupies the lower part of the bed; the patient lies on a half water-bed. Thomas's knee-splint may also be used. G. A. Wright employs a back and two side splints for about three weeks, and then a Thomas's splint, which is kept on for at least two years.

The chief points now are (1) to ensure as absolute immobility as possible; (2) to employ as infrequent [3] dressing as practicable; (3) to watch for every sign of reappearance of the disease, and to attack it at once.

After-treatment. Morphia or laudanum should be used freely at first, if needful. If there be no reason to the contrary the dressings should be left undisturbed for about a week. If tuberculous foci persist, these must be slit up with a sharp-pointed curved bistoury, and scraped out with sharp spoons. While this may be repeated every two weeks on five or six occasions successfully, the more deliberately the surgeon endeavours to extirpate the disease both in the soft parts and in the

[1] *Guy's Hospital Reports*, 1877, vol. xxii, p. 503, and the accompanying plate.

[2] The splint is usually lined with lint wrung out of the above mixture, or boracic acid lint. But the popliteal bar and any of the splint close to the wound must be metal only, uncovered, to prevent infection. If any spaces exist between the limb and the splint they may be filled in with cotton-wool, soaked in some of the hot wax-mixture.

[3] Infrequency of dressing has been strongly insisted on by Prof. Ollier (*Rev. de Chir.*, August 1887; *Annals of Surgery*, November 1887, p. 424). This most important economy — of pain to the patient, and time to the surgeon — is only to be secured by (1) Removing every atom of the disease that can be got at. (2) Providing drainage. The more thoroughly the disease is extirpated, the less need is there to drain; but however completely the disease is removed, many sutures should not be employed, especially at the ends of the wound. (3) Securing as dry a wound as possible.

bones, the more he treats it as if malignant, at first, the less often will he have to interfere later on.

In about three months, Sir H. Howse's splint may be left off and a Thomas's knee-splint is applied. This conducts the weight from the pelvis along the splint to the heel of the foot. Some such fixed apparatus should be worn, in children, for two to three years. If the case be lost sight of, the splint will be removed, with the inevitable result of flexion.

In early life callus-like material is thrown out quickly, and often somewhat irregularly, between the bones, but it is extremely slow in really ossifying. As the quadriceps extensor wastes much more quickly than the hamstrings, even when the patella is retained, the latter muscles keep up their action on the tibia for months, and even for years, until the union is firm. Tenotomy has been advised, and even resection of all the hamstring tendons.[1] I think, however, that retaining the bones immobile and in good position, securing early healing of the wound, wearing a stiff apparatus and, whenever practicable, using the trans-patellar method, will best ensure a limb soundly ankylosed in good position.

Causes of Cases not doing well, Failure and Death after Erasion and Excision of the Knee. (1) Inveterate persistence of the disease leading to (α) giving way of the suprapatellar pouch, and the results mentioned at p. 866; (β) to formation of caseating foci, especially at the back of the joint (p. 87), and only to be removed by re-excision or amputation. (2) An unhealthy condition of the bone ends, with caries and chronic osteo-myelitis. (3) Slowly progressive thickening creeping up along the lower end of the femur and down the upper end of the tibia, indicating a persistent tuberculous periostitis. While the latter mischief can be often dealt with by vigorous curetting, all these conditions are grave, and where the vitality of the patient is poor, or when other unfavourable conditions are present, indicate the need of considering the advisability of amputation. While an unpromising limb can often be saved by vigorous curettings repeated two or three times at intervals of a week, the treatment to be aimed at is preventive by thoroughly going over the ground at the first operation. When the surgeon is in doubt as to amputation he should examine the bones with the X-rays (4) Deficient reparative power, leading to bed-sores, emaciation, and hectic. (5) Co-existence of subsequent development of such visceral diseases as phthisis, &c. (6) Infective conditions. For these the surgeon will, nowadays, be, as a rule, entirely to blame. (7) Secondary hæmorrhage. Another very rare condition. (8) Fat embolism. This is a still rarer condition, but one which, on account of the interest it excited some years ago, and because it has once, at least, proved fatal, deserves mention here.

The case was that of a child, aged 12, submitted to excision for pulpy disease by Vogt, of Griefswald.[2] The bones were so fatty as to cut with a knife. Though but little chloroform had been given, and the loss of blood had been slight, the patient died twenty-four hours later with shallow respirations, feeble pulse, and low temperature. Fat embolism of the lungs, extensively diffused, was found post mortem. Vogt considered that this case predisposed to fat embolism. Thus cut vessels were exposed on the sawn surfaces with plenty of free oily matter close by, and unable to escape, owing to the bone-ends being in close contact (two wire sutures were used). A similar case, after hip resection, by Prof. Lüke, is mentioned. Prof. Vogt thought

[1] Dr. Phelps, *New York Med. Record*, July 21, 1886; *Annals of Surgery*, October 1886, p. 364.

[2] *Cent. f. Chir.*, 1883, S. 24.

that he would amputate in another case if, after excision of the knee, the limb could not be straightened without close apposition of the sawn fatty bone-ends.

(9) Shock. This, though rare, must be remembered. (10) Flexion and ankylosis. The frequency of these and their prevention have already been referred to. In cases occurring after erasion the union is always fibrous, and the limb can usually be straightened with the aid of an anæsthetic and division of the hamstrings (*q.v.*). Great care must be taken not to strain the epiphysial lines. In those cases where backward displacement of the tibia is present as well, the old incision should be opened up, and the uniting material divided with an osteotome. If this fail a partial excision must be performed, no formal wedge being taken away, but the ends of the bone successively chiselled away until the limb can be straightened. But where a much-flexed limb is completely straightened at once, the warning given below must be remembered. After excision the union is usually bony. In the slighter degrees of deformity division of the bony material with a chisel or osteotome usually suffices, the limb being gradually straightened. Where the deformity is more marked, osteotomy of the femur above the joint, and, if needful, the tibia also, is preferable to performing a second excision, or removing a wedge of bone.

As I shall not have space again to refer to this matter of ankylosis of the knee, I would strongly urge caution in rapidly and completely straightening a knee-joint which has long been the seat of bony ankylosis in a bad position. My attention was drawn to this matter in a painful way many years ago.

A girl of 19 had been admitted under my care with bony ankylosis of the knee at a right angle, dating to disease seventeen years before. Finding that I was unable to materially improve the position by subcutaneously sawing through the bony union I excised the joint and straightened it completely. The foot and leg remaining cold, an anæsthetic was given next day, and the limb put up flexed. The mischief was, however, done. The coldness remained, all pulsation in the tibials stopped, and gangrene evidently threatening, the thigh was amputated, the patient sinking afterwards.[1]

At the necropsy, osteophytes were found on the posterior border of the tibia projecting backwards, and it was evident that over these, when the limb was straightened, the popliteal vein, a very small one, had been stretched and closed.

ARTHRODESIS

By the above term is meant the denuding of a joint of its cartilage so as to produce either partial or complete ankylosis, the object being to save a hospital patient with a flail-joint the need of expensive apparatus. The operation was first practised by Albert, of Vienna, in 1878, and was introduced into this country by Mr. R. Jones, of Liverpool, who reported twenty-six cases operated on without mishap in the *Provincial Medical Journal* of December 1894.

As the knee and the ankle-joints frequently require combined attention, arthrodesis of these two joints is considered together.

The operator aims at partial or complete ankylosis. It is not easy to predict accurately which will occur. Partial ankylosis—ten or fifteen degrees of movement being advantageous for walking purposes

[1] Just after this another London surgeon published a very similar case. Sufficient attention has not been drawn to this matter. It would have been much wiser on my part, with such dense and old-standing ankylosis, to have put the limb up flexed at first, or to have rectified the position in two stages with an osteotome. I have adopted the step successfully since, in much older patients, with almost as much contraction.

—is desired usually at the ankle. Without the removal of much bone it is not easy to bring about a complete ankylosis here. If a partial ankylosis is desired merely, a thin layer of cartilage is gouged away, care being taken that the whole area of cartilage is removed. If the ankle be wholly paralysed, ankylosis should be as complete as possible. If arthrodesis is employed as an aid to tendon transplantation, the ankylosis is best if partial.

Fixation of the knee is very rarely desirable, for it is a serious disadvantage to the power of bending one or especially both knees. Even when all muscular control of the knee is lost, the patient can walk fairly well with the aid of lateral steel supports with a ring catch at the knee enabling the patient to stand firmly, and yet bend the knee while sitting. If any power of flexing the hip remains, the knee swings like an artificial limb. Occasionally the deformity is too great to allow the knee to be straightened without removal of bone at the knee.. In the rare cases in which arthrodesis is indicated at the knee, complete bony ankylosis with a straight limb is desirable, as partial fixation, with no controlling muscles, inevitably means stretching of the fibrous union. It is necessary, except in very young children, to peel the joint of its cartilage completely, even attacking the patella.

The *indications for arthrodesis* are given by Messrs. Tubby and R. Jones [1] as follows: (*a*) complete paralysis of all the muscles, resulting in a flail limb; (*b*) complete paralysis of muscles about a joint, resulting in a flail joint; (*c*) partially paralysed joints, where the deformity is fixed, or where the joint becomes deformed the moment pressure is put upon it; (*d*) as an aid to muscle-transplantation, where it is necessary to guard against over-stretching of newly transplanted tendons, or where these tendons are not strong enough to control the joint.

The *disadvantages of the operation* are: (*a*) some probable shortening of the limb; (*b*) the limitation of extension or flexion; (*c*) the need of a support in certain cases.

The authors do not consider the amount of shortening to be a factor sufficiently serious to lay stress upon. "In reference to the loss of extension and flexion, we must admit that there are circumstances where such a loss may be keenly felt. This is scarcely applicable to the ankle, but markedly so in the knee-joint. Many people with complete paraplegia or monoplegia, who have ample means to renew their supports, will feel acutely the disadvantage of not being able to bend the knee when sitting. In public places the stiff, straight limb has obvious drawbacks. To a working lad, however, it is a great boon to be independent of supports, with their expense and worries, and this independence is not at all compensated by the power of flexion. Such cases must be treated in accordance with their desires, bearing in mind that a patient may quite well know what will suit him best. The argument, however, never obtrudes in the case of the ankle, where, in the rare cases of complete fixation, a tolerable degree of movement is carried on at the mid-tarsal joint."

A painful condition after arthrodesis, when weight is borne on the joint, is comparatively common in adults, but it usually disappears in a few weeks or months.

The writers mentioned above do not recommend arthrodesis in the case of the hip-joint. "It would be difficult to carry it to a successful

[1] *Surgery of Paralysis*, p. 173.

issue, and, generally speaking, preternatural mobility at the hip is not so serious a disadvantage. The results at the ankle-joint are better than those at the knee."

As an aid to tendon-transplantation at the ankle arthrodesis has been found by Messrs. Tubby and R. Jones very successful. In equino-valgus this is especially the case. Given an ankle with very slackened structures, paralysis of the tibiales, and preternatural mobility, arthrodesis will limit movement of the ankle to a few degrees, combined with the introduction of appropriate tendons into the tibiales or into the periosteum in order to restore the movement of inversion. An operation on similar lines may be needed in equino-varus. In talipes calcaneus arthrodesis of the ankle, combined with shortening of the tendo Achillis, is far superior to shortening of the tendon alone, which is liable to be disappointing from yielding of the shortened tendon.

It is necessary in all cases to prolong the use of apparatus, as it takes a considerable time for the joints to become fixed.

Arthrodesis of the Knee-joint. As already said this should be rarely performed for even passive flexion and extension are very desirable at the knee. The skin having been sterilised and a tourniquet applied, an incision is made across the front of the joint, traversing half its circumference, and curved so as to pass below the lower end of the patella. The flap is turned up, the joint flexed strongly, the semilunar cartilages removed, and with a sharp, short-bladed knife or gouge the cartilage should be peeled off the bones, so as to leave a raw surface over their whole extent. The crucial ligaments may or may not be left. All hæmorrhage having been arrested, the joint is closed without drainage.

Arthrodesis of the Ankle-joint. This may be performed in one of four ways, according to the circumstances of the case: (1) by a transverse incision across the front of the joint; (2) by a perpendicular incision along the mid-line in front of the joint; (3) by an antero-external incision just external to the tendons of the extensor communis digitorum; (4) by a posterior incision over the tendo Achillis.

In old-standing cases, where the foot assumes the equino-varus position, and where all the muscles are paralysed, the transverse incision across the front of the joint is preferable. The division of the tendons is then of no consequence, and an excellent view is obtained of the joint. If there be any compunction in dividing the tendons they can quite easily be drawn aside, with the exception, perhaps, of the peroneus tertius. If firm union be desired not only all the cartilage, but even some of the bone as well, must be removed. Where some power still remains in the extensors of the toes, a linear vertical incision may be preferred, and so, too, where talipes equinus is present and the astragalus is displaced forwards. The posterior incision is useful in talipes calcaneus, where the joint can easily be reached from behind. The incision is made close to the centre of the tendo Achillis, which is drawn to one side or divided, while the incision is carried down to the bone. The capsule is opened, and the gouging completed. If there be any power in the gastrocnemius, the tendo Achillis must be shortened through the same incision.

Before having recourse to arthrodesis and tendon-transplantation, care should be taken to overcome completely by mechanical means any deformity of the foot or leg. If this be not done, considerable traction may be needed immediately after operation a process to be avoided

when possible. In spite of the trophic nature of the lesions, wounds heal rapidly and soundly.

In the after-treatment a Thomas's knee-splint is recommended while the patient is in bed, and this should be changed to a "caliper" when walking commences. For the ankle nothing is better than a posterior splint.

My own experience of arthrodesis is somewhat limited, being derived from six cases of the operation in the knee-joint and three in the ankle, in two of which the ankle and knee-joints were operated upon simultaneously.[1] I have never succeeded in obtaining more than close fibrous union even when the ends of the bone had been actually trenched upon. The knee was exposed by the transpatellar incision and care was taken not to damage the lateral ligaments more than could be helped; the menisci and the anterior crucial ligament were removed. In the removal of the articular cartilage by gouge, chisel, or a curved, blunt-pointed knife, a good deal has to be done by touch, if the ligaments of the already unstable joint are not to be needlessly weakened. In the case of the ankle-joint I made use of a transverse incision, suturing most of the severed tendons afterwards, and in this joint I consider the insertion of a wire between the tibia and astragalus most advisable, as a means of increasing the stability. In two of the cases thus treated, when seen respectively three and five years later, the wire had caused no trouble.

As in the case of tendon-transplantation, too much must not be expected from arthrodesis. In only two of my cases am I able to say with certainty that the result admitted of the patient entirely dispensing with supporting apparatus. The simplicity and uncomplicated nature of arthrodesis justify resort to it in the hope that it will improve the ability of the patient to make use of any remaining power which he may possess. Even when the ends of the bone have been thoroughly exposed—and this is essential—it is difficult to ensure stable bony ankylosis. The conditions necessary for such ankylosis are wanting. In early life, even if small sections of bone are removed with the saw—and no more is permissible for fear of further serious interference with the growth of the already dwarfed and dwindled limb—the surfaces of bone are scant and puny. The rims of cartilage exposed are, relatively, very large. Further, the loss of power over the muscles of the thigh and leg is, usually, advanced and confirmed.

WIRING FRACTURES OF PATELLA

In the words of Lord Lister, who introduced the operation in 1883, "no man is justified in performing such an operation unless he can say with a clear conscience that he considers himself morally certain of avoiding the entrance of any septic mischief into the wound."

The chief points to consider here are (1) the age of the patient, *i.e.* up to about forty-five, the state of his tissues and viscera, and his amenability to directions; (2) the amount of separation, *i.e.* a distance of over half an inch; (3) marked tilting of the fragments backwards or forwards; (4) great distension, as this is an indication, as far as it

[1] It is right that I should add that my cases of arthrodesis were performed at a time before tendon-transplantation was in vogue. I thus failed to obtain any of those advantages which may accrue from the combination of the two operations.

goes, of laceration of the lateral parts of the capsule; (5) the occupation of the patient: the more active this is, the more it involves work on different levels, the more is operative treatment indicated.

In any case the two sides of the question and the risks should be put before the patient. He should understand that while good results are certainly obtainable by ordinary means, lifelong care will be needed to avoid such strains as are involved in stumbling, especially on going up and down stairs, and he should realise that much of the success of the after-treatment rests with him. As I have stated in the account of fracture of the olecranon, it is well that the patient should have an opportunity of discussing the matter with another who has been operated upon.

The above remarks apply to cases of simple fracture: in compound cases, the need of cleansing the joint by irrigation, &c., is an additional reason for operating although the prospect of success is not so good.

Operation. (1) I shall first take cases of recent fracture. The rarer ones of older standing are considered at p. 884. The question as to the best time for interference now arises. While several who are authorities recommend operation during the first few hours when this is practicable, as a rule I should advise waiting until the fourth day, when synovitis and œdema are subsiding. Another reason is that this gives more time for thoroughly sterilising the parts. Owing to its density and rugæ, the skin here is one of the most difficult to deal with satisfactorily. If operation is resorted to at once the vigorous measures required, *e.g.* in a patient habitually working in dust, may lead to a condition of dermatitis. Boracic acid fomentations, applied at once and continually to remove the horny epithelium here, pave the way for thorough sterilisation with iodine. Further, in my opinion, waiting till the third day gives opportunities for a more thorough examination of the patient externally, *e.g.* for other injuries, the presence of any focus of suppuration, &c., while it finds him in a better state for the anæsthetic. I admit that this delay may lead to more coagulation in the joint, but this disadvantage I consider a minor one.

Every detail for the securing of complete asepsis having been secured, and a tourniquet applied round the upper third of the thigh, the parts are best exposed by a flap-incision. The writer generally employs one with its convexity downwards, believing that this best secures the vitality of the flap. The incision commences on a level with the upper margin of the patella, about one inch to one side, passes downwards to a point a little below the level of the line of fracture, where it is carried across the limb and then upwards to a point corresponding to that from which it started. He has not found that this incision in any way interferes with kneeling afterwards, an objection which has led others to prefer a flap with its extremity upwards or outwards. A flap-incision has the undoubted advantages of better exposure of the parts, facilitating the dealing with the fragments, the removal of clots, and uniting the lateral parts of the capsule, if injured; lastly, where drainage is necessary, it is easily secured.

Lord Lister used the vertical incision: Prof. Kocher employs a slightly curved one. In any case the transverse part of the incision should never be opposite the line of fracture, and in marking out and raising a flap care should be taken to secure uniform nutrition and vitality and to interfere with the parts as little as possible. For the exposure of the fragments, removal of any intervening tissue, clearing away of clots,

drilling the bones, and passage of and dealing with the wire, the details given for the treatment of the olecranon should be carefully followed.

Either silver wire of medium size or a Y-shaped plate may be used: the former is more difficult to insert well, but secures better apposition than one or more plates, which are apt to allow some tilting of the fragments with gaping of their cartilaginous lips. A circular wire passing above, below and twice through the patella secures the most perfect

Fig. 353. Wiring patella after reflecting a flap inwards. This method of wiring secures excellent apposition.

apposition (*see* Fig. 353). This does not enter the joint to cause later trouble from friction, as in the Barker method. Above and below the wire passes through the rectus and patella tendons, and the twisted ends of the wire are buried in the rectus tendon just above the patella, where it is safe from pressure.

By some American surgeons wire has been replaced by absorbable material, *e.g.* catgut, silk, kangaroo-tendon, thus doing away with any risk of after-trouble with the wire, a risk which is nowadays extremely small. Some have gone farther and advised suture only of the torn periosteum and fibrous tissues.[1] In a number of cases this has been found sufficient, as there is no risk of the fragments here shifting longitudinally or laterally if the quadriceps extensor be kept relaxed

[1] Gibbon Rodman, *Ann. of Surg.*, June 1904, pp. 1023, 1026.

for two or three weeks. The arguments for and against this step appear to me to be as follows: Drilling the fragment is the most difficult part of the operation, and necessarily adds to the amount of disturbance of the parts, and the risk of infection. On the other hand, if the fragments themselves are not wired, the after-rest must be prolonged in order to secure bony union. Instead of the splint being removed in ten days and the patient being up in a fortnight, a period of at least six weeks will be

FIG. 354. Plating patella. After reflecting a flap inwards. The aponeurosis is also sewn.

required. During this time massage will, of course, be assiduously employed.

I have no experience of Mr. Barker's method of passing wire around the fragments.[1] Dr. J. B. Roberts [2] has employed a simpler method (*see* Fig. 354) by passing a silk or catgut purse-string suture round the fragments. These are encircled with a suture passed, by means of four punctures, through tendon and aponeurosis. This method does not open the joint, and while not securing such perfect adaptation of the fragments as is secured by wiring, has been followed by satisfactory function. One of Dr. Roberts's patients was able to carry kegs of beer up and down stairs as well as was the case before the fracture. In answer to the objection to such methods that they do not admit of removal of blood clots or fibrous tissue between the fragments, Dr. Roberts argues that

[1] *Brit. Med. Journ.*, April 18, 1896. [2] *Ann. of Surg.*, June 1904, p. 1027.

Nature will remove the former "by absorption as she has been doing for years before the open operation was advocated." As to any periosteum between the fragments, this can be removed without opening the joint by elevating the limb so as to relax the quadriceps, and rubbing firmly together the approximated fragments. The "dull crepitus at the beginning of the manipulation will be followed by a sharp bony crepitus as the fragments of periosteum are crowded away."

(2) *Certain Cases of Old Fracture of the Patella.* This important matter must be taken somewhat in detail. Lord Lister goes so far as to consider[1] that "the ununited case is in every respect worse as a subject of operation than the recent." This is chiefly owing to the wasting of the fragments and their greater separation. Again, in recent cases, there is no need to pare the fragments, for after sponging away of clots the surfaces are ready for coaptation. The chief points here justifying resort to wiring are: (*a*) Failure of previous treatment, especially in hospital patients. (*b*) A useless limb, especially in a man whose occupation entails much walking or standing, where the gait is helpless and requires much attention, or where many falls have followed involving serious risk of fracture on the opposite side. (*c*) Where both patellæ are fractured. (*d*) Where the patient is young and has many years of active life before him. (*e*) Where, if not young, the patient is sufficiently healthy. (*f*) Where enough is known of the patient's habits to ensure his being amenable.

Operation. The fragments when exposed[2] are generally found embedded in fibrous tissue, thickened synovial membrane, and old decolorised coagulum. This must be snipped or cut away, and any spirting vessels in the thickened synovial membrane must be secured. A very thin section from each fragment is then removed with a narrow-bladed saw, this needing much caution in the case of the lower one, which is the smaller of the two. If the fragments can now be pressed into close apposition, nothing usually remains save to wire them, but the case is by no means so simple where the bones are widely apart.

Thus, in one of my cases, many years ago, after paring the fragments—these were quite two and a half inches from each other—and after most forcible traction the upper could only be made to descend three-quarters of an inch. Malgaigne's hooks were applied and tightly screwed up, but with no result on the desired approximation. The lateral expansions of the quadriceps were next still more fully divided (cut muscular fibres being seen on the inner side), but the fragments were almost as far apart as ever. As the only alternative to excising the joint (in order to substitute a firm support for the flail-like limb), I now divided partially the rectus tendon, but it was not till the upper fragment was only held by a narrow stout band at its upper and inner parts that it could be brought into apposition with the lower one. The result was excellent. At the present day, elongation of the quadriceps, if needful, would be employed. In a young man with a straight stiff knee a year after the fracture, the writer divided the quadriceps in a zigzag manner and lengthened it enough to allow the knee to be bent 90° after the patella had been wired. Later the range of movement increased and power returned to the normal.

Owing to the tension, wire must be used in these cases, according to the directions given already. Owing to the bones being probably degenerated from disease, the circular method already described is particularly valuable.

[1] *Lancet*, November 3, 1883.

[2] In one case, the skin being dimpled, puckered down, and adherent between the fragments, I had to cut away a piece about three-quarters of an inch wide.

Where the lower fragment is too small to hold a wire, this may be passed through the ligamentum patellæ, as has been done by Lord Lister[1] and Mr. Teale.[2] One wire would appear to be sufficient. Though this unites the centre of the fragments exactly, a very slight interval remains at the edges but does not interfere with an excellent result. Drainage is not required.

A massive sterile dressing is firmly applied to prevent oozing into the joint and tissues around it. The limb is elevated, but no splint is applied, the dressings limit flexion sufficiently. As soon as the wound is healed, every pains must be taken, by massage, &c., to improve the atrophy of the quadriceps. Healing should be complete in two weeks.

The **question of passive movement** now arises. From the third day passive movement is gently and increasingly carried out. Also voluntary movements are encouraged. The greater part of the dressing is removed after four days, thus allowing freer movement. Usually, in two to three weeks after the operation the patient may get up and begin to use the limb (with the aid of two sticks at first), flexion and extension being diligently practised. Unless the joint is very stiff, massage, friction, and gentle persevering movement, aided by time and patience, will be sufficient. If an anæsthetic is given, movements must be made cautiously, as the patella has been refractured on this occasion more than once.[3] In every case a knee support consisting of side steels with a stop joint is used for at least three months after the wiring. This allows movement and prevents refracture from time to time, more range of movement is allowed by altering the position of the screw stop. The instrument is not used at night, and is also taken off for the exercises and passive movements.

Difficulties in Wiring the Patella. (1) Atrophied surface of the fragments, making it difficult to refresh them satisfactorily. (2) A very small lower fragment. (3) Fragments embedded in very firm fibrous tissue, fascial, periosteal, and synovial, or old coagulum. This condition will prevent satisfactory apposition unless the intervening tissue be all removed. In a very interesting case recorded by Mr. O. Ward[4] it was found, on exploring the fragments, that the capsular tissues torn off the lower fragment remained attached above, and hung like a flap between the fractured surfaces, effectually preventing their apposition. It is suggested that some such complication may, in many cases which have been treated in the usual way, cause the fragments to fall apart as time goes on. This is the view held by Sir W. Macewen,[5] who collected thirteen cases of transverse fracture of the patella, in which portions of soft tissue intervened between the fragment in such a manner as to render osseous union an impossibility. (4) A contracted, rigid quadriceps (p. 884). (5) Indipping skin (p. 884). (6) Multiple fragments. This may cause much difficulty, especially if it is the lower and usually smaller fragment which is comminuted. If the lower frag-

[1] *Loc. supra cit.* [2] *Brit. Med. Journ.*, June 9, 1883.

[3] In one of Lord Lister's cases (*loc. supra cit.*), passive movement being employed with "considerable force" four weeks after the wiring, the rigid quadriceps not yielding, the wire gave way, and the cicatrix (a long longitudinal one), which had healed save where the wire projected, opened. The joint was at once washed out antiseptically, and, six days later, some coagula were removed, and the old wire retwisted. An excellent limb was the result.

[4] *Lancet*, November 1, 1884.

[5] *Ibid.*, November 29, 1884, and March, 1887, p. 5.

ment is not large enough to bear wiring, the wire may be passed through the ligamentum patellæ. Where the fracture is multiple, the smaller fragments may first be united by fine wire, and then by stouter, to the larger one. But where they are found to be much loosened in their periosteal covering, it will be wiser to be content with carefully uniting the torn periosteum, and enforcing longer rest afterwards.

Causes of Failure or Trouble afterwards. These are mainly: (1) Infective conditions. (2) Trouble with the wire. This rarely occurs where the wire has been well hammered down, some adjacent fibrous tissue drawn over it, and the flap-incision made use of, or a transverse one lying below the site of the wire. In one of my cases of old fracture the patient returned, nearly a year later, with great tenderness over the wire. She was extremely thin, and had knelt early and much. On removing the wire I found that I had made three or four half-twists instead of two. In another case, operated on by the late Mr. Davies Colley, a small bursa, the size of a thrush's egg, containing fluid, formed around the twist. This, made with the greatest symmetry, consisted of four half-twists. Where it is nessary to remove the wire, this may be done, with the aid of eucaine, by a small incision over it. The wire is first untwisted and straightened; one end is next cut off short, and the other grasped in dressing forceps and wound round these. It is then extracted without jerking. If this step be required before a period of six or eight weeks after the operation, care not to break down the union will be needful.[1] (3) Inability to bring the fragment together in long-standing cases. Mr. Turner[2] mentions a case in which the operation was abandoned, as it was found impossible to get the fragments together after wiring them. The patient was "no better and no worse" eventually. (4) Refracture from a fall within a few weeks or months of the operation. This is common, when a splint or stop-jointed steel support is not used in the after treatment. (5) Necrosis of a fragment. This is a complication rather than a cause of failure. It is especially likely to occur after severe compound fractures in which the periosteum was much injured at the time of the accident. This happened with an upper fragment in a case of Dr. G. R. Fowler's.[3] About three months after the wiring, this fragment, about the size of a walnut, was removed. It was now found that "the joint was perfectly closed by a thick fibrous capsule underlying the necrosed portion, connected to the upper margins of the now firmly united two lower fragments, and forming a strong bond of union between the quadriceps above and what remained of the patella below." The resulting limb was useful, with considerable movement at the knee-joint. (6) With the increasing frequency with which this operation is resorted to, there is another cause of failure, partial at least, for which surgeons must be prepared in patients no longer young,

[1] The following show that the wire may occasionally excite irritation and lead to serious results. Sir W. Macewen (*loc. infra cit.*) mentions a case which came under observation three months after suture of the patella, with acute suppurative arthritis of the joint and ulceration of the cartilage. A probe passed through a sinus detected the wire surrounded by carious bone. The twist was still intact, but the loop was loose, the bone having become inflamed, softened, and ulcerated. Excision of the joint was required. This shows that occasionally the wire may excite irritation, and thus lead to serious results. Mr. Turner (*Lancet*, 1887, vol. i, p. 572) records a case in which Mr. M. Robson, of Leeds, had wired an ununited fracture of the patella, three gold wires being employed. The patient, an epileptic, probably injured the knee repeatedly, the wires worked out, and the knee-joint became acutely inflamed, requiring free incisions and drainage.

[2] *Clin Soc. Trans.*, vol. xviii, p. 41.

[3] *Ann. of Surg.*, 1885, p. 248.

and that is a condition allied to osteo-arthritis, set up by the injury, and, in part, by the wiring. A patient of mine, aged 42, in whom the healing and movements regained had been most satisfactory, returned six weeks later on account of pain and increasing stiffness in the joint. The wire was giving no trouble whatever, but both to the feel and the ear the joint gave marked evidence of osteo-arthritis; there had not been time for the occurrence of lipping.

REMOVAL OF LOOSE BODIES [1] FROM THE KNEE-JOINT

Operation. The parts should be kept at rest for some days and most scrupulously sterilised. I will draw attention to the danger in opening a large and complicated joint like the knee, even greater care being needed here than in the case of the peritoneal sac owing to the smaller power of resistance possessed by the synovial membrane. Owing to the great mobility of some of these bodies, it is well to harpoon them with a sterilised needle, if possible, at the beginning of the operation. In all cases a skiagram is taken before operation, for in many cases several loose bodies are present. The sesamoid bones sometimes seen in the gastrocnemius tendons must not be mistaken for loose bodies. A tourniquet is always used, for this makes the operation much easier, speedier and safer. The joint is then deliberately and sufficiently opened. If there is no localising evidence, the best incision is half an inch internal to the patella and its tendon, for loose bodies are generally lodged between the condyles and are easily seen and scooped out through the incision. The scoop or finger can be passed up into the pouch of synovial membrane under the crureus. This incision has the further advantage of allowing the internal cartilage to be seen from above, so that any detachment or laceration of it can be recognised. As a rule an incision 2½ inches long suffices. A similar incision on the outer side is sometimes necessary. In difficult cases a loose body may be brought into view by putting the joint through its different movements, or by flushing it out with sterile saline solution. These steps should always be taken before making other incisions which are likely to interfere with the joint's functions.

In the case due to injury (footnote, p. 886), on cutting freely into the joint, I came down upon a tiny pedunculated body attached close to a healed depressed gap in the rim of the internal condyle. As it was certain that this body could not be the offending one, the portion of detached articular rim was only found after a prolonged search in the extreme upper end of the suprapatellar pouch. The patient made an excellent recovery, and resumed his work as a South Eastern Railway porter. This case proves conclusively that the late Sir G. M. Humphry was wrong in his statement that the articular cartilages are too strong and too well protected for any fragment to be dislodged save by disorganising violence.

[1] The following classification may be useful to a surgeon about to operate for one of these bodies: (1) A thickened or indurated synovial fringe which has become pedunculated and perhaps detached; (2) a fibro-enchondroma originating in those cartilage cells which are naturally found in the synovial fringes; (3) a portion of articular cartilage detached by injury. Years ago I removed one of these loose bodies from the knee-joint of a railway porter who came to me for synovitis, with the history that the attacks dated from the time when a cask which he was moving had slipped and struck obliquely the inner side of his right knee-joint (*Lancet*, 1889, vol. ii. p. 363); (4) a bit of cartilage may, after injury, gradually become detached by a process of quiet necrosis (Paget); (5) blood effused into a synovial fringe; (6) a mass of fibrine; (7) a detached osteophyte; (8) Mr. H. Marsh (*Dis. of Joints*, p. 182) mentions a case of Mr. Shaw's, in which a loose body on removal was found to contain the point of a needle. I have known a tarred flint stone the size of a filbert removed six months after a wound sustained by a fall. The stone had caused no inconvenience for months until the boy began to play football.

Where one body has been removed the surgeon must make certain that no others are present. Mr. R. Jones [1] thus emphasises this point: "I have on three occasions had to open up a joint a second time to remove bodies evidently present from the first."

The wound is closed with interrupted fine catgut for the capsule and a continuous fishing suture for the skin. A massive sterile dressing is firmly bandaged from the middle of the leg to the middle of the thigh before the tourniquet is removed, or when there is likely to be oozing, drainage must be provided.

No splint is applied, but the knee slightly bent is secured to a soft enwrapping pillow by a few turns of bandage. The limb is elevated on a wedge pillow. On the fourth day the outer part of the dressing is removed, and a looser bandage is applied. Movements, both active and passive, are carried out and gradually increased from this time. The stitches are removed in a week, and the patient is allowed to walk with the aid of a stick on the tenth day, when flexion to the right angle is generally easy and painless. Massage of the knee and especially of the extensors of the knee is carried out daily after the wound has soundly healed.

DETACHMENT OF A FIBRO-CARTILAGE AND OTHER FORMS OF INTERNAL DERANGEMENTS OF THE KNEE

Before the question of operative interference is considered the following remarks, the outcome of exploration of nineteen cases, may be useful. I shall divide the cases into two groups: A. Where a fibro-cartilage, far more frequently the internal,[2] has been injured, and perhaps displaced. B. Where other conditions are present. A. These fall into two classes, the typical and atypical ones. (1) In the latter, not infrequently, though the fibro-cartilage may have been much injured, there is little local external evidence, and it is impossible to tell accurately what the exact condition is; at the operation, marked mischief is found. (2) Where a fibro-cartilage has been undoubtedly injured, it is not always easy at the time of operation to be certain as to the nature of the injury. In many cases where the fibro-cartilage is detached at either end, or still attached but torn through its centre, with one or more slips torn off, the mischief is obvious. But this is not so in other cases, *e.g.* where a fibro-cartilage, which there is every reason to believe to be the cause of the trouble, is found to be *in situ*. Here its mobility must be determined: if an aneurysm-needle can be easily slipped under the fibro-cartilage from end to end, and, still more, if it can be readily hooked forwards or folded backwards into the joint, the indications for its removal are obvious—for I am not an advocate of suture (*see below*)—but there are other cases not so easily cleared up and in which a thoughtful surgeon finds it difficult to be certain as to the exact degree of mischief present, and this uncertainty is increased by the limited wound which

[1] *Loc. infra cit.*

[2] The greater frequency of displacement of the internal fibro-cartilage is due to its being more fixed and, therefore, to its feeling strains more, especially strains of the internal lateral ligament, as when the flexed knee-joint is suddenly rotated outward. The internal fibro-cartilage, in addition to its attachments by the coronary and transverse ligaments, is fastened all along its convex border to the inside of the capsule, and to the internal lateral ligament, strongly. The external fibro-cartilage, on the other hand, is more weakly attached to the capsule, especially opposite to the popliteus tendon, and has no attachment to the external lateral ligament.

it is usually advisable to make. One of these is a small semi-detached tongue projecting into the joint from the posterior third of the internal cartilage. When the internal cartilage and synovial fringes are healthy the external cartilage may be found loose. B. Often much less typical cases, where other conditions than injury to a fibro-cartilage are present. Diagnosis here is often at fault: even with the great increase of these operations, we are not yet familiar with all the different conditions which may more or less closely resemble a displaced fibro-cartilage. First of course are the "loose bodies" of which I have written at p. 887. These may simulate the results of injury to a fibro-cartilage very closely. Of the other much less obvious conditions which may cause pain, re-

FIG. 355. Exploration of the knee-joint by dividing the patella vertically, thus all the joint can be thoroughly examined, and the patella is made secure by plate or wire afterwards.

current effusion, perhaps locking and a more or less defined swelling, and cripple the joint to a varying degree. I shall mention a few with which I am familiar. Time will bring to light others which I have overlooked. When a knee-joint is opened and the fibro-cartilages are found to be normal in position and fixity, where no loose body is present, the first condition to think of is (*a*) an altered condition of the synovial fringes, especially the pads, alaria, and mucosum.

I have had three cases in which I believed this condition to be the cause of the trouble. All were young adults. In none had locking been a prominent feature. On exploration of the synovial recess between the tibia and patella, a large reddish yellow fringe with its margin much thickened in places was found. In two of the cases it was easily shown that the fringe passed during certain movements of the joint between the articular surfaces of the femur and tibia. In two of the cases the synovial membrane appeared generally injected; in none of them was any effusion present. The fringes were cut away, a ligature being applied in one case, and drainage employed. All made good recoveries, but I have not had the opportunities needful to enable me to state whether the results were permanently good. Microscopical examination showed an ordinary synovial fringe, chronically inflamed

and with ecchymoses of different dates. Prof. Annandale, who did most useful pioneer work in the removal of displaced fibro-cartilages, was, I believe, the first to call attention to these bodies.[1] Dr. C. P. Flint, of New York, has recorded three cases in which he operated.[2] Excellent illustrations accompany the paper.

Mr. R. Jones, of Liverpool (*infra*, p. 891), writes: "Hypertrophy of the synovial villi is frequently confused with a damaged semilunar. The condition is much more common than is usually suspected, and I have frequently met with it when exploring joints." On one occasion, failing to find any injury to the semilunar in a case with typical symptoms, Mr. Jones, on enlarging his incision, found a ligamentum alarium actually detached and lying in the intercondyloid notch. Its removal resulted in a perfect recovery.

FIG. 356. Removal of detached internal semilunar cartilage. A vertical incision 3 inches long is made, 1 inch internal to the ligamentum patellæ. The tourniquet is always used, and nothing but instruments are placed in the wound or knee-joint.

(*b*) While the semilunar cartilage is normal in position and its attachments, it has been bruised, and the adjacent head of the tibia is the seat of osteitis and periostitis. (*c*) The parts are normal save perhaps for some injection of the synovial membrane. While making due allowance for my faulty diagnosis and the limited access for exploration, I am convinced that such cases do occur in neurotic patients, as in some other conditions submitted to frequent operation at the present day. On this subject and the varied causes of recurrent effusion into the knee-joint, my readers should consult a most instructive article by Sir W. Bennett, K.C.V.O.[3] Before leaving this part of my subject I will add two cautions, one, that in cases where only injection and other slight changes in the synovial membrane are all that can be found it will always be well to bear in mind the possibility of early tuberculosis,[4] which commonly begins in the synovial membrane near the internal cartilage. The

[1] *Brit. Med. Journ.*, 1887, vol. i, p. 320.

[2] *Ann. of Surg.*, September 1905, p. 445.

[3] *Lancet*, January 7, 1905.

[4] I refer especially to those cases where the synovial membrane is found generally injected, and some effusion is present. It is noteworthy that in one of Dr. Flint's cases the fringe removed showed the existence of tuberculosis. A generally villous or papillary synovitis would be, obviously, most suspicious.

other is one to which I have drawn attention at p. 887. This operation, especially if followed by stiffness and the treatment necessary to meet this condition, may light up, especially in patients no longer young, a tendency to osteo-arthritis.

Indications for Operation. The chief of these are: (1) Confidence on the part of the surgeon that, as regards both himself and the patient, he can secure an aseptic result throughout: (2) failure of palliative treatment, especially in recurrent cases; (3) cases of especial expediency, *e.g.*, where the employment entails especial risks, where the patient is likely to be remote from surgical aid, or where a future career or some particular pursuit will be interfered with. Thus in a case of Mr. F. J. Steward's—

> The patient—a student—had suffered for over seven years from repeated displacement, latterly brought about by quite trivial movements, such as stepping off a kerb. The operation was performed in August 1900; the cartilage, which had been completely torn from its anterior attachments, being removed. In January 1902 the patient was playing football regularly, and did not notice the slightest difference between his two knees.

Mr. R. Jones, of Liverpool, gives the indications for operation better thus: "In the first place, *I refuse* to operate in any case I see early, the subject of a first derangement. I *discourage* operation in those recurrent cases where the symptoms are transient and not followed by irritation of the joint. I *strongly urge* operation in those cases where a recurrent displacement is at times followed by acute symptoms. I advise it in all recurrent cases where a strenuous athletic life is a means of livelihood or a physical necessity. I think operation absolutely imperative in the case of men who work in dangerous places." As "of two cases, carefully watched, each refusing operation, one resulted in rheumatoid and the other in tubercular change," Mr. Jones advises "that this danger should be kept well in view, and that patients with either a tubercular or rheumatoid diathesis subject to recurrent derangement should early be persuaded to have the exciting cause removed."

Mr. Jones's paper[1] is well worthy of a most careful study from the writer's well-known experience, proved at many points by the lucid practical details, especially where he is dealing with the difficulties which are present in the diagnosis and treatment of "certain derangements of the knee."

Operation for loose internal semilunar Cartilage. The area having been carefully sterilised and the strictest precautions taken in every way, and a tourniquet applied very tightly round the middle of the thigh, a vertical incision is made nearly three inches long, three-quarters of an inch from the inner border of the patella, downwards over the interval between the femur and tibia. If necessary, the incision can be prolonged upwards or downwards and the capsule may be nicked horizontally backwards as far as the strong and definite internal lateral ligament. The reason for placing the incision at the above-mentioned distance from the patella is explained later; the most important internal lateral ligament is to be interfered with as little as possible. The capsule, together with the synovial membrane, is now incised in the same line. The condition of the fibro-cartilage is now investigated, with the joint flexed and extended. Many of the various degrees of damage which it may have received and several of the other conditions which

[1] *Clin. Journ.*, May 9, 1906.

may be present have already been alluded to. Where the fibro-cartilage is much damaged its removal is of course indicated by dragging it forward with strong toothed-forceps, and snipping it away with curved blunt-pointed scissors. A tenotomy knife is very useful to free the posterior part of the ligament. Where its condition is more doubtful,[1] *i.e.* where it is only partially frayed, I am of opinion that its removal is the wisest step. In cases of doubt the longitudinal incision must be converted into a flap, or a second incision made on the opposite side. Attempts to suture the fibro-cartilage are never advisable. This procedure is difficult: the sutures are very likely to give way,[2] and the more prolonged rest now needed—three or four weeks instead of ten days—will very likely lead to after-stiffness. The interval between the condyles is always carefully examined for loose body; a good light is essential for this, and the tourniquet by providing a clear field is invaluable. The wound is dealt with, and the after-treatment conducted, as indicated at p. 885. Suture of the capsule with separate buried sutures of fine catgut is most important here: it promotes early union of the deep parts of the wound, thus at once facilitating the regaining of movements, and shutting out the risk of after-infection. For the insertion of these sutures the capsule must not be divided close to the patella, or there will be no edge to take up.

The case that follows illustrates the liability of clamps to fail suddenly after a prolonged period of usefulness, and the presence of osteo-arthritis, in a very marked degree, in a young subject.

R. C., aged 35, had had repeated displacement of his left fibro-cartilage since a wrench of his knee when 17 years old. A clamp gave great relief for some time, but latterly this ceased to be any safeguard. In April 1894 I opened the knee-joint by a vertical incision three inches long, placed about an inch from the inner margin of the patella, and beginning opposite its centre. The first thing to come into view when the joint was opened was the inner condyle, with its margin converted into a huge lip, everted and raised and covered with a network of many minute vessels. The head of the tibia, as far as seen, presented the same appearance along its articular rim. The internal fibro-cartilage was found detached from its connections to the tibia and carried up with the femur. It was thin, flaccid, and limp, flattened out, its circumferential border having lost its thickness and convexity. No bleeding followed on snipping through its posterior attachments. The "lipping" of the cartilage on the femur and tibia was rounded off with a metacarpal saw, some sessile growths of the synovial membrane were snipped away, and two small osteophytes removed from the articular surface of the patella. The inner aspect of the joint was carefully dried out with aseptic sponges, and, as much oozing was expected from the sawn surfaces, a drainage-tube was passed into the upper cul-de-sac and brought out through the wound. The wound healed quickly; a month later the patient could walk across Hyde Park, but it was not till nearly six months after the operation that flexion and extension were completely restored, and the patient could say that there was "not much to choose between the two knees." I saw him five years after the operation; he could then use the lower limbs with equal freedom, and the movements of the left knee were quite smooth. He was able to walk, ride, and shoot with entire comfort.

In closing this subject I cannot do better than quote Mr. Jones's article[3] on the possibility of failure of operation: "Is operative treat-

[1] In all doubtful cases, Mr. Jones's advice (p. 893) must be remembered as to the possibility of more than one mechanical factor existing in a joint.

[2] Mr. M. Moullin (*Lancet*, 1895, vol. i, p. 1233) mentions two cases in which the displacement recurred after suture. In his words, "sutures and adhesions cannot make it stronger than it was before it was hurt, unless they fix it so that it is completely rigid; and if it gave way before, it will give way all the more easily a second time if exposed to a similar strain."

[3] *Loc. supra cit.*, p. 976.

ment invariably successful? The answer is emphatically, No. In the great majority of cases a perfect recovery may be predicted; in a certain small percentage the symptoms recur. The recurrences were far more numerous some few years back, when the cartilages were sewn to their tibial attachments." In other cases "it will be discovered that the so-called recurrence is due to an overlooked accessory factor in the production of the symptoms of derangement." Mr. R. Jones illustrates this by two cases:

In one the anterior half of a torn external semilunar had been removed. Slipping again occurred within a month, and, on opening the joint on its inner side, Mr. Jones found a small fibrous nodule floating by a thin pedicle.

In the other case the anterior part of the internal semilunar had been found abnormally free and removed. For some months normal function remained restored. The troubles then reappeared, with pain, referred again to the inner side of the joint. "I followed the line of the old scar and searched for a cause. I was almost closing the wound, when internal rotation of the tibia dislodged a loose body."

Operation for loose external semilunar Cartilage. A similar incision is made over the outer side of the joint, and the subsequent steps are similar to those already described.

CHAPTER XLIII

LIGATURE OF ARTERIES IN THE POPLITEAL SPACE AND LEG

LIGATURE OF THE POPLITEAL ARTERY.

Indications. Extremely few. (i) Stab or punctured wound. Here the surgeon would only resort to ligature (1) if pressure was unsuitable; (2) if suture (p. 50) was found impossible; (3) if the patient insisted on running the risk of gangrene; (4) it would be well, if possible, to get leave for immediate amputation if the vein was found injured also, and beyond remedy by suture. (ii) In some cases of ruptured popliteal artery it will be right to explore and see if any other complication exist beyond the rupture of the artery. If there is no injury to the vein, nerves, or the joint (a very unlikely contingency), the rupture should be treated by Murphy's method of resection, if possible, and, this failing, by double ligatures. The surgeon must afterwards be prepared to amputate through the lower third of the thigh on the first sign of gangrene appearing. The operation of ligature of the popilteal artery is extremely difficult here, owing to the depth of the vessel, the strong fascia, the amount of coagulated blood, and the infiltrated, obscured condition of the parts. Primary amputation will, as a rule, be required in cases of ruptured popliteal artery, especially where skilled assistance and facilities for aspectic treatment are not at hand. A free incision will enable the surgeon to investigate the amount of injury, and at the same time will relieve tension if an attempt be made to save the limb. This incision may form part of the amputation (p. 862). (iii) The artery has been wounded in the course of an osteotomy of the lower end of the femur. (iv) Traumatic aneurysm in the upper third of the leg after gunshot wound. The writer recently had a very successful case of this nature.

Extent. From the opening in the adductor magnus to the lower border of the popliteus.

Guides. *Behind:* A line drawn from just inside the inner hamstrings above to the centre of the lower part of the popliteal space. *In front:* The tendon of the adductor magnus.

Relations (in the popliteal space):

Behind

Skin; fasciæ; small sciatic nerve above; short saphena vein and external saphena nerve below; fat; glands.

Semi-membranosus above; gastrocnemius plantaris, soleus, below.

Internal popliteal nerve; popliteal vein, outside above, inside below, exactly over the artery in the centre of the space.
Branch of obturator above.

Outside	*Inside*
Biceps above; gastrocnemius and plantaris below.	Semi-membranosus above; gastrocnemius below.

Popliteal artery.

In Front

Femur.
Posterior ligament.
Popliteus.

Collateral Circulation.

Above		*Below*
Anastomotica magna, superior articular, descending branch of external circumflex.	with	Inferior articular, and recurrent from anterior tibial.

Operations. The artery may be tied in three places. A. At the upper part of the popliteal space. B. At the lower part of the popliteal space. C. At the inner side of the limb. For the sake of experience, all should be practised on the dead body.

A. **At the Upper Part of the Popliteal Space.** The patient being rolled two-thirds on to his face, and the limb at first extended, a free incision three inches and a half long is made, in the line of the vessel, along the outer margin of the semi-membranosus, and then downwards and outwards to the centre of the space. The small sciatic nerve, if seen, should be drawn to one side: the deep fascia is then freely opened up, and the pulsation of the artery felt for at the outer margin of the semi-membranosus. The nerve is generally seen first, and this and the vein are to be drawn to the outer side with blunt hooks. The needle should be passed from the vein. A good deal of loose fat is usually in close contact with the vessels, and is liable to be a source of trouble wherever the artery is ligatured, especially in the dead subject.

B. **At the Lower Part of the Popliteal Space** (Fig. 357). The limb being in the same position, an incision four inches long is made, in the line of the artery, from the centre of the popliteal space to the junction of the upper and middle thirds of the back of the leg. The external saphena vein and its nerve being avoided, the deep fascia is freely opened and the limb flexed. The exact interval between the heads of the gastrocnemius is next sought for. The following structures may now be met with overlying the artery, and must be drawn aside, viz. the plantaris, the sural arteries which run down on the vessel, and the communicans tibialis nerve. The popliteal vein now lies to the inner side, together with the popliteal nerve, which is superficial to it, if this has not given off its branches. These structures should be drawn to either side, and the needle passed as is convenient.

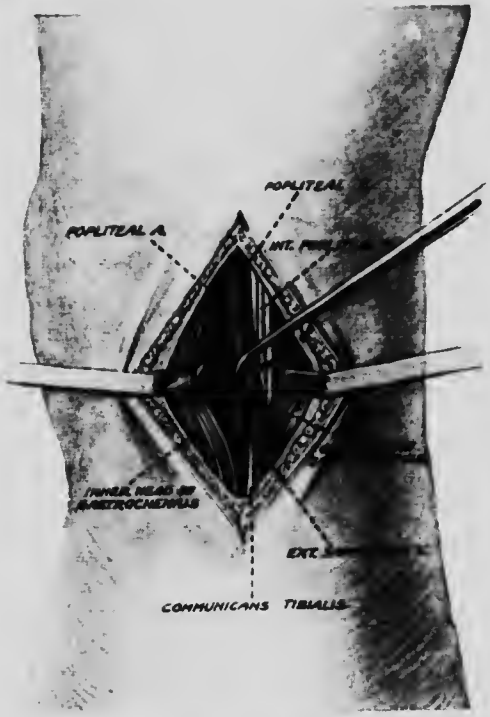


FIG. 357. Ligature of the popliteal artery from behind.

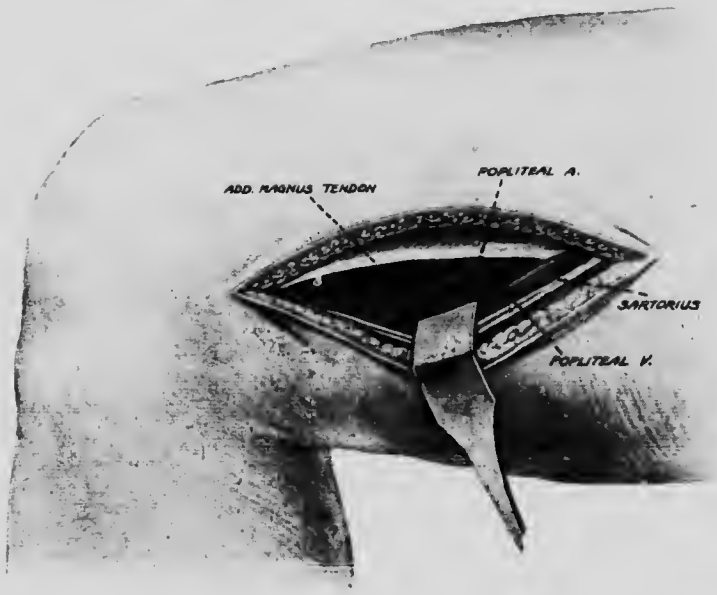


FIG. 358. Relation of parts in ligature of the popliteal from the inner side.

C. **At the Inner Side** (Fig. 358). This operation might be useful in cases where hæmorrhage recurs after osteotomy at the lower end of the femur.

The following account is taken from Sir Wm. MacCormac:[1] "Flex the knee and place the limb on the outer side. Make an incision three inches long immediately behind and parallel to the tendon of the adductor magnus downwards from the junction of the middle and lower thirds of the thigh. Divide the skin, superficial and deep fasciæ; avoid the long saphenous nerve; seek the tendon of the adductor magnus; draw it forwards and the hamstring tendons backwards. The artery will then be found surrounded by fatty areolar tissue. The nerve and vein do not necessarily come into view, being on the external aspect of the vessel."

For an account of Matas's operation for aneurysms, *see* p. 53.

[1] *Ligature of Arteries*, p. 110.

CHAPTER XLIII (*continued*)

OPERATIONS ON THE LEG

LIGATURE OF THE POSTERIOR TIBIAL ARTERY

Indications. Very few. (i) Chiefly wounds. Mr. Cripps,[1] in a very valuable paper, divides the sources of hæmorrhage from the upper two-thirds of the posterior tibial into (1) hæmorrhage after amputation: (2) hæmorrhage from injury to the vessels in continuity. (1) Hæmorrhage after amputation. This is usually due to a diseased condition of the vessels, and to the fact that the vessels lying between the bones are now especially difficult to take up. If from their constantly bleeding away it is found impossible to deal with them, the limb should at once be amputated above the knee. If the hæmorrhage occurs later on, well-adjusted pressure (p. 843) should be carefully tried, aided or followed by ligature of the femoral or by amputation higher up. (2) Hæmorrhage from wounds of the tibials in continuity. Three chief causes may lead to this: (*a*) An incised wound. (*b*) A punctured wound. (*c*) Wounds other than punctured or incised. Four methods of treatment are open to the surgeon, viz. (*a*) Pressure and bandaging. (*b*) Ligature of both ends of the vessel. (*c*) Ligature of the femoral. (*d*) Amputation. (*a*) *Incised Wound.* If this is seen soon after its infliction, the bleeding-point should be sought for and secured, the wound being enlarged if needful. If sloughing and extravasation of blood have taken place, amputation will probably be the wiser course, though, if the patient decide to run the risk, an attempt may be made to save his limb by making free incisions, providing drainage, plugging the wound (rendered, as far as may be, aseptic with irrigation and iodoform) with aseptic gauze, bandaging evenly and firmly, and tying the femoral in Hunter's canal. (*b*) *Punctured Wound.* If this is deep, and the vessel injured uncertain, the question of treatment is a very [illegible] one. Mr. Cripps shows that, in the majority of instances, pressure deserves a fair and thorough trial. If it is useless, or prejudicial to other treatment, either the femoral must be tied, or the wound enlarged to see the wounded vessel. Before these operations the features of the particular case must decide. If [illegible] made use of, it should be applied methodically and with intelligent purpose, so that it needs no alteration or repetition. (*c*) *Wounds of Vessel other than Punctured, Incised, viz. Injury to the Vessel from Fracture or Gunshot Wound.* In many conditions will be present which will call for amputation. [illegible] severity of crush; the extent of the comminution; injury to the [illegible] or both arteries, as evidenced by the condition of the foot; and the age or the general [illegible] the patient. In most of these cases, as an attempt to find the vessel involves difficulty and danger, and the probabilities of success diminish [illegible] in the infliction and treatment of the injury increases [illegible] would be less hazardous than any interference with the wound. But [illegible] frequently be needed. The above remarks apply to compound [illegible] instance of successful ligature of a lacerated femoral co-existing [illegible] and fracture of the leg is given at p. 839. (ii) Small traumatic aneurysm. The posterior tibial may be tied low down, together with the dorsalis pedis, for certain wounds of the sole or for some varicose growths of the foot.

[1] *St. Bart. Hosp. Reports*, vol. xi, p. 94. *Dict. of Surg.* vol. ii, p. 626.

Line and Guide. A line drawn from a point at the lower part of the centre of the popliteal space to one midway between the tendo Achillis and the internal malleolus.

FIG. 359. Arteries of the leg.

Relations. These differ according as the vessel is tied: A, in the middle of the leg; B, in the lower third of the leg; C, at the inner ankle.

A. *Relations in the Middle of the Leg :*

Superficial

Skin ; fasciæ ; branches of saphenous veins and nerves.
Gastrocnemius ; soleus ; plantaris.
Special fascia : transverse branches of venæ comites ; tendinous origin- arch- of soleus (above).

Outside		*Inside*
Vena comes. Posterior tibial nerve which has crossed above from the inner side.	Posterior tibial.	Vena comes. Posterior tibial nerve (above).

Beneath

Flexor longus digitorum.
Tibialis posticus.

B. *Relations in Lower Third of Leg :*

Superficial

Skin fasciæ ; superficial veins and nerves.

Outside		*Inside*
Vena comes. Posterior tibial nerve. Tendo Achillis.	Posterior tibial.	Vena comes.

Beneath

Flexor longus digitorum.
Tibia.

C. *Relations at Inner Ankle :*

Superficial

Skin ; fasciæ ; branches of internal saphena vein and nerve.
Internal annular ligament.

Outside		*Inside*
Vena comes. Flexor longus hallucis. Posterior tibial nerve.	Posterior tibial.	Vena comes. Flexor longus digitorum ; tibialis posticus.

Beneath

Internal lateral ligament.

Operation in Middle of Leg (Fig. 360). The parts having been sterilised, the knee flexed, and the limb supported on its outer side, the surgeon, standing or sitting on the inner side, makes an incision three

and a half inches long, parallel with the centre of the inner border of the tibia, and half or three-quarters of an inch behind it, according to the size of the limb. This incision divides skin and fasciæ. If the internal saphenous vein is met with, it must be drawn aside; any of its branches may be divided between two ligatures. The deep fascia is then freely slit up, and the inner edge of the gastrocnemius defined and drawn backwards. This will expose the soleus, the tibial attachment of which is to be cut through, any sural artery being at once secured. The incision through the soleus (Fig. 360) should be three inches long and quite half an inch from the tibia: as the fibres are divided, the central membranous tendon will come into view, and must not be confused with the special deep fascia or intermuscular septum over the deep flexors. Usually, before this comes into view, some additional fibres have to be divided. When this is done, the above special fascia must be identified, stretching between the bones (*see* Fig. 360). The wound must be carefully dried, well opened out with retractors, and exposed with a good light at this stage. The deep fascia being opened carefully, the nerve usually comes into view first, the artery lying a little deeper and more external. The venæ comites should be separated as far as possible, but rather than puncture them and cause hæmorrhage at this stage, or waste time, the surgeon should tie them in. The needle should be passed from the nerve. To facilitate this, the knee should be well flexed, and the foot also flexed downwards so as to relax the muscles thoroughly. The ligature will lie below the peroneal artery.

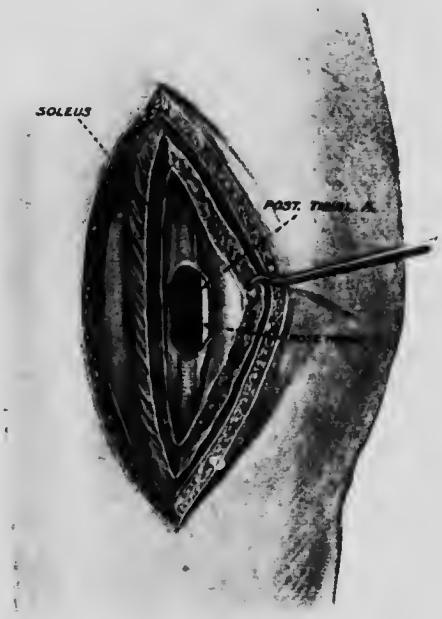


Fig. 360. Ligature of the posterior tibial at middle of the leg. The soleus is divided and retracted and the transverse deep fascia is opened to display the artery and its relations.

Operation in Lower Third of Leg. The limb and the operator being in the same position as before, an incision two and a half inches long is made through skin and fasciæ, parallel with the inner border of the tibia, and midway between it and the tendo Achillis: after the deep fascia has been opened another layer, tying down the deep flexor tendons, will require division. The artery here lies between the flexor longus digitorum and pollicis, surrounded by venæ comites. The needle should be passed from the nerve, which lies to the outer side. If the incision is made too high, some of the lowest fibres of the soleus will require detaching from the tibia; if too low, the internal annular ligament would be opened. The sheaths of the flexors (their synovial investment

commences about an inch and a half above the internal malleolus) should not be interfered with.

Operation at the Inner Ankle (Fig. 361). The limb and operator being placed as before, a curved incision, two inches long, is made, three-quarters of an inch behind the internal malleolus. Skin and fasciæ being divided, any branches of the internal saphena vein tied, the internal annular ligament is divided, and the artery found closely surrounded by its veins. The nerve lies externally, and the needle should be passed from it. The artery is so superficial here that the veins can be easily separated. The nerve has occasionally bifurcated higher up.

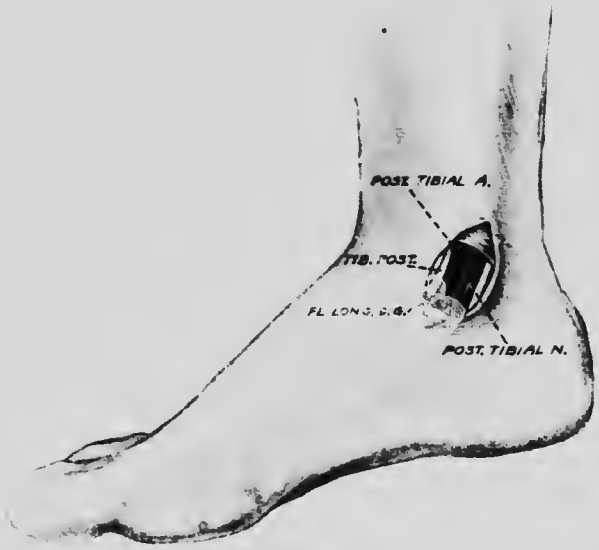


Fig. 361.

LIGATURE OF THE ANTERIOR TIBIAL

Indications. These are very few, and resemble so closely those already given for the posterior tibial, viz. wounds and traumatic aneurysm, that there is no need to go into them again here.

Line and Guide. From a point midway between the head of the fibula and the outer tuberosity of the tibia to the centre of the front of the ankle-joint; the outer edge of the tibialis anticus.

Relations:

Superficial

Skin; fasciæ; cutaneous branches of saphenous veins and nerves, and (below) musculo-cutaneous nerve.

Tibialis anticus and extensor longus digitorum (above), overlapping.

Tibialis anticus and extensor longus hallucis (below) overlapping.

Outside	Anterior tibial artery.	*Inside*
Extensor longus digitorum (above).		Tibialis anticus.
Extensor longus hallucis (below).		Vein.
Anterior tibial nerve.		
Vein.		

Beneath

Interosseous membrane.

Operation at the Junction of the Upper and Middle Thirds of Leg. The knee being flexed and the limb supported upon its inner side,

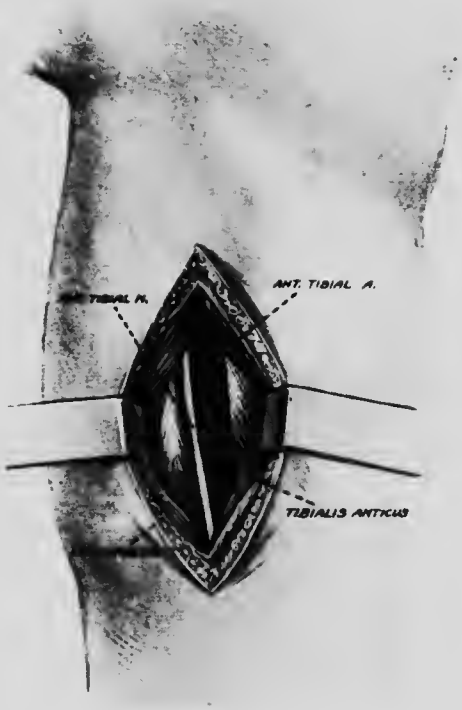


FIG. 362. Ligature of the anterior tibial artery at the junction of the middle and upper thirds.

the surgeon having defined, if possible, the outer edge of the tibialis anticus,[1] sits or stands on the outer side of the patient, and makes an incision about four inches long in the line of the artery, beginning about two inches below the head of the tibia. This incision should lie (if the edge of the muscle has not been marked out) three-quarters to one inch—according to the size of the leg—from the crest of the tibia, and should expose the deep fascia carefully, so that the white line

[1] The patient may put this into action just before the anæsthetic is taken.

which marks the desired intermuscular septum may be looked for. This line is often whitish-yellow, and varies much in distinctness. If there is any difficulty in finding it, any bleeding-points must be secured and the deep fascia slit up over the line of the artery, and the finger-tip inserted to feel for the sulcus between the muscles. A third aid is almost constant, and that is a small muscular artery [1] which comes up between the tibialis and the extensor longus digitorum. The sulcus being found between the muscles (without tearing them), they are separated with the handle of a scalpel or a steel director, and retractors inserted, the outer one being hooked over the fibula. If the limb is a very muscular one, the deep fascia should be nicked transversely at the upper and lower extremities of the wound, and the parts more relaxed by bending the knee more and pressing the foot upwards. The finger, now directed towards the interosseous space, feels for the artery deep down in the bottom of the wound. The nerve should be drawn to the outer side. If much trouble is met with in separating the venæ comites, they may be included.

Operation at the Junction of the Lower and Middle Thirds of Leg. An incision about two inches and a half long is made in the line of the artery; in the upper part, this incision will be about one inch from the tibia. The white line and the interval between the tibialis anticus and the extensor proprius hallucis are both looked and felt for. The deep fascia being divided and the muscles relaxed and retracted, the artery is found surrounded by its venæ comites. The needle must be passed from without inwards.

LIGATURE OF THE PERONEAL ARTERY

Indications. As these are extremely few, and as in the case of a wound of the vessel (which is very rarely met with) the best course would be to enlarge the wound, any formal operation for its ligature need only be very briefly described.

Relations. The peroneal artery comes off from the posterior tibial about one inch below the popliteus, descends at first parallel with this artery but separated from it by the posterior tibial nerve; it then passes outwards towards the fibula, and runs down between this bone and the flexor longus hallucis. In the upper part of its course it lies upon the tibialis posticus, and is covered by the soleus.

Operation. To tie the artery when no wound is present to guide the surgeon, an incision three inches long should be made along the posterior border of the fibula, with its centre at the junction of the upper and middle thirds of the leg. The gastrocnemius being drawn aside, and the soleus separated from its attachment to the fibula, the special deep fascia is slit up and the artery sought for close to the fibula.

[1] This was pointed out by Mr. C. Heath (*Oper. Surg.*, p. 47). I have found the same fact most helpful in the ligature of the ulnar in the middle third of the forearm.

CHAPTER XLIV

AMPUTATION OF THE LEG. OPERATION FOR NECROSIS. COMPOUND FRACTURE. SIMPLE FRACTURE AND VARICOSE VEINS

AMPUTATION OF THE LEG

Different Methods. (1) **Lateral Skin Flaps at "Seat of Election."** (2) **Lateral unequal Flaps containing Muscle.** (3) **Antero-posterior Flaps.**

Before amputating the leg, careful consideration of the level of the amputation is required. For a good artificial limb to be fitted the stump below the knee must be at least four inches long, a shorter stump here is unmanageable so that an amputation through the lower third of the thigh is to be preferred unless the patient is content to use a "peg leg" for which a very short stump is desirable as it has to be flexed into the kneeling position.

(1) **Lateral Skin Flaps, with Circular Division of the Muscles, &c.** This is a satisfactory method of amputation at the "Seat of Election" where a "peg leg" only is to be used as in old patients of hospital class. It is difficult to fit a good artificial limb here with a knee joint at the proper level, for the short stump of leg is in the way and often unmanageable, as it rarely can be fully extended. It will not only be found most convenient at the time, but it also gives very satisfactory results afterwards. The blood-supply is well and equally distributed to the lateral flaps, one can be conveniently cut longer than the other, and they are more easily shaped and dissected up than antero-posterior skin-flaps, while no mass of muscle is left to drag away from and expose the bones, as in the antero-posterior flaps, with the anterior of skin and the posterior by transfixion.

Operation. The femoral artery having been commanded, the leg brought over the table, and the damaged or diseased parts bandaged in sterilised towels—so as to give the assistant a firm hold and also to prevent his soiling the flaps later on—the opposite ankle is tied to the table. The surgeon, standing to the right of the limb, places his left index on the crest about an inch below the tubercle, and his thumb at a corresponding point behind in the centre of the limb. Looking over, he inserts his knife close to the thumb, and cuts on the side of the limb farthest from him a lateral flap broadly oval in shape and three inches long, ending at the index finger, from which point, without removing the knife, a similar flap is marked out ending on the back where the first began.[1] Flaps of skin and fascia are now dissected up, and the muscles all cut through with a circular sweep

[1] If the condition of the soft parts demand it, not only can one lateral flap be shaped longer than its fellow, but antero-external and postero-internal flaps can be employed.

of the knife at the intended point of bone-section, this sweep being repeated two or three times till the soft parts are all cleanly severed. The posterior muscles should be cut a little longer than those in front, owing to their greater retraction. The interosseous membrane is next divided, so that it shall not be frayed by the saw, and with one final, firmly drawn, circular sweep the periosteum is grooved for the saw.[1] This is then applied with the following *precautions*. The position of the fibula behind the tibia and its much smaller size must be remembered, lest it be splintered. This may be avoided by rolling the leg well over on to the inner side, and placing the saw well down on the outer side so as to start the section of the bones simultaneously, and thus ensure complete

Fig. 363. Amputation of the leg by lateral flaps. The muscles are cut obliquely and afterwards sewn over the bones as far as possible.

division of the fibula before the tibia. This object may also be effected, if the leg is held in the ordinary position, by applying the saw to the tibia, and remembering, when this bone has been sawn half through, to depress the handle, and thus complete the section of the bones simultaneously. In either case the saw should be used lightly and quickly, with the whole length of the blade, and without jamming. As the sharp projecting angle of the crest tends to come through the anterior angle of the flaps, this may be sawn off obliquely after the bones are sawn.

(2) Lateral flaps of unequal length containing muscle are very valuable for the ordinary amputation in the middle third of the leg. It is a distinct advantage to have the scar away from the end of the stump,

[1] Nowadays, with modern precautions, the old need of periosteal flaps—viz., to keep pus, &c., out of the diploë and medullary canal—is no longer present. Furthermore, these flaps are very difficult to raise, unless inflamed, especially in the thin periosteum of adults.

and some muscle is necessary for the vitality of the flaps, but the lower inch and a half are of skin and deep fascia. The site for the division of the tibia is selected at least three inches below the tubercle of the tibia and from this point, lateral flaps of unequal length are marked. As a rule the external should be about four inches long and the internal about two and a half inches. The skin and fascia are raised for an inch and a half, and the muscles are divided obliquely towards the bones, care being taken not to damage the anterior tibial vessels in raising the muscles from the interosseous membrane.

Bier's Osteoplastic Method of Amputation. The following advantages are claimed for this procedure by the inventor[1] J. H. Pringle, of Glasgow,[2] and Moscowitz, of New York:[3] (1) The patient can bear his whole weight on the stump, whether this has been made through the bones of the leg or the femur, as well as a patient can do so after a Syme's amputation. (2) He can wear an artificial limb earlier. Thus Mr. Pringle writes: "At the end of four weeks, as a rule, I fix a wooden pin-leg to the

FIG. 364. Teale's amputation by long anterior and short posterior flaps.

stump by plaster of Paris bandages, and get the patient up." The disadvantages are: (1) that the raising the bony part of the flap is not easy: a suitable saw, *e.g.*, a small one of the keyhole pattern or a Gigli's saw set in a frame, must be at hand. (2) This flap may necrose and cause trouble. (3) Longer time is obviously required.

Operation. To take the case of the leg, flaps are marked out as before, a large antero-internal or antero-external being preferred by Bier. Whatever flaps are employed, great care must be taken not to injure the periosteum on the inner side of the tibia. The next step is the raising of the osteoplastic flap. A rectangular flap of periosteum is marked out on the inner side of the tibia. This must be large enough to cover easily the sawn surfaces of the tibia and fibula, and care must be taken to cut the periosteum longer than the bone, both at the sides and margin of the flaps, so that it can be sutured in place later without any tension on the pedicle of periosteum which remains attached to the tibia. The cut edges of periosteum having been sufficiently raised, a thin bony flap is then cut out from the inner surface of the tibia partly with one of the saws mentioned above partly, with a chisel. Its base must be either snapped through or divided with a saw or chisel. Its pedicle must be carefully preserved intact. The soft parts are next

[1] *Centr. f. Chir.*, 1897, Hft. 31, S. 834.
[2] *Lancet*, November 18, 1905.
[3] *Med. News*, February 1901.

divided, the bones sawn and the vessels secured at the base of the flap or flaps, great care being taken not to injure the flap of bone and periosteum. This is now carried across the sawn surfaces of tibia and fibula and kept place by sutures of sterilised silk which take up the cut fasciæ, tendons and periosteum of tibia and fibula. If the flap be not large enough to cover the cut surface of the fibula, this bone should be divided again at a slightly higher level. Actual bony union does not appear to be absolutely essential for a perfect functional result.

SEQUESTROTOMY

As the removal of necrosed bone is most frequently required in the leg, the above operation will be described here.

Indications. The question will often arise as to whether the case is ripe for operation. The chief points bearing upon this and the looseness of the sequestrum are—(1) The time that has elapsed since the beginning of the illness; thus, two to three months will probably be

Fig. 365. Operation for acute necrosis. When pus has been found in the central canal by drilling, free drainage is provided by making a large opening into the central canal with the chisel or parting tool.

required in the case of the tibia, but more likely six in that of the femur. (2) The age and general health[1] of the patient. The younger the patient, and the more vigorous his vitality, the more rapidly will the sequestrum become detached. (3) The size of the sequestrum. The larger and more tubular the sequestrum, the slower will be the process. (4) Radiography may show separation of the sequestrum. (5) The size and amount of the new shell of bone. The more distinct this is, the more probable is it that the process of separation is complete. (6) Sometimes the sequestrum may be felt with a probe to be loose.

Operation.[2] This should be always conducted with strict antiseptic precaution throughout, for these reasons—(*a*) to prevent any risk of setting up infective osteo-myelitis; (*b*) to diminish the amount of suppuration, and so the risk of further necrosis after the interference with the involucrum which is entailed by the operation.

The limb, having been rendered a vascular by vertical elevation while the patient is taking the anæsthetic, and the application of a tourniquet round the thigh, is firmly supported on a sand bag, the surgeon makes a vertical incision on the inner surface of the tibia down to the bone. If only one sinus is present, this will probably be taken as the

[1] Freedom from syphilis and phthisis will be noted.

[2] It is supposed here that the sequestrum is one of considerable size

centre of the incision. This incision should be made to surround the sinus or sinuses so that the edges of these are removed. The soft parts, including the periosteum, are reflected with a raspatory so that the new sheath of bone, spongy and vascular, is thoroughly exposed. This is then cut into and sufficiently removed with a chisel and mallet, to expose its cavity completely from end to end.[1] No overhanging edges are left, for these prevent the rapid and permanent obliteration of the cavity by the ingrowth of the lateral connective tissues. The sequestrum is now removed with sequestrum forceps, or prised out with an elevator. If too large, it must be divided with cutting forceps. The bed of ill-formed granulation-tissue in which the sequestrum lay is then carefully examined for any small bit which may be concealed, and this tissue, together with that lining the sinuses, is all scraped away with a sharp spoon, and the cavity left thoroughly cleansed, *e.g.* with formalin solution (1 in 250), or pure carbolic acid. The resulting cavity is then

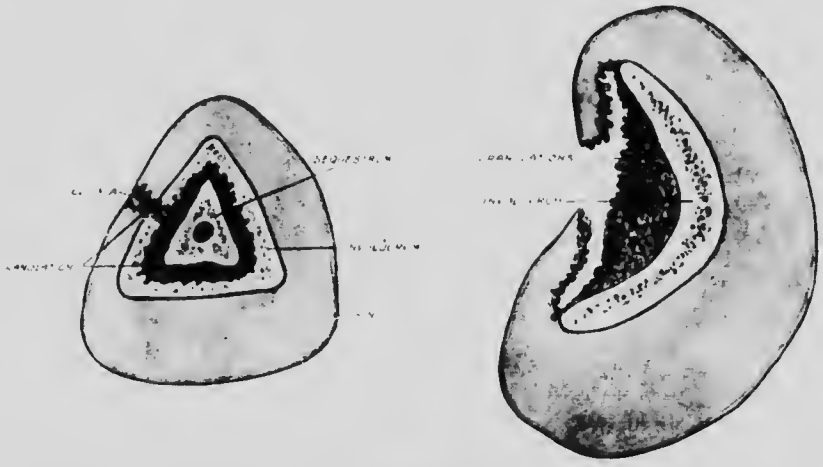


FIG. 366. Sequestrotomy. When the sequestrum is removed, all the overhanging edges of the involucrum are removed, so that the soft parts can glide in to cover the shallow pit lined with granulations which ossify in due course.

carefully plugged with sterilised gauze dusted with iodoform, the dressings being bandaged firmly on while the limb is elevated, and not till then is the Esmarch bandage removed. If the bandage is removed before the dressings are applied such free venous oozing takes place that the plugs are at once loosened and rendered inefficient, and the wound has to be re-dressed shortly. The limb is kept raised on a back splint and an injection of morphia given, if needed.

In order to curtail the period of after-treatment, which is extremely prolonged and tedious owing to the slowness with which healing takes place in the large cavity left, an attempt has been made to raise a flap which includes the anterior portion of the involucrum, by skin incisions passing down to the bone, and the latter then divided along the lines of

[1] Sir H. Howse (*Brit. Med. Journ.*, 1871, vol. i. p. 475) lays great stress on the need of this. The new bone should be removed as far as the probe can be passed upwards or downwards inside it, so as to make the whole easily granulate up from the bottom. Otherwise, the part that is not laid open will very likely persist with a sinus. Furthermore, laying the whole cavity open not only ensures its granulating up from the bottom, but also allows of the removal of all ill formed and infective material.

incision with a sharp chisel or osteotome. This having been done, the flap is prised up sufficiently to expose the cavity in which the sequestrum lies, and the latter is then removed. All the granulation tissue lining the cavity and the sinuses is now thoroughly removed with a sharp spoon, and the skin forming the margins of the sinuses excised. The cavity in the bone, the sinuses, and the surrounding skin are now thoroughly cleansed, the flap replaced and sutured, and the wound dressed. In a few cases thus treated, where the attempt at rendering the wound aseptic has been successful, rapid healing by organisation of blood-clot may take place. In some cases a small cavity may be filled with sterilised wax. It is far better and more radical, however, to remove the overhanging parts of the involucrum on one side as shown in Fig. 366, so that the soft parts may glide over the granulations which soon fill the trough of involucrum left. Later all this granulation tissue ossifies, leaving a firm well-healed limb.

As the formation of sequestra is, nowadays, very largely preventible, I shall take an opportunity here of making a few practical remarks on the disease which is largely responsible for necrosis of long bones, infective juxta-epiphysial osteo-periostitis. (i) *Anatomy of the parts first affected; its bearing on the disease.* (*a*) In a young patient, the juxta-epiphysial area contains growing cellular tissues of much activity, delicate, complicated and unstable, with an equilibrium which is easily disturbed, and a resistance which is often small; (*b*) hosts of vessel-loops are also present, imperfect in their embryonic structure, communicating freely and unable to expand; (*c*) at this age the richly cellular periosteum divides at the above area into two layers, one continuous with it, the other descending to blend with the cartilage of the joint. In the above tissues some slight injury, exposure to cold or an exanthem leads to the arrest of the ordinary pyo-cocci which, if not present in the patient, abound universally wherever men congregate. Results of such arrest are violent inflammation, hæmorrhages, thrombosis, suppuration with different lines ready for this to travel along, necrosis, and many possibilities of auto-inoculation. (ii) As *the diagnosis* is sometimes far from easy, and as this most grave disease is liable to be mistaken for acute rheumatism, cellulitis, or an exanthem, *one absolute rule should always be remembered in acute pyrexias of doubtful origin in young subjects, and that is to remember the presence of juxta-epiphysial areas.* (iii) With regard to the nature of *the early interference which is always imperatively called for*, there are two camps of opinion as to whether the periosteum is ever affected alone, *i.e.* without the medulla. In my experience it certainly is so in the early stage.

This is a question very largely affected by the surroundings. A surgeon with a well-equipped hospital at his back is very differently placed from a general practitioner in the country. The latter may feel confident that a free incision may be safely made down to the bone, in the case of the femur in either of the sites given at p. 860. The following would be indications to my mind for exploring and endeavouring to disinfect the medulla itself: (1) gravity of the general symptoms from the first; (2) obscurity of the local symptoms; (3) failure of relief after free incision of the periosteum: (4) a soft condition of the bone when cut down upon, to the finger or director.

Two more questions connected with the above disease require to be alluded to; viz. those of **amputation** and the performance of **early subperiosteal resection,** *i.e.* as soon as the bone is dead, and before any

new shell has formed around it. The following are some of the conditions in which the question of **amputation** will arise: failure of the above treatment, especially if initiated late; involvement of joints, especially if drainage of both knee and ankle has failed; presence of chronic septicæmia or pyæmia and the existence of other pyæmic lesions; a patient with a vitality so low as to render him unequal to meet further calls upon it.

Early subperiosteal resection. This is so simple an operation in the case of the tibia, and its advantages over the expectant treatment are, at first sight, so great, that it has frequently been performed. (1) Thus it removes what may be the source of dangerous infection, and (2) it avoids the need of any operation for the removal of a sequestrum, and the tediousness of waiting and of the after-convalescence. The very serious disadvantage of shortening of the limb which has occurred in the majority of cases, though the fibula is present to act as a stay between the knee- and ankle-joints, more than outweighs the above advantages. This shortening has occurred even when the periosteum has been carefully preserved and even portions of the ends of the diapyhsis left to ensure portions of the epiphysial cartilages persisting. While I am aware that successful cases have been reported, we hear nothing of the unsuccessful ones. The results are extremely uncertain owing to causes at present not definitely known. Where regeneration of bone has not taken place the limb is an extremely useless one (p. 912). Nowadays early diagnosis and early operation should render these cases of extensive necrosis extremely rare. Where they occur, it is possible that the Röntgen-rays by the information they may give as to the thickness of the periosteum and the involucrum will very likely enable the sequestrum to be removed at an earlier date.

BONE-GRAFTING. FILLING UP OF BONE CAVITIES

Sir William Macewen[1] has done much work on this subject, and many years ago succeeded in building up the shaft of a humerus with pieces of bone removed during osteotomies.

Friedrich, of Griefswald,[2] reported rapid healing and good functional results in two cases in which the diaphysis of the tibia and femur had been removed and replaced by the corresponding shaft from another human being, the bone used being first deprived of its marrow and sterilised by boiling. In a girl, at 8, in which the entire shaft of the femur had been removed for an endosteal sarcoma, a child's tibia was used. Healing was rapid, and the child was able to run with the help of a splint and cane. In another child 14 cm. of the femur were replaced by part of the femur from a woman who had died of gastric cancer.

A modification of grafting which may be termed **bone-transference** may be usefully employed in the case of two contiguous long bones.

Dr. Huntingdon, of San Francisco, drew attention to this commonsense and useful principle,[3] with a successful case, though his paper is lacking in details of technique, where these are most needed. Dr. Donald, of Paisley,[4] successfully employed the same principle in a boy of five. As in Dr. Huntingdon's case, sub-periosteal resection of the tibia had been performed for infective osteo-periostitis, and in each case the limb

[1] *Ann. of Surg.*, vol. vi, No. 4, p. 301.
[2] *Germ. Congr. of Surg.*, April 1904.
[3] *Ann. of Surg.*, February 1905, p. 249.
[4] *Brit. Med. Journ.* May 12, 1906.

was useless. "An incision was made in the original scar in its lower half and the deeper tissues retracted so as to form a suitable furrow for the reception of the bone-graft. Another incision was made over the lower third of the fibula and the superficial structures separated from the bone and periosteum. A segment of bone, about two inches long, composed of half the thickness of the fibula with its attached periosteum, was split off by a chisel, and laid in the prepared furrow." When the dressings were first changed at the end of two weeks, the wound was found to be suppurating. Small crumbs of bone came away, but the wound gradually healed well. About nine weeks after the operation the tibia was rigid in its whole length, and abnormal movements could no longer be performed. Skiagraphs taken at intervals showed increasing thickness and density of the tibia. Seven months after the transference of bones the boy was able to walk quite well, although there was some shortening of the leg. This method deserves extensive trial. Two points especially need attention: (1) Thorough sterilisation of the bed for the graft; (2) attention to the position of the foot and support to the tibia, while this is solidifying.

Filling up of bone-cavities. The following methods are available here. In all it is absolutely essential that the cavity be devoid of infection of any kind. The circumjacent area must be regularly resterilised from time to time.

(1 By detaching flaps of skin and soft parts and so "papering" the cavity which must be first carefully freshened. This method may be aided by skin-grafting. It has been alluded to at p. 876. If any portion of a muscle has formed part of the soft tissues used, adhesion of this to the cavity and subsequent interference with its action must be prevented by passive and active movements being begun two or three weeks later. The limb should not be used until six or eight weeks have elapsed.

(2) By the use of decalcified bone. The cavity having been carefully refreshed, and the periosteum if possible detached, the cavity is entirely filled up with the decalcified fragments over which the periosteum and soft parts are, separately, drawn together, if this be possible.

(3) By various "fillings." Most of these have proved failures. The following account of the method of V. Mosetig inserted by the editors, Dr. W. T. Bull and Dr. J. B. Solley, in the third volume of their translation of V. Bergmann's *System of Surgery*, p. 703, is worthy of careful attention. "The method as reported by V. Mosetig[1] before the Gesellschaft für Aertze, in Vienna in January of the same year, and which he had used during the previous three years, in over a hundred cases of caries and necrosis, was as follows: Under application of the Esmarch and with strict antisepsis the periosteum was lifted off and all diseased tissue removed thoroughly with sharp spoon, &c., until positive that the cavity was aseptic. The result depended upon the latter condition and the sterility of the filling. The filling consisted of iodoform, 60·0; spermaceti and oleum sesami, āā 40·0, heated slowly to 100° C. in a flask on a water-bath; kept at this temperature for fifteen minutes; then removed and allowed to cool and solidify, while shaking constantly. Before using, it is melted and heated to 50° C. in a thermostat After the cavity has been cleansed of all diseased tissue, it is washed out thoroughly with a 1 per cent. solution of formalin, dried out with swabs and then with hot air and filled with the melted mixture. The periosteum and skin are then sutured without drainage and a dressing applied. In

[1] *Münch. Med. Woch.*, 1903, No 2.

fourteen days the dressing is changed and the skin sutures removed. The course is almost afebrile, and there is never iodoform intoxication. The hardened filling is gradually replaced by granulations and new bone as demonstrated by the X-ray (Holzknecht). The patient can be about. The size of the cavity, according to Silbermach,[1] is no contra-indication, in some instances two-thirds of the shaft having been removed and replaced by the filling. The same author emphasises [2] the importance of absolutely checking all bleeding and drying out the cavity with hot air, and describes the electrical hot-air apparatus used in V. Mosetig's clinic.[3] To check the oozing of blood even more surely, Damianos [4] swabs out the cavity with adrenalin pledgets after thorough cleansing and drying with hot air. He cites 150 cases treated successfully, and attributes the results to extreme care in the technic and in determining the time of operation. According to Damianos v. Mosetig prefers a flap section to direct incision. In chronic osteo-myelitis the cavity can be plugged at once, but in acute cases not until several weeks after the onset."

NEW GROWTHS OF FEMUR AND TIBIA

Myeloma has been referred to in the chapter on the surgery of the bones of the forearm. In the [illegible] section was the chief operation in question, here it is scooping out of the growth, scraping the wall and filling the cavity after Mosetig's method, or in late cases with invasion of the coverings of the bone, amputation may be necessary.

In the **femur**, periosteal sarcoma requires amputation at the hip-joint by skin flaps and division of all the soft parts as high as possible is usually the only operation available. It is possible that the use of the Röntgen-rays may by rendering an earlier diagnosis possible, improve the prognosis which is at present so grave owing to the probable existence of metastases. In the endosteal variety affecting one condyle, scooping out of the growth, resection of the bone affected and excision of the knee have all been performed, but the risk of reappearance of the disease and the doubtfulness as to the utility of the limb render amputation which is usually sufficient if performed high up in the thigh with careful inspection of the medullary canal, a preferable step. But here, again, the Röntgen-rays if employed early, and aided by a free exploratory incision made without delay, may increase the possibility of saving the limb.

In the **tibia** and **fibula**, where the growth is an endosteal myeloma, from the presence of two bones and the somewhat simpler access, resection of the bones and scooping out of the growth have to be considered as well as amputation. Mr. Morton has resected the knee-joint in two cases.[5] The after use of the limb was good. As already stated, long duration, slow progress of the growth, uniformity of expansion, no evidence of increased size of the shaft, indicating extension along the medulla, or of escape of the growth into the soft parts are amongst the chief points to bear in mind when any of the less radical operations are performed. The Röntgen-rays may not only be of assistance in clearing up early a doubtful case, but also in showing the degree of thickness of the bony capsule as indicated by a darker zone contrasting with the

[1] *Münch. Med. Woch.*, 1903, No. 20.
[2] *Centr. f. Chir.*, 1903, No. 25.
[3] *Deut. Zeitsch. f. Chir.*, Bd. lxvi, p. 589.
[4] *Centr. f. Chir.*, 1904, No. 6.
[5] *Brit. Med. Journ.*, 1898, vol. i, p. 228.

adjacent lighter area, and whether the growth has perforated externally. Egg-shell crackling and pulsation are more often talked of than seen.

In the **operation for scooping out**—it is rarely an **enucleation**—the following points may be of service. The parts having been duly sterilised, and the hæmorrhage controlled by an Esmarch bandage, the growth is exposed by a sufficient flap or longitudinal incision on the aspect which gives the best access. If the periosteum be not infiltrated, it should be raised, care being taken not to rupture the capsule. With stout scissors or a chisel this is next freely opened. If it be possible the growth is now enucleated entire. But its friability and its adhesions render this rarely possible. The only mode of removal is usually that by sharp spoons. During their use the capsule must not be perforated, and cavities accessory to the main one should be looked for. Hæmorrhage now may cause much trouble.

In a case operated upon by Dr. J. C. Bloodgood,[1] the shell was found to be perforated by 25 or 30 vessels as large as the temporal artery. Each of these openings was plugged with Horsley's wax. No return of bleeding took place, but it was two weeks before all the wax was removed. The history of the case is only carried up to three months after the operation.

Where the result of the scooping out appears doubtful, the cautery, pure carbolic acid, or a strong solution of formalin should be tried. The wound is plugged with strips of gauze. The long process of healing of the cavity where this is large may be hastened by one of the steps given at p. 912.

Even where there is no local reappearance, the above operation may fail owing to metastases, or to the shell left being too weak to support the leverage of the parts below or the weight above. Where a free exploratory incision has proved that the endosteal sarcoma is a mixed one—and these growths are by no means always myelomata—amputation through the knee-joint or the lower third of the thigh is the only course. Owing to the aggravated disappointment which attends a local reappearance after an amputation, I prefer the latter step. And this operation is the only one in periosteal sarcomata of the bones of the leg.

TREATMENT OF COMPOUND FRACTURES[2]

The following **special points for consideration** arise here, viz. (1) The treatment of the wound; (2) The reduction of protruding fragments and the treatment of splinters; (3) Complications; (4) The question of amputation.

(1) In *the treatment of the wound* the one great object is to convert the fracture as soon as possible into a simple one. In a few cases, sealing a small, *clean cut* wound, the skin having been carefully washed with acetone, sterilised with tincture of iodine and at once with dry gauze, and collodion and iodoform, or tinct. benz. co., may be sufficient. The fracture is set under an anæsthetic and while powerful traction is maintained plaster bandages are applied in the lower limb from the tuber ischii to the toes, to maintain the fragments comfortably in apposition. A gap is left opposite the wound, for frequent dressing. But where the surgeon's

[1] *Johns Hopkins Hosp., Bull.*, May 1903, p. 134.

[2] From the frequency with which these occur in the leg this subject will be treated here.

surroundings admit of it, and where there is reason to be suspicious about the soil at the spot where the injury took place, it will be better to make an incision and disinfect the ends of the bones. In those cases, common enough in large hospital practice, where the wound is extensive and lacerated, and accompanied by great contusion of the soft parts, with abundant blood extravasation, with much comminution of fragments and injury to the periosteum, or where the facture is complicated with a dislocation, the following method will be found to give the best results.

(2) *Protrusion of Fragments.* It is usually the upper one which protrudes. The difficulty of reduction is in proportion to the obliquity of the fracture, the length of the protruding bone, and the amount of spasm. The wound having been freely enlarged, an attempt must be made by manipulations to bring the fragments into accurate apposition. This will often be facilitated by means of a strong elevator inserted between the fragments, and used as a lever. Division of the tendo Achillis or possibly of other tendons may also be found necessary before satisfactory reposition can be accomplished. Failing all these, part of the bone must be removed with a narrow-bladed saw, care being taken to separate the periosteum first, and to protect the soft parts with a blunt dissector passed under the bone and by retractors. If the bone is splintered, some judgment is required as to what pieces to remove. Those which are still adherent by their periosteum should be left. Those completely isolated must be removed, whether they carry their periosteum or not. As to a third set partly adherent, partly not, these are usually left in good position for they are useful in promoting union and our knowledge of the value of bone grafts makes us chary of sacrificing valuable material. If after reduction it is found that there is any considerable tendency to the reproduction of the deformity, the fragments must be fixed either by means of plates and screws, &c., as suggested by Sir W. A. Lane. If the wound is likely to have been infected, it is sometimes wise to be content with cleansing and draining it, and to defer plating until the operation can be carried out aseptically. In most compound fractures the wound is drained when plating is adopted.

While the anæsthetic is given, the leg is shaved and cleansed with a 1 per cent. solution of iodine in petrol. A tourniquet is applied after the limb has been raised. Any skin which is much damaged or into which dirt has been ground is first cut away. The wound having been freely enlarged and all recesses well opened up, the blood-clot is washed away and the whole surface of the wound thoroughly sponged over with swabs soaked in hot carbolic acid solution (1 in 30) or biniodide of mercury (1 in 2000) or iodine. Where dirt has been ground into the fragments, this must be gouged out or shaved off with a stout knife. Pure carbolic acid may be safely applied to any isolated area which cannot be safely removed. The fragments are now reduced (care being finally taken that nothing intervenes) and fixed, if needful, as described at p. 920, and counter-openings made for drainage as may be found necessary. The tourniquet should not be removed until there has been time for the antiseptics used to soak into the parts; all haemorrhage being now arrested, and any torn nerves pared and secured, the recesses of the wound are well dried out. Sterile dressings are applied or a boracic acid fomentation according to the confidence which the surgeon is able to feel in the disinfection of the wound, and the limb put up either in a back and two side splints with any needful

interruptions, or, according to Mr. Croft's directions, in plaster of Paris. Another excellent means of using plaster of Paris is in combination with metal strips so as easily to provide good access to the injury. A sterile bandage is first applied below and above the wound, two to four strips of thin malleable metal are then applied antero-posteriorly and laterally as well if needful, bent outwards over the area adjacent to the fracture, their extremities being embedded in the plaster of Paris bandages as these are applied. Of the above I prefer the first and the third, in severe cases, for the first week; infrequent dressings, wherever practicable, are most essential. But in trying to secure this end, the risk of shutting in injection must not be forgotten.

(3) *Complications.* My space will only allow me to enumerate these. They are local and general. The former include pruritus, vesicles, ecchymosis, suppuration, œdema, phlebitis, gangrene, osteitis, caries, necrosis, muscular spasms, dislocations, and implication of a neighbouring joint. The general complications are such as are common to all injuries, viz. traumatic fever, delirium, erysipelas, septicæmia, pyæmia, hectic, tetanus, jaundice, and retention of urine: in older patients a tendency to hypostatic congestion and broncho-pneumonia, and finally, in a few cases, pulmonary fat-embolism.

(4) *Question of Amputation.* The following are amongst the conditions requiring primary amputation: (1) When a limb is torn off by a cannon-ball, a portion of shell, or by machinery. (2) When the division of the soft parts is nearly complete, except in the case of a clean cut across the phalanges, metacarpus, or metatarsus: even the forearm may occasionally be saved under similar circumstances. (3) When there is much actual loss of soft parts, as when one side of a limb is torn away, or the skin is extensively peeled off. (4) When, with or without great comminution of the bones, there is much bruising and laceration of the soft parts, with protrusion of muscular bellies, and extensive tearing up of deep planes of areolar tissue. (5) In some cases when the principal artery and nerves of the limb are both divided; thus, in the case of the lower limb, primary amputation will usually be required. (6) In certain cases of severe hæmorrhage, primary or secondary. (7) Some cases of compound fracture of large joints, viz. when one bone is shattered or more than one is broken; when there is much laceration of the ligaments; when, in addition to comminution of the bones, there is much contusion of the soft parts, especially if complicated with division of an artery; when the foreign body which has caused the fracture remains in the joint, or, projecting into it from its bed in the bone, cannot easily be removed, or when there is much damage to the articular surfaces. It will be understood that all these forms of injury are most fatal when affecting the knee or hip: in dealing with other joints much greater latitude may be allowed.

Finally, before deciding on amputation, the surgeon must take into consideration, in addition to the above points which concern the fracture itself, any general information to be gained about the patient himself. Thus, the age, constitution, habits, any sign of visceral disease, and the appearance of the patient, are all points of material importance in coming to a decision between amputation and an attempt to save the limb. Thus, to make my meaning clearer, there are no more anxious cases than severe compound fractures in dwellers in large towns, who are past middle life, flabbily fat, with dilated venules about the cheeks

and nose, whose conjunctivæ are slightly jaundiced, the urine of low specific gravity and perhaps albuminous.[1] The surgeon must here bear in mind that saving the patient's life is, after all, of more importance than the preservation of his limb.

In performing amputation in these cases of compound fracture it is always to be remembered that the injury is not so localised as would appear from the surface; thus, in compound fracture of the leg there is often extensive loosening of the skin from the deep fascia, and extravasation of blood into the deep planes of connective tissue for some distance above, the knee-joint being perhaps full of blood, and its cartilages bruised. In such cases, if amputation be performed just above the injury, sloughing and separation of the flaps will inevitably follow. On the other hand, in cases of severe compound fracture of the thigh, where amputation is required high up, it will be found better practice to amputate, in part at least, through injured tissues.[2]

If, in addition to the fracture, there are serious injuries to other organs, immediate amputation is useless or injurious. The only chance of recovery here is afforded by secondary amputation after the early dangers are past.

Secondary amputation may be required for profuse suppuration with hectic, for gangrene, or uncontrollable hæmorrhage. The decision must here be made according to the needs of each case. The surgeon must, if possible, wait till the infective fever and constitutional disturbance are subsiding, till the temperature has begun to fall, and till all redness, erysipelas, and sloughing have ceased. On the other hand, if the operation be deferred till the powers of the patient are running down from profuse suppuration and hectic, and till confirmed asthenia has set in, the period of performing it will, very probably, have passed away.

At a still later period the operation may be desired by the patient, if, in consequence of non-union, incurable deformity, or tedious bone disease, the limb has become an encumbrance to him. Some of these conditions may, of course, be treated by resection, osteotomy, &c.

OPERATIVE TREATMENT OF SIMPLE FRACTURES

The wider adoption of this step has been strongly advocated by Sir Arbuthnot Lane,[3] on the grounds chiefly that (1) it is perfectly safe nowadays, (2) that otherwise the results are often bad and very frequently disabling, and (3) that it saves time.

(1) At the present date the opinion of most surgeons is that it is only in a small proportion of cases of fracture of the leg and Pott's fracture —conditions which will be considered separately—that operative interference is justifiable, for the following reasons. The value of any treat-

Note will also be taken of the occupation, as in brewers' draymen and commercial travellers.

[2] Thus, in the case of a young railway porter, whose thigh was smashed by a railway accident at Epsom, I performed amputation at the level of the lesser trochanter, in preference to the hip joint. The damaged flaps sloughed, as I expected, but the patient made a good recovery, after the removal of some dead bone. All the precautions which may be taken against shock before, during, and after the amputation, will, of course, be adopted in these cases.

[3] *Clin. Soc. Trans.*, vol. xxvii; *Clin. Journ.*, July 1897, and elsewhere.

ment, especially in a very common injury, must be estimated by the extent to which it is available by the great majority of those called upon to employ it, or to put the matter in Sir W. Bennett's words:[1] "it is quite impossible—and this is a fact that cannot be too strongly insisted upon—to estimate the value of any method of treatment upon the evidence of the report of the successful cases only. It is equally impossible to gauge the general value of any method of treatment upon the experience of a few individuals. Although a certain number of surgeons may be able, from the circumstances in which they work, or from special aptitude in operating, to produce results which are practically ideal, it does not necessarily follow that the same result can be achieved by the general body of those who attempt the same method." I need not point out that while the skin in these cases of simple fracture of the leg is unbroken, it is very often in a condition which renders it impossible to say that operative interference is, even nowadays, without risk. At the usual site of fracture it is thin and of little vascularity, its vitality is diminished by the injury; blebs and extravasation may be present. The needed thoroughness of the sterilisation can only be secured at the risk of further damage. Moreover, the patients are often habitually inattentive to cleanliness, and drunken habits may be a further complication.

(2) In my opinion the proportion of cases in which the use of the limb has been permanently impaired and the wage-earning capacity of the patient seriously diminished has been much exaggerated. To get at the truth, I consider it essential that in such cases the patient should be examined as to the accuracy of his statements by the surgeon himself. Written reports from patients have little value in my eyes. The patient's powers have to be tested by experienced and watchful eyes, and the influence of club-money and expected remuneration from actions at law to be duly weighed. That the real disability is small is confirmed by such results as Sir W. Bennett[2] obtained from his inquiries amongst practitioners in mining and colliery districts, and those who had to do with sailors in large numbers who have suffered from fractures at sea and under other disadvantageous circumstances. On this point Sir William speaks as follows: "The result of my inquiries in this respect is that I find the real disability following upon fracture is not so great as one would be led to suppose from recent writings on the subject." . . . "The fact of the matter is, I believe, as follows. In spite of what may be said to the contrary, the disability following upon fracture is much more frequently due to matting of the parts about the fracture and about the joints immediately concerned than to faulty union of the bones themselves." . . . "I believe that if in case of fracture early passive movements were methodically used so that all chance of adhesion of the parts is prevented, very much less would be heard about the disabilities in such cases than we hear now." Mr. R. W. Murray, Surgeon to the Northern Hospital at Liverpool in a paper on "The Ultimate Results of Eighty-eight Cases of Fracture of the Tibia and Fibula,"[3] writes, "In the vast majority of the cases of oblique fracture the men were able to resume their former work." While the subject of the function of the limb is being referred to, I would remind my readers that though the functional results of non-operative treatment may be excellent the Röntgen-rays may reveal the persistence of a marked deformity. As

[1] *Treatment of Simple Fracture*, p. 16; and *Brit. Med. Journ.*, October 7, 1899.
[2] *Loc. supra cit.*, p. 22.
[3] *Brit. Med. Journ.*, October 19, 1901.

to the gain of time by operative treatment in simple fracture of the leg this is certainly not so marked as in fracture of the patella. The plate, while an excellent means of holding the fragments together, sometimes requires removal, and in future as the early use of passive movement, which Sir W. Bennett has advocated so strongly, becomes more general the time required before the patient's employment is renewed will be materially shortened (*see* Fig. 367).

Indications for Operative Interference in Simple Fractures. A. Those cases of spiral or oblique fracture in which careful attempts guided by radiography have failed to reduce the displacement satisfactorily: or where reduction is effected, but on the patient's recovering from the anæsthetic the fragments slip apart into a bad position as shown by radiography. Operation is especially indicated for irreducible fractures near joints, where malposition is likely to interfere with movements. B. Some cases of Pott's fracture. The general health, vitality, and

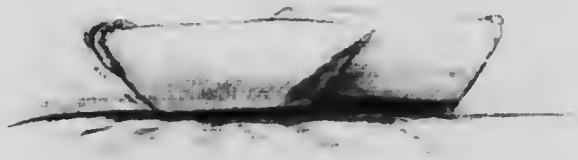


Fig. 367. Oblique or spiral fracture of the tibia. The bone is exposed for at least two inches above and below the fracture, and the skin is excluded from the field of operation by attached gauze pads.

habits of the patient must be satisfactory, and the surroundings such as to ensure an aseptic result being secured. C. Most cases of fracture of the patella and olecranon with separation of the fragments.

Operation. A. Fracture of the tibia may be taken as an example. The entire leg, foot and toes are most carefully prepared (p. 915). Any blebs should be incised after painting with iodine. The sterilisation should be carefully repeated when the patient is anæsthetised. The fragments are best exposed by a longitudinal incision over the superficial aspect of the tibia: Aseptic pads are clipped over the edges of the wound so that no skin is exposed. Any intervening blood clot or muscle or fascia having been removed, the fracture is reduced, often a matter of much difficulty. While extension and counter-extension are made by assistants, the surgeon prises the fragments into their correct position by means of a strong elevator and lion-forceps, any comminuted fragments which admit of it (p. 911) being accurately fitted into place. By bending the limb at the site of fracture, overlapping ends can be brought together, when powerful traction has failed (*see* Fig. 368). When the ends are thus locked, the limb is gradually straightened without reproducing the displacement. If it is necessary to remove part of either fragment the periosteum must be detached: otherwise this membrane is left carefully *in situ*. While the corrected position is maintained by Lane's forceps, or extension and counter-extension, the fixation is carried out. Various methods are used for this.

(1) **Lane's plates** are excellent. They are of vanadium steel, very

strong and of various sizes, and they are affixed by steel screws of various lengths and thicknesses. A series of drills or bradawls should be at hand, and the one selected should be slightly smaller than the screw (*see*

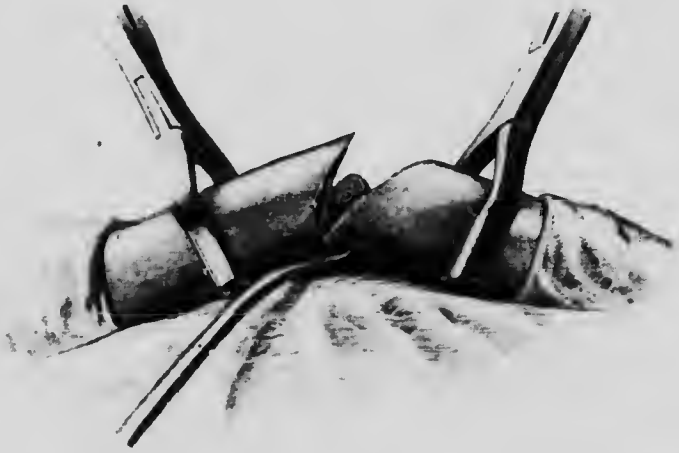


Fig. 368. Oblique fracture of the tibia being reduced by angulation and leverage.

Fig. 369). The screws are held by special forceps as they are driven in by a screw-driver. Throughout the operation no hands, gloved or otherwise, invade or touch the wound, plates or screws. One or more plates are

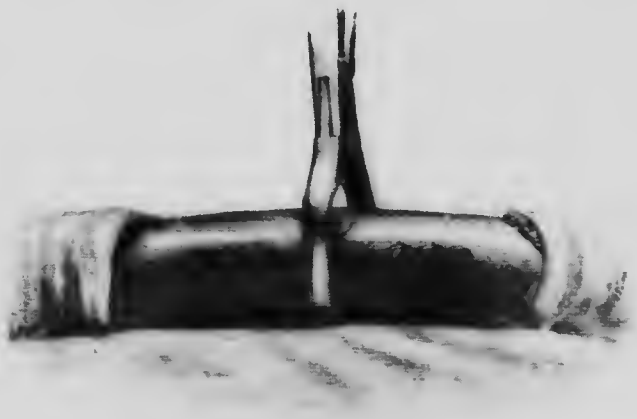


Fig. 369. Oblique fracture of the tibia held in apposition by forceps while it is plated.

used as required to maintain perfect apposition. Bleeding is arrested and the wound is closed with fine catgut for the muscles or fascia, and fishing gut or Michel's clips for the skin.

(2) **Long screws.** These are especially indicated where the fracture is known to be an oblique or spiral one. They are very valuable for fractures of the neck of the femur, and for vertical or oblique fractures of the lower end of the femur extending into the knee joint. Also for Dupuytren's and some Pott's fractures.

(3) **Wire.** While this material does not give such firm hold as plates and screws and while, if used in the ordinary way, it involves more complete exposure of the fragments, it is always available and easy of application, and if it gives after-trouble, it is more easily removed than a plate. It is very valuable for fracture of the patella. One or more strong circumferential silver wires are valuable and simple means of securing oblique or spiral fractures. To prevent slipping two notches may be made on the bone. However the wire is employed, its ends should be well twisted and embedded. The wire should be supple. The most useful sizes are Nos. 5 and 6, French gauge.

(4) **Dovetailing or Mortising the Fragments.** Very occasionally, the condition in which these are found lends itself to cutting them into step-like shape, or zig-zag fashion, so as to secure better interlocking. If necessary they are thus secured with a plate, screw or wire. In one case I impacted the shaft of the radius into the expanded lower extremity. The overlapping fragments of the ulna were shortened and plated. The result was excellent.

(5) **Gussenbauer's Staple.** This very simple method deserves a wider knowledge in this country. If any sinus form, and the staple give evidence of becoming loose, the adjacent skin must be kept sterile.

Pott's Fracture. B. Pott's fracture is one of the most troublesome fractures to set accurately, and the ultimate results of conservative treatment are in many cases deplorable. It is common to find talipes valgus when the patient begins to walk, and this deformity gradually increases and sets up arthritis changes in the ankle so that ultimately a rigid abducted and everted foot is a common result. This seriously interferes with the patient's activity and earning capacity. It is important here to consider, (i) the immediate treatment of Pott's fracture and (ii) the correction of deformity and restoration of function in late cases.

(i) **The Immediate Treatment of Pott's Fracture.** (*a*) *Conservative Treatment.* Every endeavour should be made to set the fracture accurately, and for this an anæsthetic is absolutely necessary. The knee should be well flexed, and while it is firmly held by a strong assistant powerful traction is made upon the foot, and the latter is strongly adducted and inverted while the fragments are manipulated into position. In some cases it is necessary to divide the tendo Achilles, flexion of the knee failing to afford a sufficient relaxation of this powerful tendon, which is a strong hindrance to reduction. The setting should be carried out as soon as possible after the accident, for it is much easier to get a good position before extravasation of blood and effusion into the tissues shorten the muscular and other "ties" around the ankle. Whenever possible, the setting should be actually guided by the X-rays. When this is impracticable, the result should be checked by subsequent screen examinations. While the foot is held in a good position at least three wide plaster bandages are applied from the knee to the toes, and the correct position is maintained until the plaster has firmly set. Talipes equinus is avoided, the ankle being dorsi flexed to the right angle. When there is but little swelling it is only necessary to put a thin bandage under the

plaster, but when there is much swelling, and especially if there are blebs, the limb is painted with tincture of iodine and covered with a layer of cotton wool of moderate thickness before the plaster bandage is applied. The position of the fragments is later ascertained by screen examinations, and if the setting is not satisfactory it must be repeated. The splint is not removed for ten days, but after that time it is taken off daily for massage, movement and exercises, and it is finally abandoned about five weeks after the accident, but the patient is not allowed to stand or walk for two months, and then the inner border of his boot is raised a quarter of an inch to prevent the development of abduction from the gradual giving way of the line of fracture. Better still, a double

Fig. 370. Showing antero-posterior displacement and overlapping. Prominent lower end of shaft of radius injuring the tendons and median nerve. Full supination was impossible.

Fig. 371. Rays passing antero-posteriorly after plating ulna, and impacting radial shaft in the lower end of the bone. The hand was perfect with plate in position ten years later.

steel support with a strong T valgus strap is supplied for nine months after the accident.

(*b*) **Early Operation.** When a good position cannot be obtained by the method already described and the patient is healthy and active, when there are no *contra* indications to an operation, and the services of a good and aseptic surgeon experienced in the operative treatment of fractures can be obtained, early operation, say within a week of the accident, is strongly indicated, for it offers a very good chance of a perfect limb. A tourniquet is applied around the thigh after the limb below the knee has been elevated and most carefully sterilised, and a slightly curved incision is made over the lower third of the fibula starting just

behind the bone at its lower point of trisection and extending downwards and slightly forwards and terminating one inch below the tip of the external malleolus. All the soft parts down to the periosteum are then reflected backwards. This flap method is better than a straight incision over the line of fracture. Sterilised pads are immediately and accurately secured over the edges of the wound with tissue forceps so that no epidermis is exposed. The broken ends are isolated partly with the knife and partly with broad elevators and levers. They are then brought into apposition by means of Lane's long-handled forceps, and while thus

Fig. 372. A typical Dupuytren's fracture in a very heavy commercial traveller.

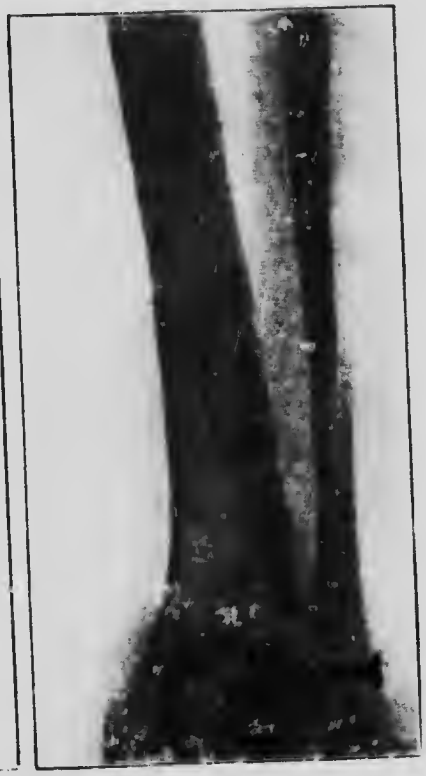


Fig. 373. The contiguous surfaces of the tibia and fibula have been pared, and a long screw has been passed horizontally to keep the bones together until bony union occurs. Note the good position of the fibular fracture.

held, are fixed in position by steel plates, wire or screws. In all cases the inferior tibio-fibular joint is exposed near the lower angle of the wound, and if there is separation of the two bones at this point indicating Dupuytren's fracture, the simplest and most satisfactory way of correcting the deformity is to chisel away the cartilage from the contiguous surfaces of the two bones, and then pass a screw obliquely inwards and slightly upwards through the fibula and tibia a little above the ankle-joint. A screw passed in a similar way is very effective for those common cases of oblique fracture extending upwards and outwards through the fibula

from just below the inferior tibio-fibular joint. This and the preceding fracture yield very bad results with conservative treatment, for the upper and outer edge of the displaced astragalus acts as the apex of a powerful wedge which gradually increases the separation of the bones at the site of injury. In many cases this is all that is required, for as the screw is driven home the fibula fragments become locked in good position. When this is not so, a small plate is applied over the outer surface of the fibula at the site of fracture, which is generally about two inches above the malleolus. When the fracture of the fibula is oblique or spiral, a circumferential wire is often simpler and more efficient than a plate. Throughout the operation the bone, screws, wire or plate, or any part of the instruments to be inserted in the wound are not touched even by the gloved hand. This "touch-me-not" technique is of vital importance in securing an aseptic union and a perfect result. The wound is then closed with a continuous salmon-gut suture, and a massive dressing is firmly applied before the tourniquet is removed. The tourniquet allows far speedier and more accurate work, and the application of the firm dressing before the removal of the tourniquet prevents extravasation of blood into the tissues.

(2) **The Correction of Deformity and Restoration of Function in Late Cases.** An attempt to restore the broken fragments to their natural position is not likely to be successful later than three months after the accident, an attempt to do this may be a very formidable, difficult and somewhat dangerous operation, for a good deal of callus has formed, matting and shortening of the soft parts have occurred, and above all the fragments themselves have atrophied and become soft so that they do not hold a plate or screw well. In these cases, it is better to do all we can to obtain a movable ankle without equinus, and to restore the proper alignment of the limb, and this is safely and simply done as follows:

When the patient is under the anæsthetic and the limb has been carefully sterilised, the knee is bent and held by an assistant while the surgeon grasps the fore part of the foot and moves the ankle freely. When flexion is considerably limited it is wise to divide the tendo Achilles subcutaneously. Stronger union is obtained in the tendon if its two lateral halves are divided at different levels about an inch and a half apart. When good movement has been obtained the limb is turned on its outer edge on a sand pillow, and a small longitudinal incision is made with its centre three quarters of an inch above the tip of the internal malleolus. An osteotome is then driven transversely outwards across the bone. At this level there is no fear of entering the ankle-joint. As far as possible the work is done sub-periosteally. When the bone is almost completely divided an attempt is made to snap the remainder, and to bring the foot into a good position. If this fails the osteotome is re-inserted and, if necessary, driven on to notch or divide the fibula. The deformity is slightly over-corrected, the wound closed with catgut and the limb secured in a good position with plaster bandages over an antiseptic dressing. The after-treatment is similar to that already described under conservative treatment.

UNUNITED FRACTURES

Recent years have shown that operative interference has made here great advances. A valuable addition to our knowledge is the information which the Röntgen-rays may give as to the condition of the ends of the bone or bones, the direction of the line of the fracture, whether oblique or transverse, how far they are symmetrical, the amount of separation, and, especially, how far they are normal or expanded, or atrophied. By the information thus gained the surgeon is aided in his selection amongst the different methods of fixation. The most rigorous asepsis is necessary for complete success in these operations, which may also require great mechanical skill, and patience. Careful after-treatment is also of much importance—in securing firm union without gradual bending, and in restoring the movements and power of the limb.

Operation. While the following remarks have been inserted here for the sake of convenience, they apply not only to the bones of the leg, but also to the humerus and femur. While the tibia offers a subcutaneous surface on its inner aspect which invites attack, its outer aspect can be safely reached by working within the detached periosteum. While this hint applies to other bones with important structures lying on one aspect it must not be taken to sanction needless detachment of the above membrane. The limb must be emptied of blood and a tourniquet applied. In making his incision the surgeon will be guided by the information given by the X-rays. A free longitudinal incision usually suffices. The remarks at p. 919 apply to the exposure of the fragments. These are next sufficiently refreshed by the removal of any scar tissue, &c., with a chisel and mallet, saw, or cutting-forceps. A thin slice is thus removed from each fragment, and if they lend themselves to mortising or stepping (*vide infra*), they are shaped accordingly. They are now brought in apposition, especial precaution being taken to correct faulty rotation of the lower fragment, partly by extension and counter-extension, partly by manipulation with powerful elevators or forceps. Much difficulty may be met with where one fragment is depressed and firmly embedded in the soft parts, and the needful disturbance of these may be great in spite of much ingenuity and patience. Any tense bands which interfere with the replacement must be detached or divided, after due examination of their possible contents. Thus in the case of the humerus the musculo-spiral nerve must be remembered. To retain them in place the *methods of fixation* already mentioned are available (p. 920).

Bone-Grafting. This subject has been referred to at p. 911. Here the graft is best taken from the bones themselves. In the case of a single bone a portion covered with and still connected with its periosteum, if possible, is chiselled off and jammed in between the freshened fragments. This fixity is essential as no wire, &c., can usually be employed. In the case of two parallel bones, like the tibia and fibula, where the intact condition of one prevents the approximation of the fragments of the other, the graft is best taken from the unbroken bone (p. 911). In other cases the bone has been taken from a distance as in Sir W. Macewen's case, where the wedges removed in osteotomies were employed. As the method of bone-grafting is chiefly indicated in the less promising cases where the ends are much atrophied or widely separated, too much must not be expected from it.

Scheuer has met the difficulty with brilliant success in a severe case of pseudarthrosis of the humerus in a boy aged four. After refreshing the ends of the bone he implanted a flap from the thorax containing a piece of the fifth rib. Bony union followed, and the pedicle was divided fourteen days later.[1] In the case of the lower extremity, it might be possible to follow this example by taking the bone from the opposite limb.

The question of drainage, and the extent to which it is advisable to close the wound at once with sutures, must depend on the amount of disturbance inflicted on the parts. Complete closure of the wound looks admirable at the time, but may well entail too much risk. From his knowledge of anatomy and the size of any vessels divided the surgeon should decide as to whether it is safe to leave the removal of the tourniquet until the dressings are *in situ*, a course always to be followed if possible.

EXCISION OF VARICOSE VEINS

This method, as old as the times of Celsus, and one which fell into disuse from the risks of pyæmia, &c., was revived with safety some years ago by the late Mr. Davies-Colley,[2] when the late Lord Lister had shown how the old dangers might be avoided.

Indications. Safe as this operation has been made, it is to be recommended with caution owing to the great risk of recurrence. If this operation is largely employed, and the cases are carefully watched, it will be found after some years that the amount of permanent benefit ensured is, in many cases, very small. I allude especially to operations performed below the knee only (*vide infra*), or to those cases, often of markedly diffuse varicosity, where small multiple incisions, thirty to fifty, are made on the two limbs.

Operative interference here requires more discrimination than it has received either by surgeons or patients. The public look upon operation here as not only absolutely safe, but as equally certain to bring about a cure. Any surgeon wishing to maintain a character for honesty will consider this claim to be a most harmful exaggeration. While careful operation in well-chosen cases will remove many discomforts and certain sources of danger, it does not always enable the patient to dispense entirely with the need of further attention to his vein.

Before the varices are removed it must be ascertained that the better supported deep veins, and the large venous trunks through which it is intended that the blood shall largely return after the superficial ones are obliterated, are healthy. A full, tumid condition of the calves, with cramp-like pains here, points to a varicose state of the sural veins, and is against operation; so too is any tendency to œdema, or increase in the size of the limb or dilatation of the superficial epigastric veins indicating thrombosis of the femoral or iliac veins. The cases best suited for operation are: (1) Where only one vein-trunk is involved, at one or two definite parts of its course. (2) Where both saphenous veins are involved, but again definitely and locally. The more the varices are longitudinal, the more they lie in the lines of the trunk, the more longitudinal incisions will suffice, the more satisfactory the operation and the better and more lasting the results. On the other hand, where

[1] V. Bergmann's *Syst. of Surg., Amer. Trans.*, vol. iii, p. 138.
[2] *Guy's Hospital. Reports*, 1875, p. 431.

the enlargement is bilateral and general, where numerous communicating veins between the trunks are enlarged, where the venous radicles are becoming dilated and their ramifications plexiform, the more, in short, that the disease shows signs of being a general one, the more will the result be disappointing. Finally, the soft parts near the varices should be in a healthy condition, free from dermatitis, and thus capable of being rendered aseptic, and of uniting quickly afterwards. In a few cases, though the conditions given above as essential for success are absent, operation is still indicated. (3) Where many varices exist, but one is especially troublesome, as where a very thin-walled vein crosses the tibia in an exposed position in a young adult, to whom playing football, &c., means very much; or where a varix is the cause of an ulcer troublesome to heal, and, perhaps, already the source of dangerous bleeding. (4) In some cases of thrombosis. Where a patient is the subject of thrombosis in "the dangerous area" (*vide infra*) and the thrombus is creeping upwards a surgeon who can rely on the case running an aseptic course is quite justified in placing a ligature on the proximal side of the thrombus with the view of preventing its reaching the large trunks. How far it is wise for him to go further and remove the thrombus at the same time or later with the object of preventing implication of the deep veins and a recurrence of the thrombus must depend on the individual case. Sir W. Bennett ("Varix and Thrombosis," p. 49) goes further and considers that in a certain number of cases of thrombosis followed by embolism "incalculable good can be done by surgical means provided that action is taken speedily and boldly." Thus if a thrombus in the "dangerous area" (*vide infra*) shows signs of softening, if one or two attacks of cardiac pain and dyspnœa have occurred, removal of the source of the emboli, or interruption by ligature of the channel by which they have reached the central parts, and by which they may produce another and a fatal attack is called for.

I shall describe two operations. (1) That by which the "dangerous area" of Sir W. Bennett is removed; (2) that of Trendelenberg. I have used the first largely and my experience justifies my saying that I consider it to be the one most suitable to the largest number of cases in which an operation is justified, and one which is least likely in its results to lead to disappointment. Sir W. Bennett,[1] has given the term "dangerous area" to that part of the inner aspect of the lower limb "which is marked off by two transverse lines, one about the middle of the thigh, and another three inches below the knee-joint, an area in which the local conditions predisposing to thrombosis in varix are present in a remarkable degree. Cysts, often of great size, huge, dilated tortuous vessels, valveless and with abrupt bends are frequent, and are constantly being subjected to the straining movements produced by flexion and extension of the knee." A little later Sir William writes: "Speaking generally, if the disease is confined to the leg, operation is useless: sometimes it is harmful." And again, "operative measures confined to the parts below the knee in general varix are useless."

(1) **The Radical Operation.** The skin of the limb or limbs must be first carefully shaved and sterilised beforehand, and the varicose veins marked as the patient stands in order to distend them. Sterilised carbolic acid fuchsin solution is applied either with a sterilised camel-hair brush or a match-stick. A sterilised dressing is then applied. When the

[1] *Loc. supra cit.*, p. 18.

patient is under the anæsthetic and the limb has been well elevated for a few minutes, a sterilised tourniquet is applied round the upper third of the thigh. This prevents a great deal of unnecessary bleeding, and if the veins have been well marked there is no disadvantage in using it. Moreover it prevents extravasation of blood into the tissues. If the central end of the long saphena vein is tied and the dressings are firmly applied before the tourniquet is removed there is no fear of bleeding after the operation. When it has been impossible to mark the veins accurately a tourniquet is a great disadvantage, for the empty veins are difficult to find. Under these circumstances, bleeding can be greatly diminished by commencing the operation near the ankle and working upwards. As far as possible longitudinal incisions are used, for in this way the nerves are less interfered with and after-pains are consequently less. There is no advantage in removing any distended veins from the foot, for these are well supported by the boot and will greatly diminish if the operation is thoroughly carried out. Several longitudinal incisions about two inches long are required on the inner side of the leg below the knee. In every case, thin sterilised pads are fixed with tissue forceps over the edges of the wound. The edges are held up by the forceps, as the vein is isolated and separated from the internal saphenous nerve. The vein only is picked up with two long bladed artery forceps, and divided between them. As the vein is liberated with a blunt dissector the forceps are rotated so that the vein is wound upon it, the winding proceeding away from the point of the forceps to prevent the coils slipping. In this way several inches of the vein are removed, and as it breaks away very little bleeding usually occurs even if no tourniquet is used, and it is easily stopped by pressure applied by an assistant for a few moments. Every lateral branch is clamped and treated in a similar way. No ligatures are used except for the lower end of the vein just above the ankle and the upper end just below the saphenous opening for which fine catgut is used, for otherwise straining after the operation may induce bleeding, especially from the upper end. This method was first introduced by Greig Smith, and is a very valuable, simple and radical method of removing the veins. Several incisions are generally necessary on the outer side of the leg and also on the calf over the short saphena vein. The simplest way of doing this is to get an assistant to hold the heel well up. As far as possible incisions about the knee, especially behind it, are to be avoided. In the thigh several incisions are required along the course of the internal saphena. In stout patients it is sometimes difficult to find the vein here, and in them it is an advantage to make the incisions somewhat oblique, for the line of the vein is by no means constant. I prefer to make the upper incision about one inch below the saphenous opening, transverse, for this makes it much easier to find the vein and the large tributary that is commonly found running obliquely upwards and outwards from the back of the thigh, the removal of which is essential for radical cure. This incision also serves well for the removal of the large saphena varix sometimes found just below the saphenous opening. This is commonly mistaken for femoral hernia. The ligature at the upper end of the vein is applied at least an inch below the saphenous opening, but this is not practicable when there is a high saphena varix. The wounds are sewn with fine fishing gut, and great care is taken not to invert the edges, and for this the button-hole stitch is valuable. The simplest, most secure and most

comfortable dressing is a sterilised, soft gauze bandage. This is covered by sterilised pads of wool, and a firm bandage is applied. The limbs are afterwards slightly raised on a wedge pillow, but no splint is applied. A small pillow is placed behind the knees to keep them slightly flexed and prevent cramp from strain of the hamstrings. When both limbs are involved it is a great advantage to have two operators working at the same time, and if the limbs are well separated, abducted and rotated outwards this can be conveniently done.

Fig. 374. Excision of varicose veins. The veins are twisted round good forceps, as they are separated by blunt dissection.

(2) Trendelenberg's operation. Here about two inches of the saphena vein are resected just below the saphenous opening. This step is only indicated in those cases to which Trendelenberg's test applies. The limb having been raised and emptied of much of its blood the saphena-vein is compressed and the limb lowered. If the blood can be seen to fill the empty vein immediately after the pressure is removed Trendelenberg considered it proved that in such a case there was a column of blood reaching from the right side of the heart to the foot, unsupported by valves. The precaution mentioned at p. 928 must be remembered here. Where there is reason to suspect that the deep veins are varicose this operation should not be performed. The spine of the pubes having been identified, a line three and a half inches long is drawn from this point and an incision three inches long made in its lower half. By some a transverse incision is preferred, for otherwise some difficulty may be met in finding the vein in fat patients. The saphena having been isolated for two inches, this portion is resected between two catgut ligatures. I need not insist upon the absolute need of scrupulous asepsis here. While Trendelenberg's operation gives fairly good immediate results in some cases, recurrence commonly follows it in a few years. For this reason except when there is eczema or ulceration of the leg, I prefer the more radical operation already described. Either operation may be performed under local or spinal anæsthesia if the patient desires.

CHAPTER XLV

OPERATIONS ON THE FOOT

LIGATURE OF THE DORSALIS PEDIS (Fig. 375)

Indications. Very rare. (1) Wounds. (2) Together with the posterior tibial in the lower third, for hæmorrhage from punctured wounds of the sole resisting other treatment. (3) For some vascular growths of the foot.

Line. From the centre of the ankle-joint to the upper part of the first interosseous space.

Guide. The above line and the adjacent tendons of the great and second toe.

Relations:

In Front

Skin, fasciæ; branches of saphenous veins, and of musculo-cutaneous and anterior tibial nerves.
A special deep fascia continuous with the sheaths of the adjacent tendons.
Extensor brevis (innermost tendon).

Outside		*Inside*
Vein	Dorsalis pedis artery.	Vein.
Anterior tibial nerve.		Extensor longus hallucis.
Extensor longus digitorum.		

Behind

Astragalus; scaphoid; middle cuneiform.

Operation (Fig. 375). The foot having been cleansed, an incision about an inch and a half long is made in the line of the artery, in the lower part of its course, commencing about an inch and a half below the ankle-joint. Skin and fasciæ being cut through, and any superficial veins tied with fine catgut or drawn aside, one of the long extensors is found (its sheath is not to be opened), and the strong fascia given off from them opened. If the extensor brevis cross the artery at this spot it must be drawn aside. The ligature should be passed from without inwards.

SYME'S AMPUTATION (Figs. 376 to 378)

An amputation at the ankle-joint by a heel-flap, with removal of the malleoli.

Operation. The thick skin of the heel requires careful sterilising. Hæmorrhage having been controlled, any sinuses present scraped out

and disinfected, and the foot held at right angles to the leg, the surgeon, standing a little to the right, but so as easily to face the sole, marks out the points mentioned below with the index finger and thumb. He then makes, with a short, strong knife, an incision (in the case of the left foot) from the tip of the external malleolus to a point half an inch below [1] the internal one, this incision not going straight across the sole as in Pirogoff's amputation, but pointing a little backwards towards the heel.[2] The horns of this incision are then joined by one passing straight across the joint, and severing everything at once down to the

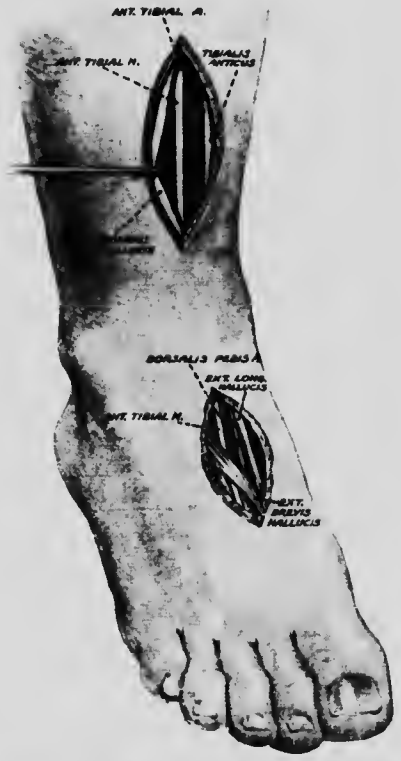


Fig. 375. Ligature of the anterior tibial in its lower third, and of the dorsalis pedis.

ankle-joint. The foot being now strongly bent downwards, the lateral ligaments are severed, and the joint thus fully opened. The foot being slightly twisted from side to side, the tendons and soft parts on either side are carefully divided, the knife being kept closely in contact with the bones. Especial precautions must be taken on the inner side to

[1] The directions usually given are to go behind this point as well as below it, but by following the above course the posterior tibial is more likely to escape section before its time, and the flap will be found sufficiently symmetrical.

[2] If the foot is small, and, still more, if the parts on the dorsum are damaged, the plantar incision should run straight across. On the other hand, the more prominent the heel, the more should the flap point backwards. This will facilitate turning the flap over the heel.

cut the posterior tibial artery as long as possible (to ensure getting below the internal calcanean) and not to prick it afterwards.

As the operation proceeds the flap is partly pressed back by the thumb, partly pulled back and so saved from damage by the knife. The chief difficulty is met with at the prominence of the heel.

The foot being still more pressed, the upper non-articular surface of the os calcis comes into view, and then the tendo Achillis. This is severed, and the heel-flap next dissected off the os calcis from above downwards, special care being taken to cut this flap as thick as possible, not to score or puncture it, but rather to peel it off the bone with the left thumb-nail kept in front of the knife, aided by touches of this.[1]

The foot having been removed, the soft parts are carefully cleared off the malleoli, and a slice of the tibia sufficiently thick to include these

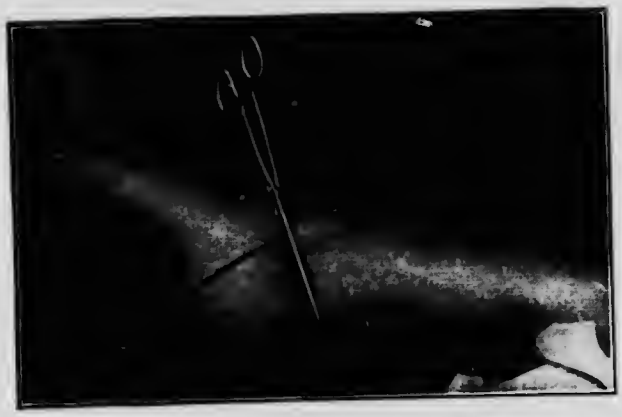


Fig. 376. Incisions and application of Lynn-Thomas's forceps-tourniquet in Syme's or Pirogoff's amputation.

prominences removed. This slice should in any case, to avoid shortening, be the thinnest possible. Prof. Macleod[2] has recommended to remove only the malleoli, leaving the cartilage on the under surface of the tibia. Prof. Macleod's advice entails less shortening of the limb and does away with the risk of infective phlebitis, which may be brought about by opening the cancellous tissue. If, on the other hand, the lower end of the tibia is diseased, it must be removed and the sawn surface gouged or treated with a sharp spoon. If the cartilage is only slightly diseased, it may be sliced off with the knife, and gouged here and there.

Tendons are now cut short, sinuses thoroughly scraped out and disinfected, and the vessels secured. Free oozing is often present in tubercular cases, or where the periosteum has been left in the heel-flap. It is best

[1] If, in a young subject, the epiphysis comes away in the heel-flap, it may remain there if the parts are healthy. The same course may be followed with the periosteum, if it is found loose and peels easily away. Mr. Johnson Smith, when amputating both feet for frost-bite, left the periosteum on one side. On the other no attempt was made to save it. The first stump was much larger than the other, harder, and more rounded; more like that of a Pirogoff's amputation.

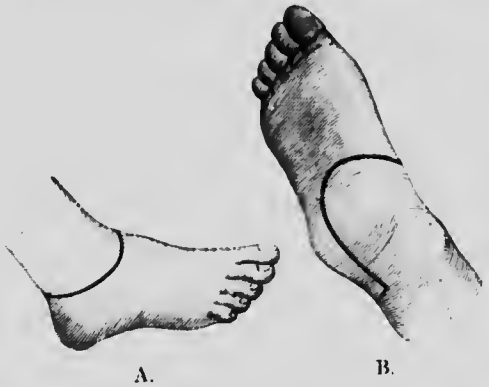
[2] *Brit. Med. Journ.*, 1869, vol. ii, p. 239.

Fig. 377. Syme's amputation.

Fig. 378. Syme's amputation. Showing the positions of the important structures in the flaps.

treated by firm pressure with dry dressings, and elevation of the stump. Drainage having been provided through the cup-like heel-flap if no sinuses are conveniently placed, interrupted fishing-gut sutures are inserted. They should be passed at such a depth and distance from the edge of the heel-flap to ensure their holding this up well. Where many sinuses have been present along[1] the line of the incision, it is no good uniting the wound closely.

While the success of a Syme's amputation depends chiefly on the care with which the heel-flap is raised, later on attention must be given from the first, and often for some weeks, to apply the bandages so as to hold the heel-flap up well and meet its tendency to glide downwards, and afterwards to hasten the moulding of it into good shape. As soon as the stump is healed, the patient, if his occupation require it, can get



A. B.

Fig. 379. Roux's amputation. The incision shown from the outer (A.) and the inner side (B.) timson.)

about on a knee-rest. In about eight weeks he will be able to bear weight on the stump.

Roux's Modification of Syme's Amputation (Figs. 379 A and B). In cases where a satisfactory heel-flap cannot be obtained, an efficient substitute can be got by a large internal flap.

The incision is commenced at the apex of the outer malleolus, and carried half across the front of the ankle-joint, from whence it should run inwards in an oblique direction over the astragalo-scaphoid joint, then pass, in a curved manner, downwards and backwards to the middle line of the sole of the foot, and, running along the under surface of the heel, ascend the posterior aspect of that part, and terminate at the outer malleolus, where it commenced. The ankle-joint should be opened at its upper and outer part, the os calcis dissected from its connections, the malleoli and a slice from the articular surface of the tibia removed, and the operation will be complete.

Causes of Failure after Syme's Amputation. (1) Sloughing of the heel-flap. This is nearly always due to faulty operating, to scoring or "button-holing" the flap, or to dividing the posterior tibial high up.[2] (2) Persistence of sinuses and tuberculous disease. If, in spite

[1] Sinuses which have been scraped out will give good drainage if enlarged. If any puncture has been made in the heel-flap, it should be utilised for the same purpose.

[2] If possible, the cut ends of the two plantar arteries should always be seen, and not the single mouth of the posterior tibial. In the former case the surgeon is certain that the main vessel is divided below the internal calcanean branch.

of repeated scraping out with the aid of anæsthetics, this condition recurs inveterately and spreads along the sheaths, the limb must be amputated higher up. This will, however, be rarely called for with perseverance on the part of the surgeon to treat this condition as a kind of malignant disease. If one or two sinuses remain, and look likely to persist, scraping out should be resorted to at once. (3) Caries in the tibia. (4) Death of the tendo Achillis.

This rare sequela occurred to me in 1890. The patient was an aged inmate of the Camberwell Infirmary. A bluish undermined patch being laid open on the back of the ankle some weeks after the amputation, the tendon was found to have died up to its junction with the calf muscles. After its removal the parts healed soundly

PIROGOFF'S AMPUTATION

An amputation at the ankle-joint, in which the posterior part of the os calcis is retained and united to the sawn surface of the tibia.

Question of the Value of this Operation especially as compared with Sy. 's Amputation. *Disadvantages:* These have been put prominently forward by Scotch surgeons. (1) The amputation is not suited for cases of disease, except of distinctly traumatic origin in young healthy subjects. (2) Occasionally the sawn os calcis fails to unite, causing either a kind of movable joint or necrosis. (3) It is said by some that the stump is more difficult to fit with an artificial foot.[1] The first two objections are undoubted, but I think that they are quite outweighed by the *Advantages:* (1) No dissection of the heel-flap is needed. (2) The blood-supply is less interfered with. (3) The stump is firmer and more solid. (4) The stump is longer by one inch or one inch and a half, often more.[2] (5) The stump does not go on wasting, as is the case after Syme's amputation.[3]

Operation. The position of the patient's foot and the surgeon being as at p. 931, an incision is made, straight across the sole, from the tip of the external malleolus to a point half an inch below the internal one.[4] This incision goes right down to the bone. Its horns are then joined by a transverse cut across the front of the ankle. The lateral ligaments are now severed, care being taken to cut inside the malleoli and to divide the posterior tibial artery as long as possible, *i.e.* below its origin into the two plantar, and not to prick it after it is divided. With a few touches of the knife at either side of the astragalus, aided by twisting of the foot from side to side and forcible bending of it downwards, the non-articular part of the upper surface of the os calcis comes into view. A groove is now cut through the fatty tissue and the periosteum, and the saw applied just in front of the tendo Achillis, obliquely downwards and forwards, care being taken to bring it out through the incision in the heel. The foot being removed, the soft parts around

[1] Prof. Macleod thinks that the presence of the heel is here "a great drawback, and that the back of the heel, not the firm plantar pad, is what comes in contact with the ground." See the remarks p. 937.

[2] Dr. Hewson (*loc. infra cit.*) gives the shortening after a Pirogoff's amputation as from one to two inches; that after Syme's operation as two and a half to three inches.

[3] The continuance of this wasting is shown by the hospital patient being for some time obliged to stuff the socket of his elephant-boot with a sock. It is not intended by this to depreciate the value of a Syme's stump. Every surgeon knows how much good, lifelong work the heel-flap is capable of, however much it shrinks, so long as it has healed.

[4] *I.e.*, not pointing backwards.

the bones of the leg are carefully cleared to a level just above the tibial articular surface and the malleoli, where the saw is next applied, and the bones divided with a similar slight obliquity, from before backwards and downwards.

The vessels, the tibials, anterior peroneal, and perhaps one or both malleolar having been secured, the tendons cut square, the bony surfaces are placed in contact, and, if needful, drilled and united with a screw or wire.[1]

If it is found advisable to convert the Pirogoff into a Syme, all that is needed is to divide the tendo Achillis and to dissect out the part of the os calcis, keeping the knife close to the bone.

FIG. 380. Incisions for Pirogoff's amputation.

Modifications of Pirogoff's Amputation. One of the chief of these is that introduced by **Dr. E. Watson.**[2] He claims: (1) That it is shorter and easier, the trouble of disarticulation being avoided. (2) That it is less likely to damage the posterior tibial artery. (3) That it does away with one of the chief difficulties in a Pirogoff's amputation for injury, viz. the want of purchase over the smashed parts while the os calcis is being sawn through.

Operation. The operator, standing as before, having cut across the sole from the tip of one malleolus to the corresponding point (p. 935) down to the bone, introduces a small Butcher's saw, or one with a narrow blade, into this wound, and saws off the posterior part of the os calcis by carrying his section upwards and backwards. This and the heel being now retracted by an assistant the surgeon, resuming his knife, cuts upwards behind the ankle-joint between the sawn bones. The ends of the first incision are now joined by one passing between them, the skin being pulled up a little and the tendons and vessels severed down to the tibia and fibula just above the ankle-joint. Lastly, these bones are sawn through in a slanting manner by directing the saw from before backwards and downwards.[3] While the bones of the leg are being sawn, the heel-flap should be held well up against the back of the leg to keep it out of the way.

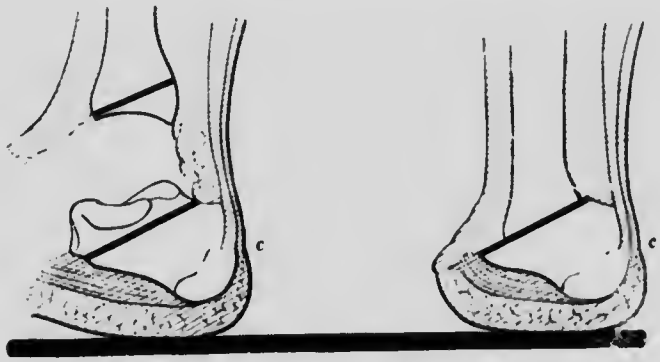
[1] If the patient is young and healthy, and if there be no tension on the piece of os calcis as this is brought forwards, this is not absolutely needful. I would recommend it in other cases. Thus I have made use of it in a Pirogoff's amputation for inveterate infantile paralysis, with excellent results. The wire, cut short, should be well hammered down and deeply embedded.

[2] *Lancet*, 1859, vol. i. p. 577.

[3] It will be noticed that the direction of the bone-section here given by Dr. Watson is contrary to that usually taught.

Modifications by Sédillot, Gunther, and Le Fort. In order to facilitate the fitting easily of the sawn surfaces of os calcis and tibia and to minimise any resistance to this step, **Sédillot** and **Gunther** have advised the very oblique section of the bones shown in Figs. 381 and 382. **Paguier Le Fort** goes still farther and saws through the os calcis, horizontally, parallel with its articular surface, the bones of the leg being also sawn horizontally.

From my experience Pirogoff's operation gives excellent results if



Figs. 381 and 382. Modifications of Pirogoff's amputation by Sédillot and Gunther. (Farabeuf.)

performed in suitable cases where the os calcis and the soft parts are both sound. One difficulty may be met with in cases of severe injury where the parts are badly smashed, and that is the want of the desired purchase while the os calcis is being sawn through. The modification of Dr. E. Watson will meet this.

Operators sometimes make another difficulty for themselves by leaving too large a portion of the os calcis. Tension is then unavoidable when the fragment is brought upwards and forwards.

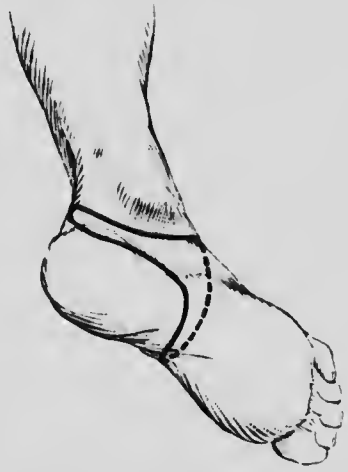


Fig. 383. The incisions in sub-astragaloid amputation. (J. Hutchinson, jun.)

SUB-ASTRAGALOID AMPUTATION

This operation consists—the soft parts being divided as at Fig. 383—in opening the astragalo-scaphoid joint from the dorsum, and the astragalo-calcanean, of which the interosseous ligament can only be divided by introducing the knife point from the outer side. The whole foot is then removed in one mass with the exception of the astragalus, which is left mortised in between the tibia and fibula.

This amputation has been rarely practised in England, partly because most surgeons have found that those of Syme and Pirogoff give good results, partly because the technique of the sub-astragaloid method is more complicated to remember, and also because this method requires

that the soft parts of the sole should be sound as far forwards as the base of the fifth metatarsal bone. Finally, Farabeuf, a high authority, states that the stump is liable to be pulled up by the tendo Achillis taking on a firm attachment, which brings the weight of the body upon this bone and the neighbourhood of the cicatrix.

Mr. J. Hutchinson, jun., in a paper [1] which, like all his writings, is lucid and instructive, strongly advocates the sub-astragaloid method, claiming the following advantages over that of Syme, of which his experience, necessarily a large one at the London Hospital, has not been satis-

Fig. 384. Sub-astragaloid amputation (right foot) by large internal and plantar flap.

factory: (1) The stump is some two inches longer; (2) it gives a broader base of support; (3) the elasticity due to the ankle movements is a marked advantage in walking; (4) the pad at the end of the stump is much thicker; (5) the arterial supply is better and runs less risk during the operation; (6) an artificial foot can be better fitted to the stump.

Operation (Figs. 383 to 385). The following account is taken, in part, from Dr. Stimson's *Manual of Operative Surgery*, p. 113. The chief guides are the external malleolus and head of the astragalus. The parts having been carefully sterilised, especially the thick skin about the heel, the outside of the foot is presented to the surgeon as at Fig. 383. The

[1] *Brit. Med. Journ.* October 20, 1900.

incision commences at the outer border of the tendo Achillis on a level of above three-quarters of an inch below the external malleolus, and is continued straight forwards below this prominence to the base of the fifth metatarsal. It is thence carried across the dorsum, slightly convex forwards, to the base of the first metatarsal. It next passes over the inner side of the foot and across the middle of the sole, again convex forwards. From the centre of the sole it is carried on to the outer border, which it gains just behind the base of the fifth metatarsal. Some operators make it join the first incision at the calcaneo-cuboid joint, others carry it onwards and backwards over the outer aspect of the foot as far as the outer tuberosity of the os calcis, whence it curves upwards over the back of the heel to join the first at the tendo Achillis.

The incision is made throughout, down to the bones, all the tendons met with being severed at once. The soft parts are separated from the os calcis and cuboid on the outer side, and on the dorsum dissected back to the head of the astragalus. The interosseous ligament is then reached by depressing the front of the foot, passing the knife between the astragalus and scaphoid, and cutting backwards and inwards along the under surface of the former. The soft parts are next separated on the inner side from the os calcis, injury to the vessels being avoided by keeping very close to the bone, the foot depressed, and the tendo Achillis divided. The posterior tibial nerve should be dissected out and cut short.

FIG. 385. Sub-astragaloid amputation (left foot, outer aspect).

M. Farabeuf advises an internal and plantar flap, whose nutrition is guaranteed by a very large base.

EXCISION AND ERASION OF THE ANKLE

These may be considered together. The operation performed is usually a combined one, and is not very often called for, and the principles which should guide the surgeon in selecting one or the other have been fully given at p. 864.

Indications. These will be considered chiefly as they relate to cases of: A. *Disease*; more briefly under the heading of B. *Injury*.

A. *Disease*. The objections made to operations on the ankle-joint are: (1) The frequency with which the other tarsal bones are involved, the depth to which the astragalus itself is affected, and the poor vitality usually present in the patients. As regards the astragalus, the whole bone should always be removed,[1] and this meets, in part, another reason

[1] Mr. Holmes, whose experience of this operation was a large one, advised (*Brit. Med. Journ.*, 1878, vol. ii, p. 875) that the whole of the astragalus should always be removed, for these reasons: (1) As it is often softened to a considerable depth, mere removal of its articular surface will often leave disease behind; (2) in patients of poor vitality the violence done by the saw may prove the starting-point of renewed caries; (3) the bones of the leg unite sufficiently firmly to the exposed cartilaginous surfaces of the os calcis and scaphoid; (4) the shortening is not appreciably increased; (5) the difficulty of the operation is lessened.

brought forward by Prof. Syme for preferring amputation at the ankle-joint, viz. the fact that in disease of the astragalus the joint between it and the os calcis is often involved. (2) The difficulty of free exposure of the parts to be dealt with. With the advantages of modern surgery this objection has lost some of its weight. (3) Amputation at the ankle-joint affords a better chance of radical cure, and also a most excellent stump. This may be imperilled by previous operations on the ankle-joint. It is only in patients with good reparative power, with disease limited to the ankle-joint and the astragalus, and of traumatic origin, *e.g.* following a sprain, with no evidence of other tuberculous disease or syphilis, that operations on the ankle-joint are to be preferred to amputation. (4) The difficulty of securing a splint which will combine (*a*) sufficient rest, and (*b*) sufficient exposure for the needful dressings. A simple method is the anterior flat bar of malleable iron moulded to the dorsum of the foot and front of leg and knee-joint, covered with india-rubber, supplied with hooks for suspension, and secured by plaster of Paris. This gives admirable access, and saves any pressure on the heel. The fitting of this splint, which can be done on the sound limb, requires the careful attention of the surgeon himself beforehand, especially as to the angle over the instep by which the foot is kept in right position. Another method is that with plaster of Paris and windows. When the patient can get up he can use a leg-rest for some months. In those cases where, in addition to a large cavity to fill up, any tendency to œdema exists, a back and two side-splints—all being interrupted may be preferable for the first week or ten days. The side-splints should be boiled after removal.

B. *Injury.* In a young, healthy patient, where the vessels and nerves are mainly intact, where the mischief is limited to the ends of the bones, an attempt to save the limb by excision, partial or complete, is abundantly justified. The steps given at p. 915 for the antiseptic treatment of compound fractures should be carefully attended to, as to the preservation of periosteum, the due providing of drainage, &c.

As to gunshot injuries, Dr. Otis[1] thought that "the substitution of excision of the ankle joint for amputation effected no saving of life," formal excisions being rarely successful. The experience in later wars appears to be similar. Mr. Makins, C.B.,[2] writes: "The ankle-joint maintained the undesirable character which it has always held as a subject for gunshot injuries. This is entirely a question of sepsis, and in great measure depends on the fact that the foot, as enclosed in a boot, is invested with skin particularly difficult to cleanse thoroughly; while the socks are an additional source of infection before the patients come under proper treatment. Of seven cases of suppurating ankle-joint of which I have notes, only two retained the foot, and one of these after a very dangerous illness."

Operation. The necessary exposure may be secured either by two lateral incisions or by a transverse one, dividing the tendons in front, some of which are sutured afterwards. Of these the first is preferable, theoretically, owing to the smaller injury inflicted upon the soft parts. For myself, considering that a stable and sound foot is the first desideratum, and that in most hands a transverse incision, prolonged laterally as freely as is needful, gives the best exposure, and thus facilitates the eradication of all the diseased parts, which is so essential in dealing with

[1] *Med. and Surg. Hist. of the War of the Rebellion*, Part iii, p. 610.
[2] *Surgical Experiences in South Africa*, 1899-1900 p. 239.

tuberculous disease, I have generally employed this method. If the suturing of the chief tendons is not successful—and this is a matter of difficulty with the usually small tendons—the subsequent stiffness of the toes is partly made up for by the mobility gained, in young subjects, at the medio-tarsal joint.

Lateral Incisions. There are numerous modifications of these, but the chief point to remember is to make them freely from a point about two inches above the malleoli to one about the centre of the lateral aspects of the foot. The parts having been carefully sterilised, and a tourniquet applied, the foot is laid upon its inner side, and firmly supported by a sand pillow. A slightly angular incision is then made from a point two inches above the external malleolus behind this prominence to one within an inch of the base of the fifth metatarsal. The external saphena vein is drawn aside or secured between two ligatures. The two peronæi tendons are carefully preserved. The wound being protected with sterile gauze, the foot is turned over and a similar angular incision is made on the inner side forwards and downwards as far as the projection of the internal cuneiform. In the centre of the incisions the operator should work down to the capsule of the joint; the ends are made free in order to give room, and also to admit of identification and displacement of the tendons. Thus the peronei on the outer, and the tibialis posticus and flexor longus digitorum on the inner side, must be carefully but sufficiently displaced from their connection with the fibula and tibia, or difficulty will be met with in adequately displacing the foot inwards or outwards. The capsule being identified, by means of a periosteal elevator the structures in front of the joint, tendons, vessels and nerves are raised *en masse* by pushing inwards and outwards from the lateral incisions and up and down as well. As much of the anterior part of the capsule as possible is then snipped away in one piece. The next step is removal of the astragalus. The joint between it and the scaphoid is first opened, and its connections with the os calcis taken next. By alternate eversion and inversion of the foot the lateral ligaments are divided, with the help of an elevator and sequestrum-forceps the astragalus is raised and drawn in different directions as the ligamentous fibres are divided with strong blunt-pointed curved scissors. The interosseous ligament is next severed; if disease be present here it must be thoroughly treated with a gouge. The difficult removal of the astragalus must be effected gradually, and without any needless bruising of the adjacent bony and cartilaginous surfaces. The presence of the flexor longus hallucis, posteriorly, must be remembered. The articular surfaces of the tibia and fibula are next scrutinised, by thrusting them through one of the lateral incisions. If they appear healthy the cartilage should be well rubbed with sterile gauze to ensure the removal of any tuberculous material. Any disease present must be removed by shaving off the cartilages, or by a gouge. Removal of either malleolus, even subperiosteally, and in a young subject, is likely to interfere with the after-stability of the foot. Free access having been thus attained, any remnants of the synovial membrane at the back and postero-lateral aspects of the joint are removed, and sterilised iodoform or emulsion of iodoform and glycerine (10 per cent.) applied to the cavity left. As this must in any case be a considerable one, I recommend that the needful drainage be secured by only suturing the upper extremities of the incisions, and slinging the foot for the first few days laterally, so that one of the incisions is kept facing down-

wards. After the deeper dressings have been secured by a few figure-of-8 turns the bandage should be carried firmly, beginning at the roots of the toes (this area having been sterilised) from below upwards, so as to prevent any œdema of the foot. As the only arteries cut are small ones, branches of the peroneal and malleolar, the Esmarch bandage need not be removed until the dressings are *in situ*.

To secure a good result much care is needed afterwards to meet the tendency to displacement, which is two-fold: (*a*) pointing of the foot downwards; (*b*) a lateral displacement. While here, as after other erasions, it is not always needful to disturb the deepest dressings, it is well to re-apply the bandage at short intervals to promote early consolidation of the deeper parts of the wound, and aid in the obliteration of any infective material. After three weeks, if the wound be healed, active and passive movements may be gently begun. No weight is to be borne on the foot for two months. A boot with lateral supports will be required for some time.

A Transverse Incision. After the full account given above it is needless to go into details here. In my opinion this method is especially indicated in doubtful cases, where the surgeon has the probability of amputation being required strongly before him, it being now very easy to proceed to removal of the foot by Prof. Syme's method.

The parts having been sterilised and rendered evascular as before, a transverse incision between the malleoli is made down to the tendons. Before these are severed guiding sutures of sterilised silk are placed in the tibialis anticus, extensor proprius hallucis and digitorum, and the anterior tibial nerve. All the structures in front of the joint are then severed, the joint opened, and the operation completed on the lines already given. It is always well to remove the astragalus, in order to secure better access to the diseased structures.

G. A. Wright, of Manchester, who gave such a healthy impetus to erasion of joints, thus describes a case operated on as long ago as 1882.[1]

> The child was 8 years old. The joint was opened by a transverse incision across the front of the joint, dividing all the extensors, &c.; tuberculous synovitis existed with subchondral caries, all the diseased tissue, as well as the loosened cartilage, were removed as far as possible. The tendons were stitched together with catgut and the wound closed. No attempt was made to unite the nerve; the anterior tibial artery was twisted. The wound was very slow in healing, but three years later the child's condition was as follows: "Foot sound and well, but the toes are somewhat pointed, and he 'throws' the foot in walking. He gets about well with a boot and without any support. A good deal of new bone-formation about line of incision, but some mobility."

Those interested in erasion of this joint should refer to a paper by Sir W. A. Lane,[2] in which a very free extension of the transverse incision is advocated; and one by the late Mr. Chtton,[3] in which four vertical incisions are made, one in front and one behind each malleolus, and the tendons and ligaments alike avoided. The disease is removed by the sharp spoon and irrigation, aided by the finger. As stated by Mr. Chtton, an exactly similar method was described by Bruns.[4]

1 *Diseases of Children*. Ashby and Wright, p. 633.
2 *Clin. Soc. Trans.*, vol. xxvii, p. 15.
3 *Trans. Med. Chir. Soc.*, vol. lxxvii, p. 101.
4 *Münch. Med. Woch.*, 1891.

EXCISION OF BONES AND JOINTS OF THE TARSUS

Before considering these separately, I would invite attention to the following **practical points**:

(i) Those cases are the least hopeful in which there is no history of injury, in which there is evidence of a tuberculous constitution, or perhaps of disease dating to an exanthem and coupled with the above constitution; cases in which the patient is wan and sickly with long-lasting pain and sleeplessness: those in which the parts are much swollen, dusky red, and glossy, with sinuses numerous or excavated, all points denoting a disease that is not limited to one joint or to few bones. (ii) Mere laying open, and, still more, injection of sinuses where there is disease of the tarsus is absolutely useless in most cases. (iii) When a patient is under care for caries of the foot, his lungs should always be carefully examined before operative treatment is undertaken. (iv) When the amount of disease present is being estimated, it must be remembered that patients, especially children, will often use their feet with much freedom, limping, even bearing their weight on their toes with the aid of a crutch, though all the time extensive disease is present (v) That, before an operation, the parts should always be rendered absolutely avascular by elevation and a tourniquet, and that thus the limit of the disease should be defined as accurately as possible. (vi) Subperiosteal excision is in my opinion rarely advisable in tuberculosis. It is here a step full of risk and does not offer any sufficiently compensatory advantages except in the os calcis which is important as the insertion of the powerful tendo Achillis. (vii) Strict antiseptic precautions should be made use of wherever this is possible, because—(*a*) Prolonged suppuration will exhaust a patient whose powers are already sufficiently handicapped by disease and operation. (*b*) Suppuration will cause destruction of the periosteum, and thus fresh caries and necrosis: (*c*) Interference with inflamed bones may, if infection result, easily cause osteo-myelitis and pyæmia. (viii) When the question arises between excision and amputation, if the powers of repair have been duly considered, the question

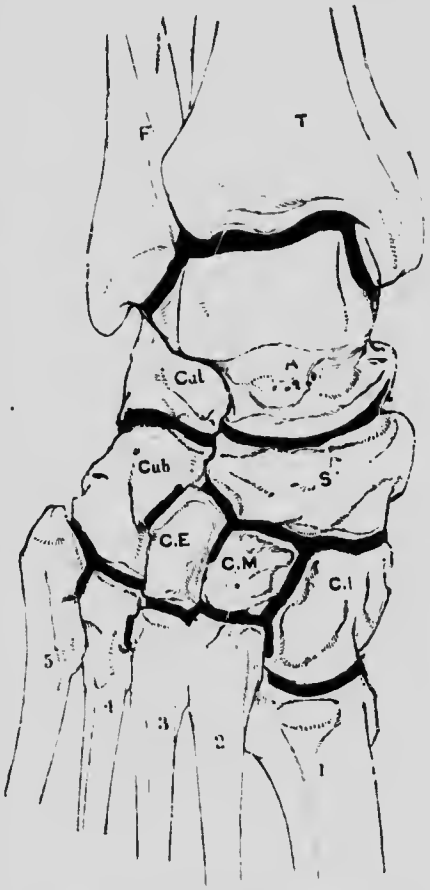


FIG. 386. To show the arrangement of the tarsal synovial membranes. (MacCormac.)

of time and the rank of life should also be remembered. Thus, after an extensive excision, six months will probably be required before the foot can be used, but only three months after an amputation. The time in the first case may after all be wasted, a point of much importance, when the question of schooling, learning a trade, &c., have to be considered. (ix) No use of a foot can be permitted after an operation till firm consolidation is obtained. (x) If tuberculous mischief persist after an operation, the sharp spoon must be freely used, together with laying open sinuses, snipping away of undermined skin, &c. If all carious bone has been removed, the above steps may be repeated here, as in the knee, with ultimate success, if good general health be maintained.

EXCISION OF THE ASTRAGALUS

Indications. These will be for A. *Disease*, B. *Injury*.

A. *Disease*. (1) Caries of the bone, especially when comparatively recent and of traumatic origin in a young and healthy patient, and when the disease is found to be limited to the upper surface. (2) In disease of the astragalo-calcanean joint, where it is thought, from the position of the sinuses, &c., to be more advisable to expose this joint by removing the astragalus than the os calcis.

B. *Injury*. (1) Primarily. (*a*) In simple dislocation of the astragalus not reducible with the aid of anæsthetics and tenotomy of the tendo Achillis and the tibials or extensors, if it seem likely that the skin will slough. (*b*) In compound dislocation of the astragalus when the bone is too far displaced or comminuted to admit of replacement, and when the condition of the soft parts, vessels, and tendons does not call for amputation. (2) Secondarily, when the foot is useless and painful. In these cases, especially, strict antiseptic precautions must be taken and free drainage provided.

Operation. This may be performed by two lateral or a transverse incision, with subsequent suture of the tendons, as already described (p. 942). In tuberculous cases, especially where amputation may be found needful, I prefer the freest exposure. In some cases where a sequestrum is found on the upper surface, the removal of this and the use of the gouge is all that is required. More usually the bone needs removal and its articulation with the scaphoid and the os calcis requires attention. The necessary steps and the after-treatment have been fully described at p. 942.

EXCISION OF THE OS CALCIS

Practical Remarks. Disease here is not very infrequent, and often remains limited to this bone for a long time. It may commence in one of three sites, viz. (*a*) the posterior epiphysis, which, not appearing until the tenth year, does not unite till between the fifteenth and nineteenth years; (*b*) the body of the bone; (*c*) the calcaneo-astragaloid joint, *de novo*, or as an extension from the astragalus. The diagnosis of primary disease in this joint is often difficult: thus the swelling and position of the sinuses recall disease of the ankle-joint. The pain is usually greater than in ordinary disease of the os calcis itself, and the foot is sooner disabled. With the X-rays, and an anæsthetic, the ankle-joint is found free, and probes introduced by sinuses may pass towards the level of the

upper surface of the os calcis (known by the tubercle for the extensor brevis).

Operation. The parts having been sterilised and rendered evascular, and the foot firmly supported on its inner side at the edge of the table, an incision [1] is made with a strong-backed scalpel, commencing at the inner edge of the tendo Achillis, and passing along the upper border of the os calcis (*vide supra*) at the outer border of the foot as far as the calcaneo-cuboid joint, which lies midway between the outer malleolus and the fifth metatarsal bone. This incision should go down at once upon the bone, so that the tendon should be felt to snap as the incision is commenced. Another incision is then to be drawn vertically across the sole, commencing near the anterior end of the first, and terminating just short of the inner surface of the os calcis, beyond which it should not extend for fear of wounding the posterior tibial vessels. The bone being now exposed by throwing back the flap, the calcaneo-cuboid joint is first found and opened. The peronei must be dissected out,[2] and drawn aside with a blunt hook. The astragalo-calcanean joint is next attacked; and the close connection between the bones at this point constitutes the principal difficulty of the operation, unless the ligaments have been destroyed by disease. This difficulty can best be met by grasping the bone firmly with lion-forceps, and wrenching it backwards and outwards, aided by levering movements of an elevator, and a knife-point kept very close to the bone. Especial care must be taken on the inner side to avoid the vessels. The bone being removed, the gap is lightly plugged with gauze, and the dressings applied before the tourniquet is removed.

The question of preserving the periosteum has already been referred to (p. 943). I have found subperiosteal excision of the tuberculous os calcis a good operation, and a healthy new bone of good size has usually resulted.

OPERATIONS FOR MORE COMPLETE TARSECTOMY

It is scarcely worth while to give directions for the removal of other single bones, *e.g.* the scaphoid and cuboid, as these are rarely diseased alone, and, if this should be so, their removal is easy.

The operation of Dr. P. H. Watson will be described to meet those cases where more extensive disease is present, and where the patient's age and condition justify a trial of these severe operations instead of amputation. In the very few cases which call for these operations Watson's is, in my opinion, to be preferred, as it leaves a foot at right angles with the leg.

Operation of Watson. This is adapted to cases where the medio-tarsal articulation is involved, the importance of which, from the number of bones and the complicated synovial membrane, is well known (p. 943). In other words, the disease should be situated between the bases of the metatarsal bones in front and

[1] The above incision is taken from Mr. Holmes' article (*Syst. of Surg.*, vol. iii. p. 771). A still better one is that advised by Farabeuf (*Man. Oper.*, p. 759):—A horseshoe-shaped incision is made round the heel, beginning at the calcaneo-cuboid joint, dividing the tendo Achillis, and ending on the inner aspect of the foot, external to the posterior tibial vessels and nerves. To this incision a short vertical one is added, running up along the outer side of the tendo Achillis. By turning aside the flaps thus marked out the bone is most thoroughly exposed.

[2] Mr. Holmes (*loc. supra cit.*) says that he has always divided these without ill effect. Care must be taken in drawing them aside, for, if this is done too vigorously, one may slough, as happened to me in one of my cases.

the os calcis and the astragalus behind. The parts being rendered avascular, incisions three to four inches long are made, on the outer side from the centre of the os calcis to the middle of the fifth metatarsal bone, and on the inner from the neck of the astragalus to the middle of the first metatarsal. The soft parts are carefully dissected off from the dorsal and plantar aspects of the foot by means of these incisions, the left thumb being kept between the point of the knife and the soft parts. With a curved probe-pointed bistoury the joints between the astragalus and scaphoid, and os calcis and cuboid, are opened up, and, a saw being passed between the plantar soft parts and the metatarsal bones, these are cut through from below upwards. The diseased bones being removed, the wound is firmly plugged and pressure applied with gauze pads and bandages before the tourniquet is removed. That this operation, though little known, is an excellent one in Dr. Watson's hands is shown by the fact that five out of his six cases did well. It must be remembered that it is an operation in the dark, and one that may involve a good deal of damage to soft parts, owing to the amount of disease which has to be removed by somewhat limited incisions.

CHOPART'S AMPUTATION (Fig. 387)

In this medio-tarsal amputation only the astragalus and the os calcis are retained, disarticulation being effected through the joints between the above bones and the scaphoid and the cuboid.

Value of the Operation. This has been a good deal disputed. The following objections have been raised to it:

(1) That the tendo Achillis, no longer counterbalanced by the extensor muscles, which have now lost their attachment, draws up the heel, tilting down the scar, which now becomes tender and irritable (Fig. 388). (2) In the normal foot the weight of the body is transmitted through the astragalus to the other bones of the tarsus and metatarsus. When, as in this amputation, these bones have been removed, the weight of the body tends to thrust forward the astragalus, no longer supported by the elastic bones in front, against the scar, and thus renders this tender and crippling. The above objections apply to the operation performed for injury or disease, the next to amputation for the latter only. (3) If the operation be made use of in caries, this disease is likely to recur in the two bones left. In answer to the first two of the above objections it may be said that this tendency to tilting upwards of the heel and downwards of the scar may be met: (*a*) By stitching the anterior tendons, *e.g.* tibialis anticus, extensor proprius hallucis, and some of the tendons of the extensor communis, into the tissues of the sole-flap with catgut, so as to give them a fixed point by which they may counterbalance the tendo Achillis;[1] (*b*) by cutting the plantar flap sufficiently long, and securing firm primary union; (*c*) by division of the tendo Achillis. This, however, is only of fugitive value; (*d*) wearing a wedge-shaped pad in the boot to raise the front of the stump.

The third objection is answered by only performing this operation for caries when the disease is limited to the front of the foot, is of distinctly traumatic origin, and occurs in a healthy patient.

Operation (Figs. 387 to 389). A tourniquet being applied, and the foot supported at a right angle over the edge of the table, the surgeon,

[1] We owe this ingenious precaution to Mr. Delegarde, of Exeter. Till it is more frequently made use of, and a larger number of cases are collected, the value of this amputation must remain somewhat undecided. I have operated on five occasions—one a severe crush, another for the results of perforating ulcer, and in three for caries of the front of the foot; in all this precaution was taken, and the stumps proved sound and useful. One of these cases of Mr. Jacobson was seen by me thirty years later. She had an excellent stump. The writer has seen similar good results years after intra-uterine amputations.

standing to the right side of the foot, and so that he can easily face the sole, places (*e.g.* on the right side) his left index and thumb immediately above the tubercle of the scaphoid and the corresponding point on the outer side, viz. the calcaneo-cuboid joint, which lies midway between

FIG. 387. Chopart's amputation. The dorsal flap has receded due to the extreme plantar flexion.

the external malleolus and the base of the fifth metatarsal bone. He then joins these points by a slightly curved incision crossing the tarsus, and dividing everything down to the bones. The foot being flexed upwards, a plantar flap is then marked out by an incision running from the outer extremity of the first up the outer side of the little toe, then across the sole on a line just short of the balls of the toes, and then down the inner side of the great toe to join the inner extremity of the first.[1] The

FIG. 388. Stump after Chopart's amputation. (Fergusson.)

FIG. 389. Stump stated by Farabeuf to be often met with after Chopart's amputation, showing its shape, the position of the bones, and the influence of the tendo Achillis.

flap thus marked out is raised with the same precautions given at p. 949. It is then held out of the way, and the anterior half of the foot being strongly depressed, disarticulation is effected by passing the knife above the tubercle of the scaphoid between this bone and the astragalus, and

[1] The flap should be a full inch shorter than that in Lisfranc's operation (p. 949), if the tissues are sound. An unduly long and large plantar flap will here, as after a Lisfranc's amputation, form an unwieldy pocket (Treves).

then between the concavo-convex surfaces of the calcaneo-cuboid joint. In effecting this the position of the joints and the shape of the astragalus must be remembered, and Mr. Skey's words borne in mind: "The joints should be opened with tact and not by force: if the knife be applied to the right surface, it will pass without effort into the articulation; if in the wrong direction, no force will effect it."

The anterior tibial and plantar arteries are then secured, and, on removal of the tourniquet, any other vessels which require it. The flap is then folded up over the bones, but without any forcible bending, which might interfere with the blood-supply. While it is held in this position, before any sutures are inserted, the extensor tendons (*vide supra*) should be carefully stitched with sufficiently stout silk into the fibrous tissues which abound in the plantar flap, care being taken, in so doing, not to puncture the external plantar vessels, but at the same time to secure a sufficient hold.

Fig. 390. Lisfranc's amputation. The ventral flap extends to the bases of the toes and includes nearly all the soft parts below the metatarsal bones.

AMPUTATION THROUGH THE TARSO-METATARSAL JOINTS

(Figs. 390 and 391)

This, though usually spoken of as Hey's or Lisfranc's amputation, includes, accurately speaking, the following **operations**: (1) **Lisfranc's.** Amputation by disarticulation through all the joints. (2) **Hey's.** This is usually described as amputation here by sawing through the bases of the metatarsals. In reality, Hey seems to have disarticulated through the outer four joints, and sawn off the projecting internal cuneiform.[1] (3) **Skey's.** Disarticulation through the outer three and the first joints, the second metatarsal being sawn through.[2]

Indications. Few. (1) Limited crushes in which the sole is sound. (2) Disease limited to the front of the foot. (3) Inveterate bunion, with persistent sinuses and recurrent attacks of cellulitis. (4) Perhaps perforating ulcer. (5) Some cases of frost-bite.

Owing to the complexity of the synovial membrane here (Fig. 386), any disease which has invaded the synovial membrane between the second and third metatarsals and the second and third cuneiforms, has also spread to that between the scaphoid and three cuneiforms. This, though of small moment in cases of injury, should put this amputation aside in most cases of disease.

[1] *Observations in Surgery*, third edition, p. 552.
[2] *Oper. Surg.*, p. 406.

Lisfranc's Amputation (Figs. 390 and 391). The preliminaries are the same as in Chopart's amputation. The surgeon, standing to the right side of either foot, and so as easily to face the sole, places his left index and thumb on the bases of the little and great toe metatarsals respectively. The first of these can always be found by pressure, even if swelling is present; if there be any difficulty with the latter, it will be found a full inch in front of the readily detected tubercle of the scaphoid. These two points thus marked out are joined by a slightly curved dorsal incision with its convexity forwards. As a rule, if the tissues in the sole are sound, no dorsal flap should be made, the above incision being kept close to the line of the joints through which disarticulation is to be performed.

The foot being now flexed upwards, the surgeon, looking towards the sole, marks out a plantar flap by an incision running from the outer extremity of the first cut (for the right foot) up the outer side of the foot, then across the heads of the metatarsals, and down the inner side, so as to join the inner extremity of the dorsal incision. This flap should be made a little longer on the inner than on the outer side of the foot, so as to cover the additionally projecting bones on this side. Its cut edge being taken firmly between the finger and thumb, the flap is then dissected up as thickly as possible, *i.e.* containing all the tissues possible in the sole. In keeping the knife close to the bones some of the metatarso-phalangeal joints will probably be opened. Below these the flap, if steadily pulled upon, will, with light touches of the knife, readily separate from the metatarsal bones. The flap should be raised evenly, and without scoring or any button-holes. The prominent bases of the first and fifth metatarsals being laid bare, a few strong touches of the point of the knife may be required to separate part of the tibialis anticus and peroneus longus from the base of the former. The anterior part of the foot is now strongly depressed so as to stretch the dorsal ligaments, and the knife, having been thoroughly carried round the base of the fifth metatarsal, is drawn obliquely forwards and inwards so as to open the joints of the outer three metatarsals with the cuboid and the external cuneiform. The joint between the first metatarsal and the internal cuneiform is next opened, and lastly, the second metatarsal is freed as follows: The knife being held firmly in the fist, its point is inserted between the first two metatarsal bones, and the knife carried backwards and forwards in an antero-posterior direction in the long axis of the foot. The same is then done between the second and third metatarsal bones, the lateral ligaments being thus divided, the joint between the second metatarsal and the middle cuneiform is found and opened,[1] this being facilitated by strongly depressing the foot, care being taken not to do this so violently as to separate the second metatarsal from its upper epiphysis, or to fracture the bone.[2] A few remaining touches of the knife, aided by a twisting movement, will then suffice to separate the foot.

The method by disarticulation may be a useful test of a candidate's knowledge and skill at an examination. In practice, sawing through

[1] The position of this joint must be remembered, and the way in which the base of the second metatarsal bone is locked in between its fellows and the cuneiform bones. Its base projects upwards between a third and a quarter of an inch above the others.

[2] While the surgeon is disarticulating the metatarsal bones the plantar flap must be held well out of the way to prevent its being punctured.

the metatarsals just below their bases may nearly always be substituted, as giving equally good results with a great saving of time and trouble. The truth of this I have personally tested.

FIG. 391. Lisfranc's amputation. The internal cuneiform is sawn across to make an even stump.

This method of cutting the plantar flap before any attempt is made to disarticulate is strongly recommended in preference to disarticulating immediately after making the dorsal incision by passing the knife behind the bones and cutting the flap from within outwards. In thus disarticulating before making the plantar flap, it is quite possible to puncture the tissues in the sole, and perhaps to wound the external plantar artery. Again, passing the knife behind the metatarsal bones often leads to a hitch, especially with the projecting fifth.

The dorsalis pedis and the external plantar artery are now secured with any smaller vessels which need it. Tendons are cut square, nerves shortened, drainage provided, and the plantar flap then brought up and secured in accurate position.

Owing to the thickness of the plantar flap and its tendency at first to unfold itself downwards, numerous points of suture, of sufficiently stout wire or silkworm-gut, must be made use of.

AMPUTATION OF THE TOES

Practical Points. (1) Any plantar scar is to be avoided. (2) The line of the metatarso-phalangeal joints lies a full inch further back than the inter-digital folds of the skin (Holden). (3) Partial amputations (save in the case of the great toe) are very seldom advisable, the stumps left being of little use, and inconvenient owing to their liability to project upwards.

AMPUTATION THROUGH THE PHALANGES OR THE INTERPHALANGEAL JOINTS

These operations are not recommended, for the reasons just given. If a patient insist on having one performed, the directions already given for the fingers will be found sufficient.

AMPUTATION OF ANY OF THE FOUR SMALLER TOES AT THE METATARSO-PHALANGEAL JOINTS

This amputation is performed much as in the case of the fingers (chap. iv.), but the following points must be remembered:

(1) The line of the joint lies a full inch above the web. (2) The head of the metatarsal bone is not here removed, so as to leave the supporting power of the foot undiminished. (3) It is most important to avoid, as far as possible, any scar on the sole.

The scar, a simple antero-posterior one, is well protected by the adjacent toes. The incision should always be begun on the dorsum, even in the case of the little toe, so as to avoid friction of the boots.

Fig. 392. Amputation of the little toe.

AMPUTATION OF GREAT TOE AT THE INTER-PHALANGEAL JOINT

This is usually performed with a plantar flap (chap. iv.).

AMPUTATION OF GREAT TOE AT THE METATARSO-PHALANGEAL JOINT (Fig. 393)

This is performed by the methods described in chap. The following points must be borne in mind:

(1) Owing to the large size of the head of the metatarsal bone, the flaps are often cut of insufficient length. The incision must be begun an inch and a quarter above the joint, and carried well on to the phalanx, one flap being cut longer than the other if needful. (2) The sesamoid bones must be left in connection with the head of the metatarsal bone, as any attempt to dissect them out is likely to imperil the vascularity of the flaps, especially after middle life.

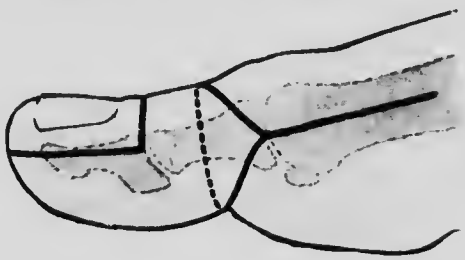


Fig. 393. Amputations of the great toe at the interphalangeal and metatarso-phalangeal joints.

In all other details the steps of this amputation are very similar to those already given in chap. iv.

Though it is recommended by some excellent surgeons to remove the head of the metatarsal bone either transversely or obliquely from within outwards, this step, narrowing as it does the treading width of the foot, is not advisable, unless the condition of the skin is such as to render it impossible to obtain sufficient flaps to cover the entire head.

AMPUTATION OF THE GREAT TOE, TOGETHER WITH REMOVAL OF ITS METATARSAL BONE

This may be performed by a modification of the oval method as described for the fingers in chap. iv.

Hammer Toe. In cases requiring operation the choice lies between excision of the head of the first phalanx and amputation, the former is nearly always adopted and gives good results.

Ingrowing toe-nail. Operation is the best treatment of cases of any severity of this incorrectly named condition. Many methods have been described; the following is simple and efficient. It may be performed under local analgesia and the aid of an improvised tourniquet round the base of the toe. If, as is usually the case, an ulcerated and infected condition of the soft parts be present, this must be first dealt with by the use of boracic acid or dilute formalin fomentations, pure carbolic acid, &c.

From a point at least a quarter of an inch above and a little to the outer side of the inner angle of the nail-fold, a curved incision is carried through sound skin to a corresponding point below the nail, to reach which the incision is curved outwards. From the starting-point a straight incision is then made between these two points, directly forwards, through the nail and its bed. The included nail, skin, nail-bed and angles of the nail-fold are then completely excised. The edge of the skin, carefully dissected free if needful, is then brought into contact with the edge of the nail and there kept in position by circular strips of gauze not applied too tightly. The tourniquet is then removed and a larger dressing applied, if needful. The foot should be kept well elevated. The patient can, usually, get about in ten days, especially if a leg-rest is used at first. After-attention to well-fitting boots, and to cleanliness of the toes and the way in which the nails are regularly trimmed, must of course be enforced.

CHAPTER XLVI

OSTEOTOMY

OSTEOTOMY OF THE FEMUR FOR ANKYLOSIS OF HIP-JOINT OR FOR COXA VARA. FOR GENU VALGUM. OSTEOTOMY OF THE TIBIA. OSTEOCLASIS AND MANUAL REDUCTION

FOR ANKYLOSIS OF HIP-JOINT

This includes **Adams' operation** of division of the neck of the femur and **Gant's operation** of division of the shaft of the femur just below the trochanters. The latter being much the simpler, and giving excellent results, should, I think replace the former.

Fig. 394. Osteotomy of the femur. Usually the methods of Gant and Macewen are the best at the upper and lower end of the femur. Adams' operation is sometimes useful for adolescent coxa vara.

Indications. Cases in which the hip-joint is permanently flexed and stiff, and the patient accordingly crippled, either from old hip disease, or from ankylosis after rheumatic fever, pyæmia, or the neck of the femur is bent as in coxa vara, &c.: cases in which extension has failed, together with trials of straightening the limb with the aid of anæsthetics.

Adams' operation divides the neck of the femur subcutaneously within the capsule. It is best suited for those cases in which the neck remains unabsorbed, as in ankylosis after rheumatic fever, and, much more rarely, pyæmia. A long tenotome or a straight narrow bistoury is entered about one inch above the top of the great trochanter, and carried on the flat downwards and inwards over the anterior aspect of the neck (p. 820). The edge is then turned towards the bone, and by cutting deliberately and freely on this, a passage is made for the saw. The knife being withdrawn, the excellent saw which bears Mr. Adams' name is passed along the wound made down to the neck of the bone, which is then sawn through. After sawing for about four or five minutes the limb should become movable. If this is not the case, the section has been made, not through the neck itself, but through the junction of the neck and shaft. Where the surgeon remains in doubt he should remove the saw and convert his wound into an open one, and make sure of his path by means of a sterilised finger.

In order to bring down the limb completely, the contracted tendons of the adductor longus, sartorius, and perhaps the rectus, will probably require subcutaneous division.

The limb is strongly abducted and extended and fixed in this corrected position in a plaster splint extending from the waist to the toes.

This operation gives good results, though, as stated below, I prefer Gant's owing to its greater simplicity. For there is no doubt that if the bone is dense from previous inflammation, and if the section trenches upon the shaft instead of going through the neck only, the sawing may be

FIG. 395. Osteotomy for contracted ankylosed hip to correct flexion, adduction and shortening.

very tedious. Thus, I have seen two cases in which this took over half an hour.

A case is mentioned in a report from a committee of the Belgian Academy of Medicine, in which a patient who had been submitted to Adams' operation insisted on getting up on the twentieth day. Hæmorrhage came on from the fragments wounding the femoral vessels or some large branch. The femoral was tied just below Poupart's ligament; the hæmorrhage ceased, but free incisions were required for suppuration. The patient ultimately recovered. The same committee reported a death from hæmorrhage, and one from purulent infiltration. No bad results have, as far as I am aware, followed in England.

Gant's operation. Here the shaft of the femur is divided just below the trochanters.

Advantages. The operation is a simpler one than that just given, as the shaft is more readily reached and divided than the neck. Moreover, it is an operation of wider applicability, for it is suited to all cases, not only those in which a neck remains, but those more common cases of ankylosis after hip-disease, in which repair has taken place with partial displacement of the head, or what remains of it. In these cases there is next to no neck of femur to be divided by Adams' method.

A transverse incision one inch long is made just below the base

of the great trochanter. The osteotome is then introduced obliquely downwards and inwards well down to the bone, and the outer two-thirds of this divided, the rest being effected by snapping the bone by lateral movements. The tendons mentioned above will probably require division.

The limb is fixed in a plaster splint extending from the epigastrium to the toes in the over-corrected position for three months. Then a Hessing's splint is applied. This conducts all the weight from the pelvis and thus prevents strain at the fractures until all risk of bending has passed.

OSTEOTOMY FOR GENU VALGUM

I. **Division of the Shaft of the Femur from the Outer Side** (Fig. 396). The limb being supported, with the knee flexed, on a sand-bag, an incision about an inch and a half long is made at a right angle to and down to the bone on its outer side, about three inches above the external condyle. The knife—a narrow, straight bistoury—should go down to the bone deliberately, and cut firmly and strongly on it, enlarging the wound slightly as it emerges, in order that the soft parts may not be damaged if the heel of the saw is depressed, and that there may be no lip of tissues to hinder the escapes of discharges. The saw or chisel is then introduced, and the bone divided for its outer two-thirds. As the thicker part of the bone is on the outer side, as soon as this is divided the inner third usually gives way readily on carrying the knee and leg from without inwards. But the operator should continue the division of the bone till he can feel certain that two-thirds are divided, for if, after dividing only half, he tries, especially in the case of a dense bone, to fracture the rest and straighten the limb, either great or prolonged force must be made use of, leading possibly to damage of the vessels and other soft parts; or the saw or chisel must be re-introduced, a point to be always avoided if possible, as the difficulty which is usually met with in hitting off the original track will be likely to lead to the above drawbacks.

The *advantages* claimed of the above method are (1) that as the femur is divided at a much narrower part than in the supracondyloid operation of Macewen, it is more easily and quickly done. (2) The bone section is farther away from the epiphysis and the line of the synovial membrane. (3) There are no important blood-vessels near.

I do not like the method, for it does not treat the deformity at the best spot, and the shaft being small, firm union takes some time and gradual bending at the fracture is not uncommon later on.

II. **Division of the Lower End of the Femur from the Inner Side, just above the Epiphysial Line** (supracondyloid of Macewen[1]) (Fig. 394). The knee being flexed and supported firmly on a sand-pillow by the hands of an assistant grasping the middle of the thigh and leg, the skin resterilised, the position of the adductor magnus tendon and its tubercle is defined, and a longitudinal incision about an inch long (a little longer than the breadth of the chisel to be used) is made down to the bone at a point one inch above and in front of the adductor tubercle. The scalpel goes at once down to the bone. Superficial veins may be cut, but no artery normally distributed, as the incision is below and anterior to the anasto-

[1] *Osteotomy*, p. 120.

motica magna and above the superior internal articular. Before withdrawing the knife, the osteotome is introduced by its side down to the bone in the same way as the knife, *i.e.* parallel to the long axis of the limb, is then turned at a right angle to it, and the inner two-thirds cut through. *The direction of the bone-incision* is most important. The surgeon must cut transversely across the femur on a level with a line drawn half an inch above the top of the external condyle. This incision will avoid the epiphysis and synovial membrane. The line of the former may be usually represented by one crossing the femur at the level of the highest point of the femoral articulating surface, and running through or just below the adductor tubercle, so that, the incision being an inch above the tubercle, the epiphysis will be cleared. The only part of the synovial membrane which is as high as the bone incision is that under the quadriceps, which may reach in the adult as high as two inches above the trochlear surface. There is generally a quantity of fat between it and the bone. The spot selected by Sir W. Macewen for his incision is posterior to this point. As in a valgous limb the whole internal condyle is lowered, a line drawn transversely from the adductor tubercle might land the operator low down in the external condyle. The osteotome, placed against the inner edge of the bone, must be driven at first from behind forwards and to the outer side; it is then made to move forwards along the inner border until it comes to the anterior surface, when it is directed from before backwards and towards the outer posterior angle of the femur. By keeping on these lines there is no fear of injuring the artery. The hard external surface usually resists the osteotome, especially in adults, but the surgeon will soon recognise by touch or sound when his osteotome [1] meets this layer. It is the inner border and the anterior aspect of the bone which it is essential to divide thoroughly if the reintroduction of the instrument with the difficulties of ensuring its entering the old groove, and the risks of infection are to be avoided. If it be thought desirable to penetrate the outer dense part, it must be done very steadily, so as to check any undue impetus on the part of the osteotome. A sterile pad having been secured over the wound, the surgeon, pressing the thigh down on the table with his left hand, and taking the limb low down with his right, gives it a quick jerk outwards, this being repeated if needful. If it be necessary to reinsert the osteotome, care must be taken to get it into the groove again, and to use it coolly and methodically in accordance with the above-given directions.

Mr. Keetley thus writes [2] on "cases in which the surgeon has almost entirely failed to get the improvement possible from the operation. Such cases are often supposed to be cases of recurrence, but they are really only examples of bad management. The points to attend to are: (1) Correct the deformity while the limb is in a position of extreme extension at the knee. The slightest flexion of the joint hides the deformity and deludes the surgeon into a false sense of satisfaction. (2) The exact amount of looseness of the knee-joint, if any, should be noted before the bone is divided, and allowed for in putting up the limb. To this

[1] The osteotomes must be bevelled on both sides, wedge-like, and sufficiently trustworthy for hardness and toughness, points only to be secured by getting them of first-rate and painstaking makers. Sir W. Macewen's test is as follows: If the instrument will neither turn nor chip in penetrating the thigh-bone of an ox, it is well suited for cutting human bones. Its edge should be sharp enough to pare easily the finger-nail (Keetley).

[2] *Orthopædic Surg.*, p. 33.

end the adjustment will sometimes have to be a position of distinct varum. (3) A certain amount of spring in the bones and extensibility in the ligaments, especially in the case of children, must be allowed for in the same way."

III. Division of Tibia as well as Femur. The division of the tibia (and the fibula also) as well as the femur has been advocated by Mr. Borwell and others. In the majority of cases, though, at first sight, there may seem to be one striking curve localised to one spot, a closer examination shows that in reality several curves are present, and often of different kinds, antero-posterior as well as lateral, diffused over the whole shaft rather than limited to one end. In these cases, rectifying one curve often makes the others more prominent. Multiple osteotomies are required here, the femur and the tibia each requiring division in two places. In one very aggravated case of genu varum, in which the limbs (when the ankles were placed together) formed a circle, Sir W. Macewen performed ten osteotomies at one time.[1] In such severe cases most operators will prefer to straighten one side at a time.

Operation. A vertical incision is made over the inner surface of the tibia just below its tubercle, and the bone divided with an osteotome or saw from within outwards. The tissue on the anterior part just below the tubercle is much the densest. The division is commenced at the posterior part of the tibia and made, at first from behind forwards, and then before backwards. The section of the tibia should be made on the same occasion as that of the femur.

The wounds are closed with fine catgut.

Sir W. Macewen uses a splint consisting of a long outside, and a short back, with a foot-piece.[2] I have usually preferred plaster of Paris, applied by Mr. Croft's method, for children, amongst whom my experience has mainly been. It makes even, steady pressure upon the muscles around the wound, keeping them and it at rest, and it allows the patient to be more easily moved, especially when both limbs have been operated on. The outer piece of flannel should be brought high up, to the level of the iliac crest, so as better to command the muscles which disturb the upper fragment. In all cases of osteotomy, a long outside splint should be applied at first. However the limb is put up, the bandages must be applied firmly and evenly, but without undue tightness. The condition of the toes, as to colo[illegible]and movement, must be carefully watched. When the dressings [illegible]oved at the end of ten or fourteen days I like to have an anæs[illegible]given if neces[illegible]ary, and to rectify any slight remaining deformity.

The splints or plaster of Paris should be continued for six weeks, when the limb may be only supported with sand-bags if the union is firm. Passive and active movements are now allowed. In about three months the patient may be got up, with a stick, under observation. From an early date, care should be taken that he can bend his knee well.

[1] *Loc supra cit.*, Figs. 40 and 41.

[2] Sir W. Macewen advises the use of a mattress consisting of four parts, the two centre pieces corresponding to the gluteal region, and being easily removed to admit of the introduction of the bed-pan.

GENU VARUM

As the tibia is usually the bone which is most at fault, the directions for its osteotomy given below will suffice. When the femur is also much concerned it must be divided by means analogous to those given for genu valgum. And, as in this condition if the lower third of the tibia be also curved, osteotomy of this bone and the fibula (*vide infra*) will be required. Division in two places may be necessary.

OSTEOTOMY OF THE TIBIA

This may be (A) **Simple Division** or (B) **Cuneiform**, *i.e.* **the taking out of a wedge of bone.** The former of these, a very simple operation, will suffice for the ordinarily curved tibiæ, where the bone is bent laterally and the bend is most marked at the junction of the middle and lower thirds. Cuneiform osteotomy will be required when the bending is not only lateral, but antero-posterior as well.

A. **Simple Osteotomy of the Tibia.** The parts being sterilised, and the limb resting on its outer side on a firm sand-pillow, the surgeon notes, at the anterior and inner margins of the tibia, the spot where the curve is sharpest. Opposite this a longitudinal incision half an inch long is made just external to the anterior border of the tibia. The periosteum is divided over the crest, and separated from the internal surface of the bone. A fine Adams' saw is now introduced in the same way as the knife, carried horizontally down to, but not through, the puncture through the skin of the inner border of the tibia. The left index finger keeping guard over the tibial artery, the saw is turned towards the bone and cuts through the inner two-thirds of it. The entrance of the saw into cancellous tissue can be known by the diminution of resistance and the increased bleeding which often occur, but the best test of the depth to which the operator has arrived is the depth of the groove in which the saw has sunk. If it be preferred a sufficient wound is made, and a narrow osteotome employed. When the bone is divided sufficiently, a sterile pad is placed on the wound, and the surgeon, firmly placing his two hands, close together, immediately above and below the wound, sharply carries the lower fragment outwards. If the saw has been sufficiently used, the tibia snaps distinctly, while the fibula yields with a "greenstick" sensation. But if there be any difficulty here, this bone must be divided through a second incision. Great care must be taken to exert the force just on the sawn portion, or the ligaments of the ankle or the superior tibio-fibular joint may be strained and damaged. Attention has already been drawn to the need of using the saw sufficiently, otherwise the parts will be bruised and damaged in the futile attempts at fracture.

B. **Cuneiform Division of the Tibia. Removal of a Wedge.** I have not found the plan of estimating the size of the wedge to be removed by first making an outline on paper of much service. The parts being duly sterilised, an incision is made along the crest of the tibia equal to the base of the wedge which is going to be removed. It need not be longer, as the skin can be pulled up and down if needful. The periosteum is then divided cleanly and separated from the tibia with curved scissors. This membrane being held out of the way with retractors, a wedge is next removed with an osteotome or a narrow and sharp chisel but little bevelled. The gap can then be enlarged by removing from either side further slices

as required. Occasionally free haemorrhage takes place from the medullary artery, but this soon stops with firm pressure. The limb is now straightened by bending the lower fragment upwards [1] so as to bring the surfaces of the gap in contact. Difficulties which may be met with now are usually due to the wedge removed being inadequate in size or in shape. A sharp pair of bone-forceps may now be useful. The resistance of the periosteum at the back, or of the tendo Achillis are also factors. The former may require the removal of more bone, the latter division. The periosteum at the upper and lower angles of the wound may be closed with catgut sutures. In some cases accurate and firm apposition can only be secured by means of a plate and screws. The wound is closed with catgut. In this and the preceding operation sufficiently thick dressings should be applied to meet any oozing from the bone. Plaster of Paris or back and side splints should be applied.

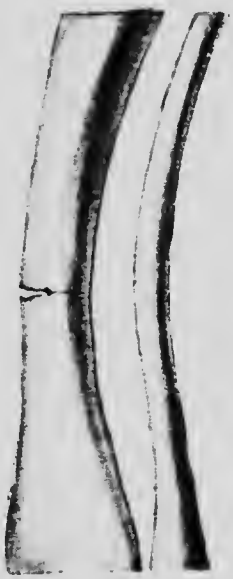


Fig. 396. Manual osteoclasis of the left tibia for bow-leg. The figure was drawn from a skiagram. A greenstick fracture of the tibia has occurred, but the fibula has merely bent. The deformity was completely corrected.

Causes of trouble after Osteotomy. (1) *Infective troubles.* Such a case will be found published in the *Clin. Soc. Trans.*, vol. xii, p. 27. It is too probable that other operators have not been so candid. (2) *Hæmorrhage.* At least one case has occurred of haemorrhage from the femoral and one from the anastomotica after division of the femur. I have also heard of a case in which the posterior tibial was injured in osteotomy of the tibia.

(3) *Division of the tibialis anticus tendon.*

This occurred in an osteotomy of the tibia performed by one of my dressers, who forgot how close the tendon lies to the outer side of the crest. The cut ends were joined by chromic catgut, and the action of the muscle was, afterwards, unimpaired.

(4) *Non-union.* I have never seen a case, but though extremely rare, its occasional occurrence [2] should be a warning against needless removal of bone, and any neglect of strict asepsis.

Treatment of severe curvatures of the tibia by manual osteoclasis. Mr. Openshaw thus describes his method: [3] "With the child fully anæsthetised, the leg is encased in cotton-wool and bandaged. The child is then turned over so that the leg which is to be broken lies upon its outer side. A wedge-shaped block, seven inches by three inches at the base and six inches high, is used. The upper edge of this block is about one inch wide and four inches long and is covered with thick india-rubber. The block is put underneath the leg transversely at the centre of the curve. The operator with one hand grasps firmly the foot, ankle and lower part of the tibia, and with the other hand the upper part of the tibia, the hands of the operator being two to three inches

[1] Aided by movements in the opposite direction, and from side to side if needed. The fibula should always in these cases be also divided to secure exactitude.

[2] Little, *Trans. Med. Chir. Soc.*, 1891.

[3] *Lancet*, March 4, 1905.

apart. With the block resting quite firmly upon a firm table, and the child's leg on the rubber-covered edge of the block, with a steady and increasing pressure, the bones are snapped across and the leg can then immediately and easily be made to assume a straight position. In a few instances the fibula can be heard to crack first, but in the majority the fibula is simply bent, and the tibia alone is broken." In some forty cases thus operated on, Mr. Openshaw has met with no untoward result. The limb is put up in two lateral well-padded splints, and the child sent home. It must be brought for inspection the next day, when a skiagraph can be taken. The child is able to walk in three or four weeks. It is necessary that the tibia should be actually fractured. The two legs are dealt with at different times. In Mr. Openshaw's opinion the leg of any child under ten can be dealt with in this manner. One of us has treated a great many children under five in this way in the out-patient department, with excellent results. Only a "greenstick" fracture of the tibia is produced, a wedge-shaped gap appears at the hollow of the curve of the bone, and is well shown by radiograms. The periosteum on the outer side is not torn, so that overlapping is impossible. In children over five the writer often finds it easier to use a small osteotome at the postero-internal aspect of the tibia to cut through a part of the bone, the remainder being snapped. The limb is immediately secured in good position by plaster bandages.

CHAPTER XLVII

TENOTOMY AND TENDON LENGTHENING. SYNDESMOTOMY. TENOTOMY OF THE HAMSTRING TENDONS. TENOTOMY OF THE STERNO-MASTOID. TREATMENT OF SEVERE TALIPES

TENOTOMY OF THE TENDONS ABOUT THE FOOT

DIVISION OF TIBIAL TENDONS.

Tibialis Anticus. This is usually divided where it is crossing the ankle-joint from without inwards, a little above its insertion into the internal cuneiform. It has, here, the dorsalis pedis vessels on its outer side, but separated from it by the extensor proprius hallucis.

The surgeon usually stands on the outer side of the leg, while the assistant stands opposite to him, grasping the foot with one hand and the leg with the other. The position of the tendon is made out by making it tense by abducting and plantar-flexing the foot, or by the voluntary contraction of the muscle when the patient is conscious, a local anæsthetic only being used. It is rarely necessary to give an anæsthetic to an infant, as the operation is so trivial and is over in a few seconds. The danger and after-effects of an anæsthetic are thus avoided and the tendon can be accurately localised as the child moves his foot. The surgeon notes the position of the anterior tibial vessels, defines exactly the width of the tendon, and places the tip of his index finger exactly on the side of the tendon farthest from him. He then inserts the tenotomy knife vertically close to the outer side of the tendon so as to avoid the vessels; sinks it lightly till he feels sure it is on a level lower than that of the tendon; then sends it horizontally across till he feels its point just under his index finger, and, having turned its edge upwards, finally, by a series of light levering or sawing movements, cuts through the tendon. The assistant relaxes the foot, *i.e.* adducts and bends it upwards, when the knife is first introduced, but places it on the stretch at a signal from the surgeon. Finally, as soon as the completion of the creaking sound and the sudden snap denote the division of the tendon, the foot is again relaxed. A small pad of sterile gauze being at once applied, the foot is put up in the everted position. For this purpose nothing is, to my mind, so simple and efficient as a well-padded splint of the proper width, with two notches at its lower end, the upper end being just below the knee in infants, and the lower projecting two inches and a half below the foot. The splint is applied to the outer side, the leg being first rolled in a flannel bandage to prevent pressure-sores.

Tibialis Posticus. It is usually recommended to divide this an inch and a half or two inches above the internal malleolus.[1] The tendon is

[1] The tendon is here rather farther from the artery, and the surgeon will be above the commencement of its synovial sheath, in which it traverses the internal annular ligament.

here separated from the posterior tibial vessels by the flexor longus digitorum.

The surgeon and his assistant occupying positions as above, the exact site of the tendon is defined, if possible, by abducting and bending down the foot. In fat infants it is often quite impossible to feel the tendon, and in these cases a spot midway between the anterior and internal borders of the leg will be the best guide, as denoting the inner margin of the tibia. The surgeon then introduces a sharp tenotome so as just to touch, if possible, the inner margin of the tibia, taking care to sink the blade sufficiently to open the sheath freely. This being done, a blunt-pointed tenotome is introduced through the same opening, and pushed under the tendon; the edge being then turned towards it, and the tibia used as a fulcrum, the tendon is severed, together with that of the flexor longus digitorum. The assistant first relaxes and then extends the tendon, as advised above.

If the artery be cut, as shown by the jetting hæmorrhage and the blanching of the foot, firm pressure must be applied, the foot being first bandaged. The writer generally prefers to expose the tendon through a short vertical incision. This avoids injury of the flexor longus digitorum and post-tibial vessels; moreover, some of the tibialis posticus tendon may be excised if desirable to prevent reunion.

Plantar Fascia. This may be divided just below its origin from the os calcis, or in advanced cases of talipes close to the transverse crease, which is here found in the sole. With regard to this fascia, the surgeon should not tie himself down to any fixed spot, but divide resisting bands whenever they are felt. The writer prefers to excise two inches of the plantar fascia in order to prevent recurrence of contracture, which is very common and difficult to prevent even with a good instrument and careful after-treatment. A longitudinal incision one and half inches long is made on the inner side of the sole, and the posterior two inches of the fascia, when the latter is narrow and thick, is excised.

Syndesmotomy. This term was introduced by Mr. R. W. Parker[1] who believes that in many cases, *e.g.* severe ones, cases not treated in early life, and in some relapsed cases, the foot cannot be rectified even by multiple tenotomy. He attributes this, not to adhesions, but to the faulty shortness, and unyielding nature of the ligaments. Chief amongst these, in equino-varus, are the ligaments about the astragalo-scaphoid joint. "In these cases there is a capsule made up above and internally by a blending together of the superior astragalo-scaphoid ligament with fibres from the anterior ligament, and the anterior portion of the deltoid ligament below with fibres from the inferior calcaneo-scaphoid ligament. To these are united fibrous expansions of the tendons of the anterior and posterior tibial muscles; together they form an unyielding capsule of great strength, which is attached to the several bones, not in the usual manner, but in adaptation to their altered relative positions. This I would name the 'astragalo-scaphoid capsule.'" Mr. Parker gives directions for dividing this structure which can be made to combine division of the tibial tendons. While I consider this method superior to that just given, I much prefer that by a flap, by which the needful tendons, fascia and ligaments can all be divided together. In syndesmotomy it is more difficult to make sure of dividing the tibialis posticus.

The site chosen for this combined division of tendons and ligaments is a little below and anterior to the tip of the internal malleolus.[2] Other guides are the site of the astragalo-scaphoid joint, and in older cases the transverse crease which, running down on to the sole, denotes the continued inversion of the foot. Two

[1] *Congenital Clubfoot*, p. 62 *et passim*.

[2] Mr. Parker (*loc. supra cit.*, p. 78) shows that Velpeau and Syme pointed out the possibility of dividing the tendon of the tibialis posticus here.

tenotomes are required, one of ordinary pattern, and one curved, somewhat sickle-shaped, and with a cutting blade about half an inch in length.

The surgeon notes the position of the arteries, and the lines along which the tibial tendons are curving towards the internal cuneiform. Having marked, at the spot above given, the position of these tendons, he enters a sharp-pointed tenotome, the parts being relaxed, just above the posterior tibial artery, and pushes it outwards on to the dorsum to a spot just short of the dorsalis pedis artery, the knife travelling just beneath the skin to make a path for the next instrument, which does the work. The curved tenotome is then inserted under the skin, and pushed on, flat-wise, till its tip can be felt over the tibialis anticus; it is then turned blade downwards, the tibialis anticus is felt to give way, and, as the knife cuts on the subjacent bones and cartilages, the ligaments are felt to yield to it, while, as it is withdrawn, its edge divides the tibialis posticus.

Tendo Achillis. This should be divided half an inch above its insertion in an infant, and an inch and a half in an adult.

The foot and leg being turned well over on to the outer side, and the tension being relaxed by the assistant bending the foot downwards, the margins of the tendon are accurately defined. The knife is then introduced vertically close to the inner side of the tendon till it reaches a sufficient depth to ensure being beneath it;[1] it is then pushed horizontally across under the tendon till it is felt under the skin by the left index finger, which accurately marks out the outer limit of the tendon; the blade is then turned towards the tendon, which being at the same time put on the stretch by bending up the foot, is divided by a series of levering movements of the handle. Creaking movements, followed by a sudden snap or thud, denote complete division, when the tendon is to be at once relaxed and the knife brought out horizontally. The writer prefers to hold the foot himself, always standing on the outer side of the affected limb and holding the tenotome in the left hand for the right limb and vice versa. When the shortening of the tendo Achillis is over one and a half inches the writer divides the two lateral halves of the tendon at different levels, subcutaneously, and splits the tendon between. This gives quicker and stronger union, and avoids the risk of non-union.

The Peronei. The peroneus longus and brevis occasionally require division. They may be divided simultaneously by entering a tenotome between them at the bone about two inches above the external malleolus. Immediately above this process they are more under cover of the bone. If divided below it, their synovial sheath would be opened.

Date of rectification. In the case of the smaller tendons, and in the more common cases of tenotomy, *e.g.* for congenital equino-varus, this should be immediate. While the tendo Achillis has been divided, and in many cases of tenotomy for infantile paralysis, correction must be made more gradually. Whatever operation is performed, *over-correction* must be ensured during the first fortnight, owing to the certain tendency to relapse. For retaining appliances I prefer felt or poroplastic in children, or a notched splint, like a Dupuytren's (p. 961). If a plaster of Paris bandage is employed it should be removed as soon as possible, to allow of the needful daily movements of the joints, and rubbing. Thus, after about ten or fourteen days, the foot should be *daily* manipulated by the surgeon for a while and active exercises performed by the patient; and, later on, several times daily by the mother or nurse, the surgeon seeing the case every few days. If such manipulations are daily persevered with, and the

[1] Young operators often do not insert the knife sufficiently deep; they thus, when it is pushed across, get *into the tendon* instead of *beneath it*, and so divide it incompletely.

case kept under the surgeon's eye, recurrence in deformity is unlikely, especially if suitable day and night instruments are used. To allow of these manipulations being begun early over-correction is essential. Finally, if only justice were done to the methods of tenotomy and division of ligaments and to ensuring early over-correction by suitable boots and instruments, we should hear little of severer methods.

TENOTOMY OF THE HAMSTRINGS

Semi-tendinosus and Semi-membranosus. These tendons can be divided subcutaneously. A contracted knee can generally be straightened after division of the biceps and semi-tendinosus. If it is needful to insert the knife more deeply so as to divide the semi-membranosus, it would be well to use a blunt-pointed tenotome, or to operate through an open incision. The writer generally divides the inner hamstrings as follows. After dividing the biceps through an open wound over it, he inserts a finger to feel and protect the popliteal vessels, while a tenotome is introduced in front of the inner hamstrings from the inner side, guided by the finger behind the large blood-vessels.

TENOTOMY OF THE STERNO-MASTOID

The **open method,** in which the muscle is divided through a curved incision across the lower end of the sterno-mastoid, is the best here, as it allows of every step being seen, of avoiding abnormal vessels, and securing not only complete division of the muscle, but also of any fascial bands. It is often necessary to divide or lengthen these tendons for straightening the knee contracted as a result of arthritis, spastic paraplegia, or infantile paralysis, imperfectly healed by apparatus.

Biceps. The proximity of the external popliteal nerve makes an open incision far safer. An incision two inches long is made parallel to and just in front of the biceps tendon, and the latter carefully separated from the nerve, which lies just behind and internal to it. The tendon is either divided or split and lengthened as required. If necessary for the correction of associated genu valgum the ilio-tibial band and the external lateral ligaments of the knee can be divided at the same time, after lengthening the incision as required.

If **punctures** are employed the two heads are best divided separately just above the clavicle. The muscle being made prominent, by one assistant manipulating the head and another depressing the shoulder, the surgeon, standing facing the patient on the side to be operated upon, defines the limits of the inner border of the sternal tendon, opens the fasciæ sufficiently freely here and then, taking a blunt-pointed tenotome, insinuates it horizontally behind and close to the tendon till it is felt just beneath his left index finger, which is placed at the outer margin; the edge is then turned towards the tendon, and divides it. It is withdrawn with the usual precautions. The clavicular tendon is divided in a similar way through another puncture.

Care must be taken to avoid the anterior jugular, which runs outwards under the muscle a little above the clavicle, and the external jugular, which lies at a varying level close to the outer border of the clavicular head. If a sharp tenotome were dipped too deeply, the internal jugular might also be wounded.

If any smart venous hæmorrhage occur, a pad of dry gauze should be firmly bandaged on.

Lengthening the Sterno-Mastoid. For moderate, and especially severe shortening of the sterno-mastoid, and except in infants when subcutaneous tenotomy is satisfactory, lengthening the muscle is by far the most satisfactory operation. This operation, which was introduced by the writer some ten years ago, has proved most satisfactory, the after-treatment being rendered simple and of short duration, and the functional results and appearance being almost perfect. A curved incision similar to Kocher's incision for goitre but much shorter and only on one side, is made, and the sternal tendon is detached from the bone, and the clavicular fibres are divided obliquely upwards and backwards about an inch and a half or two inches up. The sternal head is joined to the clavicular fibres at this point by a catgut suture. A massive dressing is applied to maintain the over-corrected position.

Causes of Failure after Tenotomy. (1) Incomplete division of the tendon. (2) Division of important structures, *e.g.* the tibial arteries, the external popliteal nerve, the anterior or internal jugular veins. (3) Non-union of the tendon. (4) Mal-union of the tendon, *e.g.* adhesions formed by it to adjacent structures, its sheath or a bone. These are both extremely rare, and are due to neglect of early movements, both active and passive. (5) Breaking off the point of the tenotome, usually against a bone.

THE OPERATIVE TREATMENT OF TALIPES

Space does not allow a full discussion of the treatment of the various forms of talipes here. Only a few suggestive methods for some of the common deformities will be described. Talipes equino-varus, either congenital or acquired and paralytic, is by far the commonest and will be most fully discussed. Calcaneo valgus and equino valgus, pure equinus and pes cavus are far less frequent and will be more briefly discussed. Flat foot, the commonest form of talipes valgus, does not often require operative treatment, but this and the grave variety following fracture dislocation of the ankle will be briefly considered.

SOME POINTS IN THE TREATMENT OF SEVERE TALIPES

Before proceeding to describe the operations a few remarks may be made upon the prophylaxis of paralytic talipes and the early treatment of congenital talipes, for the old proverb that "prevention is better than cure" is very true of deformities. Most deformities are either preventable or curable in their early stages by safe and simple means. If these facts were more widely and thoroughly appreciated, there would be fewer hopeless cripples and far less misery and poverty. Many cripples, now hopelessly handicapped in the struggle for existence, would be useful members of society. The ignorance that prevails concerning the proper treatment of congenital talipes is appalling. The parents are commonly told that it is of no use commencing treatment until the child is several months old. The most hopeful time for treatment is thus allowed to pass, and deformities, which are curable by manipulations and simple splints in the first few weeks of life, are allowed to become serious and more or less intractable. Paralytic talipes develops so insidiously that it may appear

to be inevitable, whereas it is mostly preventable by simple means. The value and importance of suitable instruments designed to prevent overstretching of the paralysed muscles and fibrous retraction of their antagonists are not sufficiently realised. The surest way of completing the paralysis of a weak muscle is to overstretch it, and one of the most important conditions of its recovery is the avoidance of excessive tension.

There is a current belief that instruments of all kinds do not aid but hinder the restoration of function of the paralysed limb. This is by no means true of suitable instruments, provided that their use be combined with well-planned exercises designed to develop the weak muscles, and manipulations for stretching muscles that tend to retract. Too much faith is placed in massage and electricity. They certainly tend to maintain the nutrition of the weak muscles in the early stages of paralysis, but their good effect is often more than neutralised by the neglect of the other and better means which have been already mentioned.

After the talipes has been more or less corrected by simple operation, recurrence and increase of the deformity is exceedingly common because of the want of care in the after-treatment. Without this care operations and instruments are more or less wasted. The after-treatment of hospital patients is peculiarly difficult because of the trouble and expense of getting suitable instruments. The patients often fail to attend regularly for various reasons; they may not take a sufficient interest in their condition; circumstances may make it impossible for them to keep their instruments in repair, and frequently they reappear only when their deformity is obviously getting worse.

Operations. Tenotomy and division of ligaments; tendon lengthening; transplantation of tendons; resection of bone; nerve anastomosis.

Tenotomy and tendon lengthening have been considered. It is rarely necessary to do any other operation for correction of congenital talipes in infants, or for *early* acquired talipes in young children. Careful after-treatment along the lines already mentioned serves to complete the cure.

For later cases ligaments sometimes require division; for instance, the plantar ligaments are divided when there is much elevation of the arch of the foot, and the plantar fascia is divided, or better, a portion of it is excised.

Transplantation of tendons. The whole or a portion of a tendon is shifted to a new insertion. The best example is the transference of the tibialis anticus insertion from the inner to the outer side of the foot, thus changing its adductor function into abduction, while maintaining its power of dorsi-flexion of the ankle. Similarly other tendons are transferred. Experience has shown that certain rules must be observed in order to secure good results from this operation.

(1) It is better to sew the tendon to the periosteum or ligaments than to another tendon, for the latter is apt to split, making the insertion less secure.

(2) It is better to transfer the whole tendon than to use only half of it, for the new function desired is rarely obtained when some of the old insertion is preserved. It is clearly unreasonable to expect a portion of the tendo Achillis transferred to the front of the foot to act as a dorsi-flexor of the ankle.

(3) The adaptation of the nervous system to the new result of any voluntary effort is easier when the new movement is simple and not entirely antagonistic to the old one.

(4) Relaxation of the transplanted tendon is essential for some months after the operation, for over-stretching paralyses the muscle. It is evident that in many cases transplantation of a tendon is far more permanently efficient than mere division of it, which, as a rule, is followed by a return of some of the original power, the amount varying with the care bestowed upon the after-treatment. After transplantation of the whole tendon the old function is permanently lost, and moreover a new one is acquired. As a rule, however, transplantation of tendons is most efficient when combined with other methods such as resection of bone.

Nerve anastomosis. In certain cases nerve suture or nerve anastomosis is of value; for instance, after division of the external popliteal nerve secondary nerve suture should be performed, but the secondary talipes equino-varus must be corrected at the same time in order to ensure the return of power in the stretched and paralysed muscles. And the nutrition of the paralysed muscles must be maintained by massage and electricity until the nerve recovers its function. In other cases, especially of infantile paralysis affecting one of the popliteal nerves, a portion of the central end of the healthy nerve is joined to the peripheral end of the paralysed one. Up to a third of the healthy nerve can be used in this way without permanently damaging its function. Here again correction of the talipes by direct means is necessary to secure the best results.

As a rule operations on the soft parts with instrumental after-treatment are sufficient for children up to three or four years of age. It is rarely necessary to resect any bone under this age, for the bones are soft and capable of moulding by constant endeavour with instruments.

After this age too much is expected from tenotomies and similar tinkering measures, and too much is left to the after-treatment, especially with hospital patients. It should be our endeavour to anticipate the well-known tendency to recurrence, and to design our operations accordingly, making the patient as independent as possible of *prolonged* after-treatment by instruments. Such operations need not be mutilating in any sense of the term. On the contrary, they should restore both the shape and function of the foot as far as possible. The false conservatism that prevails may be a survival of pre-aseptic days when it was dangerous to perform extensive operations for talipes.

Operation for severe Talipes Equino-varus. The operation which I am about to describe is suitable for neglected cases. It is even applicable to severe deformities, which are often regarded as unsuitable for operation other than amputation. For these late cases it is particularly important to secure a free range of movement, especially of the ankle-joint. This is essential for the development of the muscles which have degenerated as a result of over-stretching and inaction. It is astonishing to notice the recovery of function that may follow the provision of a free range of movement, and the relaxation and exercise of the over-stretched muscle. With time I have gradually learnt to combine a variety of methods in order to be more certain of getting good results, which depend upon the cumulative effect of the various procedures. Some of the steps and precautions may appear trivial in themselves, but the best results are obtained only by making use of every available means. The operation recommended for severe talipes equino-varus may be described first, and the various procedures and modifications of them may then be discussed.

Operation. The leg and foot are cleansed with the most scrupulous care. A general anæsthetic is given. The leg and foot are elevated for a

few minutes, then a tourniquet is applied round the lower third of the thigh, the skin being protected with lint. The tense plantar fascia is divided subcutaneously. The ligaments below the medio-tarsal joint are similarly divided through a puncture placed below the inner side of the joint; meanwhile the fore part of the foot is forced upwards and outwards. An incision about three or four inches long is made in the groove internal to and in front of the lower part of the tendo Achillis. This tendon is transfixed in the antero-posterior direction and cleft for several inches, the extent being determined by the amount of equinus (*see* Fig. 397). The inner half of

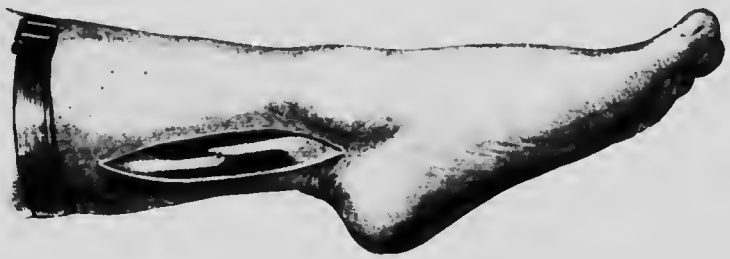


Fig. 397. Lengthening the heel tendon. The tendon is slit longitudinally and the fibres are divided obliquely, and the ends are joined with catgut. The incision is placed in the groove in front of this tendon on the inner side. Dorsi flexion beyond the right-angle must be easy after the lengthening.

it is cut off the os calcis and the outer half is severed obliquely upwards and outwards from the upper end of the cleft. If necessary the tibialis posticus is divided from the wound. The ankle is forcibly flexed as far as possible. If the deformity be incompletely corrected an elliptical incision is made over the front and outer side of the foot, commencing a little below and internal to the middle of the anterior surface of the ankle and extending downwards, forwards, and outwards nearly to the outer border of the foot opposite the medio-tarsal joint, or about one inch behind the prominence of the fifth metatarsal bone. The width of the piece of skin to be removed varies in different cases, but it must be just enough to leave no slack when the wound is closed after the bone is removed. The upper and lower edges of the wound are mobilised a little, care being taken not to cut the musculo-cutaneous nerve. The skin is excluded from the field of the operation by means of gauze pads carefully fixed to the edges. A longitudinal incision is then made through all the soft parts covering the prominence of the head of the astragalus. No tendon need be divided. The capsule of the astragalo-navicular joint is then opened and separated from the head and neck of the astragalus by means of a suitable knife carefully used from within the joint and kept close to the bone. When the head and neck of this bone have been fully exposed they are removed by means of a Macewen osteotome. The section is made more or less obliquely in two senses, both from above downwards and forwards and from without inwards and forwards. In this way both the equinus and varus are diminished. A similar longitudinal incision is made through the soft parts covering the fore part of the outer side of the os calcis. The calcaneo-cuboid joint is opened and a wedge-shaped piece of the anterior and outer part of the os calcis is removed. The tibialis anticus tendon is exposed in its sheath and divided close to its insertion into the navicular

and internal cuneiform. An attempt is made to correct the deformity, and if this be impossible, some more bone may have to be removed and some ligamentous fibres lying below the medio-tarsal joint may need careful division from within the joint. When the deformity is over-corrected and the foot is held in this position the tendon of the tibialis anticus is carefully sewn to the periosteum and ligaments on the dorsal aspect of the cuboid and to the tendon of the peroneus tertius. The sutures are not tied until the foot is brought into the over-corrected position, and with the foot still held in this attitude the overlapping ends of the heel tendon are sewn together with fine catgut. The dorsal ligaments attached to the scaphoid and astragalus may be shortened by means of catgut sutures. The wounds are accurately closed, and the foot is covered with antiseptic dressings and firmly bandaged. The tourniquet is removed, and the leg and foot are placed on a comfortable back splint and foot piece, and well elevated.

Fig. 398. Operation for severe talipes equino-varus. The fore-parts of the astragalus and os calcis have been removed, and the tibialis anticus tendon transplanted to the dorsal ligaments of the cuboid, thus converting it into an abductor of the foot.

Comments upon the Various Steps of the Operation. In commenting upon the various steps of this operation I wish again to lay stress upon the great importance of perfect cleanliness. There is no doubt that it is a very difficult thing to clean the deformed foot satisfactorily. It needs a great deal of scrubbing with soap and water and the use of ether soap or turpentine. This is followed by painting with tincture of iodine. The toes are carefully covered before the operation is commenced. The tourniquet is very valuable for these cases, for it not only saves blood but also time, and it enables the surgeon to do far more accurate and clean work. There is no need to take the tourniquet off for the purpose of catching up the vessels before closing the wound. These peripheral vessels are easily controlled by means of firm bandaging over plenty of elastic dressings, provided that the pressure be applied before the tourniquet is removed and the foot be kept elevated after the operation. This also lessens the pain. There are great advantages in taking the steps of the operation in the order recommended. It is sometimes almost impossible to tell beforehand how much may be necessary for the over-correction of the deformity, but by adopting the order suggested it is quite easy to decide this point and to leave off at any stage when the required result has been obtained. For instance, in some fairly severe cases, resection of bone for the correction of the equinus or varus may prove to be unnecessary after the soft parts have been divided in the order described. It must be remembered, however, that it is necessary to over-correct the deformity, and that a comparison with the passive mobility of the opposite foot is often valuable.

Nothing less than the normal range of mobility is sufficient. It is easier to divide the plantar fascia and the plantar ligaments efficiently while the

FIG. 399. J. L. The extreme talipes equinus is well shown with the prominence of the head of the astragalus in front, the scaphoid articulating with its inferior surface only. The head and neck of the bone were removed, the section passing almost vertically. Note the malposition and atrophy of the heel-bone.

os calcis is fixed by the tendo Achillis. It is difficult to divide the plantar ligaments until the arch of the foot is opened out by first dividing the plantar fascia and then forcibly pushing the fore part of the foot upwards

and outwards. In bad cases tendon lengthening is more satisfactory than tenotomy, for non-union with flail ankle may follow the latter when the ends have to be separated more than about 2 in. Further, the tendency to retraction after it is much greater than after tendon lengthening, so that it is a matter of common experience that tenotomy may have to be repeated, whereas tendon lengthening, if properly done, is final. After

Fig. 400. J. L. The same foot as shown in Fig. 399, but the radiogram has been taken from the outer side, whereas Fig. 399 was taken from the inner side. Note the improvement in the shape of the whole foot, in the position of the heel-bone, the absence of the head and neck of the astragalus, and the approximation of the scaphoid to the front of the body of the astragalus.

repeated tenotomies the lower part of the tendon is often found to be replaced by broad and thick sheets of adherent and contracted fibrous tissue. The simple method of cleaving the tendon into two lateral halves is quite satisfactory. For varus the outer half of the tendon is left attached to the os calcis, and for valgus the inner half. Other tendons are often transplanted with advantage. For instance, a part of the tendo Achillis may be diverted into the peroneus tertius or peroneus brevis. The removal of the head and neck of the astragalus and the fore part of the os calcis is better than the resection of a wedge on the outer border of the foot, because it is more efficient and interferes less with the insertion of tendons, and therefore with the natural functions of the foot. The tarsectomy is usually done too far forward, whereas the head and neck of the astragalus forms the keystone of the arch, so that a limited and oblique resection produces a very striking degree of correction of the deformity.

The mobility of the medio-tarsal joint need not be seriously interfered with if care be taken to preserve the articular cartilage of the navicular and cuboid, and to adopt massage and movements in the after-treatment. Complete astragalectomy is not nearly so efficient in correcting the deformity, and it has the serious disadvantage of shortening the limb. This is especially to be avoided when congenital talipes is unilateral, and in all paralytic talipes in which the paralysed limb is already a good deal shorter than its fellow. In my experience, the removal of the head and neck of the astragalus and the fore parts of the os calcis is far more efficient in correcting the varus than taking a wedge from the side of the body of the astragalus within the ankle-joint. Moreover, the method which I have described does not interfere in the least degree with the mobility of the ankle-joint, which is the most important joint to preserve in the foot. It may be said that the foot is shortened by the operation which I have described, but this is not true, as is shown by the actual measurements taken before and after operation. The removal of bone from the convexity of the arch, and the division of the plantar fascia and plantar ligaments, allows the arch to open out so much that the foot is lengthened. Malleotomy is apt to disturb the stability of the ankle-joint.

Modifications. When the deformity is the extreme equino-*valgus* so often seen in infantile hemiplegia, the incision is a longitudinal one over the prominence of the head of the astragalus, and only the head and neck of the astragalus need be removed. The section of the bone is oblique, so that the base of the wedge removed is above and internal, instead of above and external as for the correction of equino-*varus*. It is not wise to remove any of the os calcis, for this would exaggerate the valgus deformity. In certain paralytic cases an attempt may be made to get bony union between the astragalus and navicular, the os calcis and the cuboid. In these cases, therefore, it is an advantage to remove the articular cartilages of the navicular and cuboid and to take particular care to get and to maintain accurate bony apposition. When the tibialis anticus is completely paralysed it is hardly worth while to transplant it, and in certain patients who have been already submitted to multiple tenotomies for congenital talipes, the tendon may not be long enough for transplantation into the cuboid, but the gap may be bridged by means of silk threads.

For the accompanying illustrations of two of my cases I am much indebted to the photographer at Guy's Hospital.

Operations for severe Talipes Calcaneo-Valgus. Congenital talipes calcaneo valgus is very easily cured during the first few months of life by manipulations and instruments, and it rarely calls for operation. On the other hand, the paralytic variety in older children and adults is very difficult to cure. The following is the operation which I have designed and found most efficient.

The preliminary preparations are the same as already described, the strictest asepsis being maintained, and a tourniquet used. A sand pillow is placed behind the leg so that the foot is raised from the table and turned well out. A curved incision with its convexity downwards is made from just below the tip of the internal malleolus to the inner border of the tendo Achillis. The tendons of the tibialis posticus, flexor longus digitorum, and flexor longus hallucis are identified and drawn aside. The posterior tibial vessels and nerve all together are separated from the ankle-joint and gently drawn outwards. The posterior ligament of the ankle is divided, and with an osteotome, wedge-shaped pieces of bone and cartilage

are removed from the posterior two-thirds of the articular surfaces of the tibia and astragalus. The bases of the wedges are posterior, and their thickness varies with the degree of deformity. This corrects the calcaneus. Now a wedge with its base directed inwards is removed from the upper and inner surfaces of the astragalus, and the foot is vigorously adducted and inverted. More bone is removed if necessary until a satisfactory position is obtained, some being taken from the lower surface of the tibia just external to the internal malleolus. The malleoli are carefully preserved, but their articular cartilage is removed. If necessary to get the heel well back and up, the os calcis is divided with the osteotome at its narrow part. This lengthens the heel and confers a great mechanical advantage. In young children the flexor longus digitorum is divided and its central end is joined to the tibialis posticus to serve as an additional adductor of the foot. The peripheral end is joined to the flexor longus hallucis, which is thus made a flexor of five toes instead of one. The tendo Achillis is divided obliquely, and the superfluous length of it is excised: the remaining oblique surfaces are sutured with catgut. The tendons, vessels and nerves are replaced, the wound closed and a firm dressing applied before the tourniquet is removed. A suitable tin splint is applied to retain the foot at rest in the corrected position. Standing and walking are not attempted for two months and then only with the aid of a surgical instrument, which prevents dorsi-flexion of the ankle beyond the right angle. After this operation a well-shaped and stable foot is obtained and yet some movement is preserved at the ankle-joint. This and the mobility of the mid-tarsal joint are sufficient.

Operations for Congenital Spastic Paraplegia. For mild degrees of this condition tenotomy of the tendo Achillis is enough, but when the knees are flexed the hamstrings may need division in the manner already described (p. 963). When the thighs are adducted the shortened adductors may be divided a little below the spine of the pubis, and the abducted position maintained by an instrument. For severe cases, some of the corresponding posterior nerve roots have been divided with success; but it must be remembered that loss of voluntary movement of the legs or paralysis of the sphincters may follow it unless great care is taken in the selection of the posterior nerve roots to be divided. In 59 recorded cases[1] there were 8 deaths and 16 excellent results, *i.e.* in all of which the mental condition was good and careful after-treatment adopted for a year. The details of this operation are discussed under Laminectomy.

Operations for Severe Contractures of the Legs. In these cases all the muscles of the lower limbs may be paralysed, and in some the hip-joints may be insecure. When the hip-joints are firm and there is a little power of voluntary flexion of one or both hip-joints, severe deformities may be corrected and the patient enabled to walk about. With the aid of operation and instruments many patients who could only crawl about or go on crutches before have been enabled to walk about and enjoy life. For instance, a young solicitor 24 years of age, whose legs, knees and ankles were so severely contracted, as a result of infantile paralysis, that he could only get about on crutches with great difficulty, could walk thirteen miles with the aid of only one stick and his concealed instrument a year after his operation. A feather merchant, aged 27, who had one lower limb completely paralysed and the other partly, so that he could only hobble about with a crutch, was enabled to walk naturally

[1] Hey Groves, *Med. Ann.*, 1913, p. 453

and even go up and down stairs, and return to his work three months after operation. Generally the hips are contracted and somewhat abducted, the knees flexed, the legs everted and abducted, and the feet are in severe talipes equino-varus.

Operation at one sitting. (*a*) *To straighten the hip.* The patient is lying on his back and the surgeon finds the pulsating femoral artery in the groin, and then judges the position of the anterior crural nerve to be half an inch external to this. He places his left index finger over the nerve to serve as a guide, and then inserts a long slightly curved tenotome on the outer side of the hip, and passes it in front of the contracted tissues until its point is a little outside the left index finger. Now an assistant standing on the other side, presses the knee well back and flexes the opposite hip fully while the surgeon cuts directly backwards towards the hip-joint until the whole length of the thigh can be easily pressed back to the table. Then the tenotome is partly withdrawn and its point directed backwards between the skin and shortened fascia on the outer side of the hip. This is divided as the assistant draws the knee well inwards. The opposite hip is similarly treated if necessary, and a sealed dressing is applied over each puncture.

FIG. 401. Showing the mode of progression and the talipes valgus in a case of paraplegia from extensive infantile paralysis.

(*b*) *For straightening the knees.* A longitudinal incision three inches long is made just in front of the lower part of the biceps tendon. This tendon is divided, great care being taken of the external popliteal nerve lying behind and internal to it. Then the left index finger is inserted to feel for and protect the popliteal vessels and nerve, while a tenotome is inserted from the inner side in front of the inner haunstrings, which are divided backwards, while the knee is pushed backwards to keep them on the stretch. Sometimes a great deal of force is required to straighten the knee even after all the tendons have been divided, and the posterior ligament may give way with a loud report. All force should be gradually increased without any violent or jerky movements. In a few cases it is necessary to prolong the wound down over the external lateral ligaments, which are divided to correct the genu valgum, and in some the crucial

ligaments have to be divided from this opening into the joint. In very severe cases the knee cannot be straightened with excision, but, as a rule, it is wise to preserve the knee-joint and to be satisfied with gradual com-

Fig. 402. Showing the patient wearing the apparatus after operation.

pletion of the extension of the knee with the aid of the instrument mentioned later on. When both knees have been straightened, the talipes equino-varus is easily corrected by subcutaneous division of the tibialis anticus and the inferior calcaneo-navicular ligament, the tendo Achillis, and, if necessary, the tibialis posticus (*see* Fig. 402). Manipulation completes the correction. The wounds are dressed and the knees are put slightly flexed in a massive dressing. An attempt to keep them straight at this stage may lead to gangrene from over-stretching of the popliteal vessels. A few days later the knees are gradually straightened by instruments made before

the operation. With the aid of side steel supports provided with joints, racks and screws, there is little difficulty in getting complete correction without much pain. The deformities of the feet and hips are treated by daily manipulations and suitable instruments. At the end of a month the patient can begin to stand with the aid of special supports, and he learns the art of walking perhaps for the first time. At first he needs crutches, but he gradually dispenses first with one and then both. Soon he goes about with two sticks and ultimately with one.

Operations for Talipes Valgus and Flat Foot. *Flat foot.* Operations should be rarely required for ordinary weak or flat foot, for in its early stages the condition is amenable to treatment by correction of bad habits of standing and walking, perseverance with exercises designed to strengthen the supports of the arches of the foot, and the use of suitable supports. But when the foot becomes rigid and painful as well as deformed, and does not react to massage and manipulations, and instruments fail to bring relief, an operation is required. Under general anæsthesia, with the muscle relaxed, an attempt is made to correct the deformities by manipulation. The shortened peronei often need subcutaneous division, and so do the ligaments above and external to the mid-tarsal joint. Occasionally a contracted heel tendon needs division. Forcible adduction and inversion of the foot usually completes the correction. The removal of a wedge of bone from the depressed inner border of the foot is rarely satisfactory, for this removes the key-stone of the arch. The foot is fixed in the over-corrected position by means of plaster of Paris bandages extending from the toes to the middle of the leg. The bandages are applied over a layer of cotton wool and should not be tight. The feet are elevated and the plaster splint left on for nine days, when massage, movements and exercises are begun and a suitable instrument is provided to maintain the correction during standing and walking.

FIG. 403. Operation for correction of hallux valgus. The prominent inner half of the metatarsal head is removed, and the extensor brevis hallucis is divided.

The talipes valgus and flat foot which is far too common after fractures dislocations of the ankle can be corrected as follows:

A general anæsthetic is used and the ankle is moved as freely as possible. If necessary the peronei are divided and in many cases the tendo Achillis also. The ankle is again freely moved in all directions. The ankle is laid on its outer side on a sand pillow, and an incision half an inch long is made over the inner surface of the tibia, one inch above the internal malleolus, and the tibia is divided transversely with a narrow osteotome. If necessary to ensure correction the osteotome is driven into the fibula. The foot is strongly adducted and inverted so as to ove

correct the deformity. The wounds are closed with catgut and a dressing is applied. The foot is secured in the slightly over-corrected position in plaster of Paris for fifteen days, and then treated by daily massage, movements and exercises, and at the end of eight weeks the patient is allowed to walk with the aid of side irons, a T valgus strap and a boot raised a quarter of an inch on its inner border.

Operation for Hallux Valgus. The best operation, as a rule, is the one illustrated in Fig. 403. The prominent inner half of the head of the first metatarsal is removed, and sometimes the prominent inner basal angle of the first phalanx. The extensor brevis hallucis is divided and sometimes the extensor longus hallucis is lengthened. Movement is good after the operation, and walking is easy and comfortable. For hallux flexus the dorsal prominence on the head of the metatarsal is removed with similar relief.

CHAPTER XLVIII

OPERATIONS ON NERVES

NERVE SUTURE. NERVE GRAFTING. NERVE ANASTOMOSIS

NERVE SUTURE

This may be required as a **primary** or **secondary operation.** The latter is accompanied with much more difficulty, owing to the greater retraction of the nerve ends, their bulbous or filiform extremities, their being often buried in scar tissue or matted by it to neighbouring parts, *e.g.* tendons and fasciæ; to which must be added other unfavourable points, *e.g.* the atrophy and fatty change in the muscles and the stiffness of the joints.

Primary Suture.[1] As the mode of uniting nerves will be fully described under the head of secondary nerve suture, the more difficult proceeding, it need not be repeated here. It only remains to emphasise the importance of always resorting to it, and not trusting to spontaneous cure. Howell and Huber[2] have collected 84 cases of primary nerve suture; 42 per cent. of these were successful, 40 per cent. were improved, and in the remaining 18 per cent. the operation failed. Sherren,[3] speaking after careful observation of over 50 cases, says that in every case of primary suture which he watched, "motor power was regained and the second stage of recovery of sensibility completed. All cases uncomplicated by suppuration which he was able to keep under observation for a sufficiently long period regained perfect sensation." The results of secondary suture can never be so good as these.

The chief cause of failure here is infection of the wound. As in all accidental wounds sterilisation may be incomplete. Irrigation with some dilute antiseptic should be employed; the wound should not be closely sutured at first, sufficient drainage should be employed, and a boracic acid fomentation frequently applied for the first few days, when the remaining sutures can be drawn together, and the usual dressings employed.

Secondary Suture. The operation on the radial or ulnar will be considered, as these are so commonly injured. The following steps must be remembered: (1) Finding the nerve ends. (2) Freeing and resecting them. (3) Passing the sutures, and bringing the ends into apposition. (4) Dressing the wound, and the after-treatment.

(1) *Finding the Nerve Ends.* With accurate anatomical knowledge this is easy. An Esmarch bandage does not appear to be necessary,

[1] Much information on the subject of primary and secondary suture will be found in the section on Suture of Tendons.

[2] *Journ. of Physiol.*, vol. xiii.

[3] Injuries of Nerves and their Treatment, p. 116.

as the incision is made parallel with the vessels, and the use of one leads to oozing afterwards. Sir Anthony Bowlby[1] thinks that the parts should be rendered bloodless. If this course is adopted care must be taken to provide any needful drainage, and the bandage must, if possible, be applied sufficiently far from the wound not to interfere with pressing down the parts when the nerve ends are approximated. If this bandage is employed, the parts should be [illegible] absolutely evascular; careless application will only cause most annoying oozing. An incision, three or four inches long, being made over and parallel to the nerve ends, the deep fascia and any scar tissue are carefully divided and the nerve found well above and below the injury, where it is easily recognised. It is then traced towards the injury without fear of doing damage especially to the smaller peripheral end. The upper end is bulbous and the lower filamentous usually, and not always in a line with each other, so that the distal end may be very difficult to find owing to its filiform shape and its being embedded in scar tissue. The ends are next freed from the adjacent parts, and cleared of cicatricial tissue.

(2) *Resection of the Nerve Ends.* This is best effected by a *sharp* knife, with one stroke, and without any bruising. If the [illegible] held with forceps, these must hold the sheath only. In case of pri[illegible]ture, jagged or frayed ends need only be pared sufficiently. In later cases there is much more difficulty. Supposing the upper bulbous end to be taken first, before this is pared the nerve should be carefully stretched, so that dissecting-forceps or any other means of holding the nerve may inflict any necessary damage on parts that will be cut away. It is necessary to cut away the whole of the bulb. With regard to the lower end, Sir Anthony Bowlby says all that is needed is "to cut away the extreme end, which, being matted with fibrous tissue and compressed by the surrounding scar, is very likely to contain no nerve tubules. It is seldom necessary to remove as much as a quarter of an inch, and, however unhealthy the section may look, no good is ever to be gained by a further sacrifice."[2]

(3) *Passing the Sutures and bringing the Nerve Ends into Apposition.* The sutures should be of properly prepared catgut. Silk is not so satisfactory, for in some cases it may lead in the course of time to a gradual interstitial inflammation, or even to the formation of an abscess, especially after primary nerve suture in accidental cases. Under these circumstances paralysis returns. There has been much dispute as to whether the stitches should be passed through the substance of the nerve itself or only through the sheath. Experience has shown that the former practice is not only harmless to the nerve, but is the method most generally applicable. One fine catgut suture is generally sufficient to secure accurate apposition. It should be passed at a sufficient distance from the ends, viz. at least a quarter of an inch, otherwise it may cut out when they are tightened. If necessary a few additional ones in the sheath will remove some of the tension. Where there is much separation, several sutures should be passed through part of the depth of the nerve, one suture thus taking off some of the tension from its fellows. Another method is to pass one suture completely through the nerve trunk at least a quarter of an inch

[1] *Loc. infra cit.*, and Hunt. Lect., *Lancet*, July 16, 1887.

[2] As the whole length of the lower end is in the same condition of degeneratio[illegible] throughout, manifestly no good can be done by cutting off [illegible]cessive sections in the ho[illegible] that the cut surface may look more healthy than that [illegible] is s[illegible] in the first secti[illegible] (Bowlby).

from each cut end. When the sutures in the nerve itself have been tied, two or three more very fine ones may be placed in the sheath, where the nerve is large enough.

In cases of much separation, before any sutures are passed, and again before they are tied, the parts should be as much relaxed as possible, and the upper end brought down by pressing down the soft parts. Stretching the nerve has been already advised. The sutured part of the nerve is surrounded with Cargile membrane, which is supplied already sterilised and is not absorbed for about six weeks. It prevents adhesion to the surrounding tissues and lessens the invasion of the nerve by inflammatory cells from these tissues.

All hæmorrhage being scrupulously arrested, and drainage provided according to the amount of the disturbance of the parts, &c., the usual dressings are applied, and the limb placed on a well-padded splint in a position which will best retain the nerve ends in apposition with the least discomfort to the patient.

Amount of Nerve Tissue which may be successfully removed. From half an inch to three-quarters of an inch is probably an average amount.

Causes of Failure. (1) Infection of the wound. (2) Wide separation of ends and subsequent tension. (3) Atrophy, bulbous enlargement and sclerosis of nerve ends, so marked as to require much trimming, and thus tending to wide separation. (4) Unnecessarily rough handling of the nerve ends.

Aids in Difficult Cases. (1) Previous stretching of the ends. (2) Approximation of the ends by position of the limb. (3) Using several sutures, which distribute the tension evenly. (4) The use of "stitches of support." (5) In some cases it is impossible to bring the pared ends together, then a piece of nerve of suitable size may be grafted between the ends. Preferably this should be taken from the patient himself; for instance, the upper part of the radial nerve may be shifted (without loss of sensation) to fill a gap in the lower part of the musculo-spiral nerve; failing this, a healthy nerve from a newly amputated limb should be used, or a nerve may be grafted from a sheep. (6) Autoplastic operation with nerve-flaps is not so good. M. Letiévant advises to make a slit through the nerve with a narrow bistoury about one-fifth of an inch from the end; the knife being then carried upwards for an inch or an inch and a half is made to cut to one side so as to make a flap. The same is then done with the lower end, and the two flaps, being turned towards each other, are united by their raw surfaces. Dr. C. A. Powers, of Denver,[1] from a collection of cases in which this method was used, concludes that of six (all doubtful ones being excluded) two were failures, and four partial or complete successes. (7) Gluck and Vanlair advise that the nerve ends, whether united or only placed as closely as possible in apposition, should be passed through and left in a decalcified bone-tube, so as to keep the uniting material and granulations in a straight line. (8) The substitution of threads of catgut may be tried; and this may be combined with the last mentioned plan.

(9) *Nerve Anastomosis.* Implanting one nerve trunk upon another, or joining a part of a healthy nerve to the peripheral end of the divided nerve. Dr. Powers[2] gives abstracts of ten cases in which implantation or anastomosis was employed; in five or six the results are encouraging.

[1] *Ann. of Surg.*, November 1903, p. 641.
[2] *Loc. supra cit.*

This method is indicated where nerve trunks run parallel, *e.g.* in the forearm; in the case of the popliteals it has been much less satisfactory. Two noteworthy cases are quoted from Dumstrey.[1]

In one of extensive destruction of the ulnar, Dumstrey implanted the peripheral portion of this nerve into a button-hole in the median and placed substitution threads of catgut between the same point in the median and the proximal portion of the ulnar. In three months there was a marked return of sensation, to a less degree of motion, and a diminution of the contraction. In a case quoted by Dumstrey, Sick and Senger thus dealt with a case of extensive destruction of the radial. The peripheral portion of the radial and the median nerves having been exposed by one incision, a flap was split from the median and carried under the muscles to the peripheral portion of the radial. For several months there was no improvement, but, in a year and a half, the paralysis had almost entirely disappeared. In other cases the central end of the injured nerve has been sutured into a parallel one, at one point, and a little lower down, the peripheral end is implanted in like manner. Nerve anastomosis has been fairly successful in the treatment of infantile and other forms of paralysis. Up to one-third of the trunk of an ordinary mixed nerve may be divided, and the central end of the divided part raised as a flap and formed to the peripheral part of the paralysed nerve.

(10) Making use of nerve-grafts. Gluck has resected an inch and a half of the great sciatic in chickens, and replaced it by a bit of a rabbit's sciatic sutured in. The birds walked afterwards as well as those treated by direct suture. In man the results have been more satisfactory in recent years.

Mr. Mayo Robson [2] after the removal of a growth from the median nerve, leaving a gap of two inches and a half between the ends, successfully made use of a corresponding bit of the posterior tibial nerve from a limb which was amputated in the adjoining theatre. The following conditions are rightly given as essential: First, the entire absence of tension; two inches and a half of nerve being employed to fill an interval of two inches and a quarter. Secondly, great care was observed in handling the nerve to be transplanted. Thirdly, the transplanted posterior tibial nerve was transferred immediately as living tissue into its new bed. Fourthly, only one fine catgut suture was employed at each end to fix the nerve. The same surgeon successfully used the spinal cord of a rabbit as a graft in the median nerve of a man.[3]

Mr. Damer Harrison, of Liverpool,[4] gives nine other cases of nerve-grafting. The nerves used were the sciatic of recently killed rabbits or kittens, and the median from a human arm. Of the ten cases, three are stated to have been perfectly successful, six partially successful, and only one a failure.

Mr. C. Heath made use of nerve-grafting, replacing a gap in the ulnar, due to removal of a sarcoma, by two and a half inches of the posterior tibial nerve from a limb just amputated.[5] A fibro-sarcoma had been removed from the ulnar nerve. The graft was retained in position by two fine silk sutures at either end. About twenty minutes elapsed from the time at which the limb from which the nerve was taken was severed from the body and the time when the junction of the piece of nerve with the ulnar nerve was completed. The wound healed by first intention, but fourteen months later there was no restoration of function in the nerve.

Nerve Crossing. In this a healthy nerve of less value is divided and its central end is joined to the peripheral end of a valuable nerve. It is chiefly applicable to the facial nerve.

Period required for Repair. The following appears to be a fact not sufficiently recognised. The period required for union after secondary nerve suture is very much longer than is usually supposed to be necessary, owing to the peripheral end being degenerated, the muscles atrophied, and the joints fixed. Complete restoration of function will often require

[1] *Deut. Zeitsch. f. Chir.*, Bd. lxii, 1901–1902, s. 376.
[2] *Clin. Soc. Trans.*, vol. xxii, p. 120.
[3] *Brit. Med. Journ.*, October 31, 1896, p. 1312.
[4] *Clin. Soc. Trans.*, vol. xxv, 166.
[5] *Lancet*, 1893, vol. i, p. 1195.

from one to three years. A patient who leaves his surgeon apparently but little better for the operation may return at the end of the above time with great improvement in the function of the limb. But it is seldom possible to restore the function of the part absolutely.[1]

It is the condition of the muscles and joints which alone puts anything like a limit on the period at which secondary suture can be successfully practised.

The longer the interval[2] between the injury and the suture, the more persevering must friction, electricity, passive, and active movement, and massage be made use of, and the more will patience be required by both patient and surgeon.

Modern Gunshot Injuries of Nerves. Mr G. H. Makins,[3] C.B. gives the following advice as to *operative treatment*. "Early interference was only warranted by positive knowledge that some source of irritation or pressure could be removed; thus a bone splinter, or a bullet, or part of one, particularly portions of mantles.

"In case of contusion, the expiration of three months is the earliest date at which operation should be taken into consideration. The two strongest indications for operations are (1) signs pointing to the secondary implication of the nerve in a cicatrix, especially when these are of such a nature as to indicate local tension, fixation or pressure; (2) the possibility of the irritation being the result of the presence of some foreign body: in such cases the X-rays will often give useful help.

"With regard to the early exploration of cases of traumatic neuralgia, it may be pointed out that when this was undertaken the results were, as a rule, very temporary. In many cases, either no macroscopic evidence of injury to the nerve was discovered, or a bulbous thickening was met with of such extent as to make excision inadvisable.

"Even when complete section of the nerve was assured by the absence of any power of reaction to stimulation by electricity from above on the part of the muscles, operation was better not undertaken until cicatrisation had reached a certain stage. If done earlier than the end of three weeks, the sutured spot became implicated in a hard cicatrix, and any advantage to be obtained by early interference was lost. When partial division of a trunk was determined, the same date was the most favourable one for exploration, the gap in the nerve being freshened and closed by suture. There is little doubt, however, that in some cases such injuries were recovered from spontaneously."

The same authority thus advises in cases where the lesion to the nerve was of doubtful nature.[4] "As favourable prognostic elements we may bear in mind low velocity on the part of the bullet, and with this a lesser degree of contiguity of the track to the nerve. The early return of sensation is a favourable sign, and in this relation the development of hyperæsthesia, whether preceded by anæsthesia or not, points to the maintenance of continuity of, and a moderate degree of damage to the nerve. The early return of sensation, even if modified in acuteness, was always a very hopeful sign; also the production of formication in the area of distribution of the nerve on manipulation of the injured spot."

[1] Bowlby, *Lancet*, July 26, 1902.

[2] The longest of these with which I am acquainted is a case of M. Tillaux's in which fourteen years had elapsed between the injury to the median and its suture.

[3] *Surgical Experiences in South Africa*, 1899–1900, p. 372.

[4] *Ibid.*, p. 370.

PART V

OPERATIONS ON THE VERTEBRAL COLUMN

CHAPTER XLIX

SPINA BIFIDA. LAMINECTOMY OR PARTIAL RESECTION OF THE VERTEBRÆ. TAPPING THE SPINAL THECA. SPINAL ANÆSTHESIA. ANOCI-ASSOCIATION

SPINA BIFIDA

Indications. All operative treatment should, if possible, be postponed until the child is two years of age or older. The operation is then borne far better, as shown by published results. Where, in younger children, rapid increase in the size of the swelling is, however, taking place, and leakage is threatening or has actually occurred, the methods of injection or tapping may be resorted to as palliative measures, although the results, with few exceptions, will be disappointing. Briefly, the smaller the swelling, the less the evidence of involvement of the spinal cord or nerves;[1] the more the overlying skin approaches to normal, the less the swelling shows signs of increase in size; and the older the child the greater are the chances of cure. The greatest possible importance, therefore, attaches to the question of careful selection of cases to be submitted to operative interference.

Operations. Simple tapping being merely palliative and any form of drainage, *e.g.* with sterilised horsehair, being very liable to be followed by infective meningitis, especially if the coverings of the sac are thin and unhealthy, the only methods before us are: (1) **Injection with Morton's Fluid.** (2) **Excision.** (3) **Drainage of the Cerebro-spinal Fluid into the Connective Tissues or into the Peritoneum.**

(1) **Injection with Morton's Fluid.** The Clinical Society's Committee[2] collected 71 cases treated by this method. Of these, 35 recovered, 27 died, 4 were relieved, and 5 unrelieved. In a letter to the Committee (dated May 11, 1885), Dr. Morton was able to refer to 50 cases thus treated. Of these, 41 appear to have been successful, and 9 unsuccessful. But it is obvious that these statistics are largely unreliable. It is not unfair to say that nearly every successful case has been at once reported, while scores of unsuccessful ones have never been heard of. Owing to

[1] Points which make it probable that nerve trunks or the cord, or both, are present in the sac, are paralysis of the sphincters or lower extremities, a large sessile tumour with a broad base, and the appearance of cord like bands when the sac is thin enough to transmit light.

[2] *Trans.*, vol. xviii.

the large number of successes which attended the use of this method, it is the only one which was recommended by the Committee of the Clinical Society. In four of the cases in which I have employed this method while complete shrinking of the sac was secured in each, hydrocephalus eventually supervened. And where this is not the case, the later effects of pressure of the cicatricial tissue upon any nerves present must be remembered.

The parts having been sterilised, a syringe which will hold about two drachms of the iodo-glycerine solution[1] is chosen, and a fine trocar. The calibre of this must not be too fine for the thick fluid which has to pass through it. The puncture into the swelling should be made well at one side, obliquely through healthy skin, and not through the membranous sac-wall, the objects being to avoid wounding the cord or nerves, and also to diminish the risk of leakage of cerebro-spinal fluid. Unless the sac is very large it is probably better not to draw off much, if any, of the fluid from the sac on the first occasion. The position of the child during the injection has been a good deal dwelt upon, most recommending that it should be upon its back. The Clinical Society's Committee advise that the child should be upon its side. About a drachm of the fluid should be injected. Every care must be taken to prevent any continued escape of the cerebro-spinal fluid, now and later, it being clearly understood that any such leakage, which is most difficult to prevent, will lead to infective meningitis and death. When the needle is withdrawn the puncture should be pressed around it, and immediately painted with collodion and iodoform, a dressing of dry gauze being also secured with collodion. I prefer to give a little chloroform to prevent any crying and straining at the time. The child should be kept as quiet as possible afterwards, on its side, and an assistant should make sure, for the first hour at least, that no leaking is going on. Shrinking of the cyst, continuing steadily, shows that all is well. If the injection fail altogether, or only cause partial obliteration of the sac, it should be repeated at intervals of a week or ten days.

(2) **Excision of the Sac.**[2] This is the method which, in spite of certain grave dangers, promotes, on the whole, the best results in carefully selected cases. The dangers are, of course, the suddenness with which the fluid may escape, with grave resulting changes in the hydrostatic pressure and circulation in the cerebro-spinal system, shock from interference with important nerve filaments, and meningitis set up at the time or as the result of subsequent leakage.

A wise selection of cases is most difficult. It is only possible to advise in general terms. A condition of the overlying parts which renders it doubtful if asepsis can be secured to begin with, should forbid operation. Weak antiseptics are likely to be useless, and strong ones harmful; they may even inflict further damage on the closely adjacent nerve tissues. An advanced degree of paralysis present should contraindicate interference; it will, probably, be impossible to separate and return the nerves present in the walls of the sac, and what is the real value of the life which it is attempted to preserve? It will be remem-

[1] The fluid is iodine, gr. x; iodide of potassium, ʒj; glycerine, ʒj.

[2] The Clinical Society's Committee collected twenty-three cases treated by excision of the sac. Of these, sixteen recovered, seven died. They point out that no mention of the contents of the sac is made in six cases; that nerves were certainly absent in sixteen cases; and that in one, which was fatal, they were certainly present (*Trans.*, vol. xviii p. 380).

bered that this condition and the preceding one often coexist. Other severe malformations are also contra-indications. As I stated above, any operation should, when possible, be deferred till about the age of two years. The effects of the interference are better met, the parts are more easy to handle, and one source of infection, that from the usually closely adjacent anus, is diminished. In the rare variety of meningocele such delay is especially indicated.

Operation. If needful, the too rapid escape of fluid can be prevented by a preliminary tapping and attention to the position of the patient. Every precaution against shock must be taken before, during and after the operation, and this must be completed as quickly as is consistent with safety. The parts having been sterilised and arrangements made for keeping the head low prior to and during the opening of the sac, elliptical incisions are made through the skin on either side of and sufficiently far from the base to ensure if possible (α) sound skin and (β) sufficient skin to meet in the middle line after partial excision of the sac and removal of the fluid. Such incisions are always to be employed when the central skin is unsound and undermining will be required. In other cases a flap may be preferable. The skin is then dissected back on each side with great care so as to avoid, if possible, punctures of the membranes, until the laminæ are reached. It may now be found that the tumour is clearly a meningocele being attached by a pedicle, which may be quite slender. In such a case the interior of the pedicle is inspected, and if it contain no structures of importance, it should be surrounded with a purse-string ligature of fine kangaroo-tendon, and the sac beyond cut away.

If there is no pedicle the sac is now carefully opened, at first with a trocar so that the fluid is slowly withdrawn, and the effects on the cerebral centres noted. The opening is then enlarged, and the interior carefully examined. If no nerve structures are present, the redundant sac is then cut away with blunt-pointed scissors, and the edges brought together with a continuous catgut suture. The connective tissues are similarly sutured over the stump, and sometimes a flap of the lumbar aponeurosis is sewn over it. So far the operation has been simple and straightforward. We must now consider more difficult cases. Where the coverings are in great part thin and translucent, even when this condition extends to the margin of the swelling, if the coverings can be rendered aseptic they may be partly utilised to form the meningeal flaps, the adjoining skin being undermined and made to slide over the new meninges.

When on opening the sac nerve structures are seen within, that part of their course which lies in the sac must be carefully detached with blunt-pointed instruments, until they can be gently pushed through the opening that communicates with the spinal canal. In more difficult cases, incisions must be made with blunt-pointed scissors between portions of nervous structures, in order to set them free, or they must be returned with a part of the sac *en masse*. In cases where the presence of nerve structures difficult to detach is marked, the safest plan will be the last. Having opened and examined the sac, the surgeon cuts away any superfluous part that is safe, then detaches the remainder and returns it with the nerves which run in it, through the opening, into the canal. It is greatly to be desired that surgeons should specify what nervous structures were present, and how they were dealt with. As a rule this has been

most imperfectly done. Where it is plain that the sac and its contained nerves cannot be returned without sacrificing some of the latter the surgeon should hold his hand and close the wound. However small the nerves may be, it is impossible to determine their importance. Their removal runs a decided risk of causing permanent paralysis, or of increasing that already present.

The nerve structures having been returned, the flaps of meninges and skin are sutured separately and not in one line. A precaution of Mr. Robson's [1] should be followed here. The skin and meningeal flaps should be so cut that their lines of union, when sutures are applied, are not opposite. Thus, the flaps should be cut of unequal width, so as to bring, *e.g.* the wider skin flap on the left side, and the wider meningeal one on the right. Another means of obtaining the same end is to suture the membranes transversely, and the skin longitudinally. In some cases periosteal grafts [2] or bones from freshly killed animals have been introduced with varying success, and are to be preferred to attempts to close the gap by fragments chiselled off from the laminæ or sacrum. Considering the tender age and feeble powers of these patients—infants, as a rule—it is certainly not worth while to prolong an operation, anæsthetic, &c., for this purpose. If, however, the patient is not an infant and the condition is good, and moreover if the gap in the spine is a large one, an attempt should be made to protect this by means of flaps of aponeurosis and muscle derived from the erector spinæ. Either one large flap may be raised and swung across so that the line of sutures is at the side, or two flaps may be used and united in such a manner that the line of sutures is not immediately beneath the skin sutures. The very lowest part of the meningeal and skin flaps may be left unsutured, but no drainage will be needed, and leakage is greatly to be deprecated. Sterilised pads having been placed on the wound, a sufficient thickness of salicylic wool is then applied, and bandaged with firm and even pressure. For the first few days the head should be kept low and the spine raised so as to prevent the tendency to leakage of cerebro-spinal fluid, and to take the tension of the sutures. Prof. A. Henle [3] advises strapping the child to a plaster of Paris cast of the anterior surface of the body, reaching from the neck to the feet. The hips and knees are partially flexed and the legs somewhat separated. Soiling of the dressings is thus prevented. The patient is raised for the purpose of feeding. A shield of silver, vulcanite, or thin sheet-lead should be worn later until the parts have thoroughly consolidated.

(3) **Drainage into the Tissues.** Heile [4] has recorded a successful case of drainage of the fluid into the peritoneum by means of six silk threads connecting the two cavities. The patient was only two days old, had a tense meningomyelocele in the lumbar region. An attempt at excision was made but proved impossible, and silk threads were passed forward into the peritoneum, just external to the spinal membrane.

[1] *Clin. Soc. Trans.*, vol. xviii. p. 211.

[2] Dr. R. T. Hayes, of Rochester (N.Y.) introduced twenty grafts of periosteum from a freshly killed rabbit. Three months later the case was reported to be satisfactory, with a firm, hard, resistant covering. (*Med. Record*, June 16, 1883.) Messrs. Watson Cheyne, C.B., and Borgbard (*Man. of Surg. Treat.*, Part iv. p. 301) advise the use of the scapula or skull bones of rabbits. "The scapula, divested of its muscles, forms a very satisfactory plate, and has succeeded in more than one instance."

[3] V. Bergmann's *Syst. of Pract. Surg.* (Amer. Trans.), vol. ii. p. 662.

[4] *Berlin Klin. Woch.*, 1910, 2298.

The child was well ten months later. It is probable that drainage into the subcutaneous tissue of the back will prove as effective.

Causes of Failure after the Radical Cure of Spina Bifida. (1) Leakage and infective meningitis. (2) Convulsions and rapid death. Mr. Clutton, who brought a successful case of Dr. Morton's treatment before the Clinical Society,[1] mentioned another in which this treatment was immediately followed by fatal convulsions. The same proved fatal in about ten hours in a case under my care. Sir W. Bennett, during the same discussion, mentioned a case in which, owing to the child being indisposed at the time, he declined to operate. On its way home the child died of convulsions. He remarked that if he had used the injection, this would have been credited with the convulsions. (3) Paraplegia. This setting in after injection or operation may be temporary or permanent. (4) Hydrocephalus. This also may make its appearance after the injection with iodo-glycerine or excision, as happened in a case of my own three weeks after the latter operation. The nerves here were few and small and easily detached with the adjacent sac into the canal. (5) After tapping or injection the swelling may progress unaltered.

LAMINECTOMY, OR PARTIAL RESECTION OF THE VERTEBRÆ

This operation may be referred to here under the following indications: A. *Cases of injury, i.e. hæmatorrachis or bleeding into the spinal theca; fractures and dislocation.* B. *Penetrating wound of the canal.* C. *Gunshot injuries.* D. *Cases of inflammatory disease, e.g. Pott's curvature; chronic spinal meningitis.* E. *Cases of new growth.* F. *For resection of posterior nerve roots or section of lateral columns of the cord.*

A. *Cases of Injury.* Here the operation has been suggested by the analogous one performed on the skull, and the large amount of success which has followed it. But the analogy is, for several reasons, a deceptive one. Thus, owing to the small size of the cord, an injury which would only damage the brain slightly, almost inevitably destroys the structure of the cord throughout its thickness. Again, it must be remembered that a fragment of bone often inflicts injury upon the cord instantaneously, and that, in a moment, irremediable damage may be done, though all deformity may be absent. Further, the cord may be most severely damaged, though its theca shows no sign of injury.

Again, when the surgeon trephines the skull, he not only hopes that the damage is slight and of a removable nature, but he also believes that the only damage to the bones is that which lies close to his trephine and finger. But in the case of the spine we are faced by this dilemma: If the fracture has been from direct violence, and the spinous processes and lamina have been driven in, it is only too probable that when these are elevated the spinal cord, so limited in size, will be found too much damaged to profit by the operation. On the other hand, if the fracture has been caused by indirect violence, it is almost certain that the bodies of one or more vertebræ will have been crushed down, and a portion shot back into the canal. Usually the cord is nipped between the postero-superior edge of the body below and the lamina of the vertebra above the fracture-dislocation. In this case the part which has inflicted the injury, and which is keeping up the mischief, will be in front of the cord and difficult to reach. With a good exposure and perseverance the

[1] *Trans.*, vol. xvi. p. 34.

surgeon may be able to remove the projecting bone in front of the cord, after drawing the theca first to one and then to the other side and using gouge-forceps.

But it must be remembered that permanent compression of the cord—compression that can be removed, as can fragments of the skull—is a very rare event.[1] Even where permanent compression is present laminectomy will do but little. The surgeon may find it possible to restore the lumen of the vertebral canal, but the cord has usually been crushed as well as compressed. Mischief, usually hopeless mischief, has been done, for it has been proved by experiments and otherwise that a crushed cord is incapable of regeneration.

It remains to be shown that trephining the spine is not only likely to be void of any good results, but that it also involves serious risks and entails additional dangers of its own. Thus, the conversion of a simple into a compound fracture, the formation of a large, deep, and more or less ragged wound, the risk of subsequent suppuration with free access to the sheath of the cord, the opening up of cancellous tissue with its various channels and exposure of these to possible suppuration—all these have, I admit, been lessened by the use of modern precautions. But the risk, though diminished, remains; the large amount of venous oozing tending to soak quickly through in this region can only be met by frequent dressing. And though it has been shown that in some of these cases the wound has healed quickly, and though no improvement has followed, the spinal column has not been fatally weakened by the removal of the laminæ and spines, yet the weakening for a time must be considerable; and it must be remembered that by the removal of these structures the mobility of the fractured parts will be much increased, and when any attempt is made to vary the position of the patient in bed, there will be, for some time, a risk of disturbing the fragments and, thus, of inflicting further injury on the cord.

It will be seen from the above that my own opinion is averse to any surgical interference in cases of fractured spine, owing to the amount of damage to the cord being usually, from the first, irreparable. To quote other writers: Mr. Thorburn [2] comes to the same conclusion, but draws an important distinction between the cord and its nerves. This writer thus sums up the question of operative interference in fractures and dislocations of the spinal column:[3] "In compound fractures, operate. In fractures of the spinous processes and laminæ, with injury to the cord, we also operate. In simple fractures and dislocations of the bodies of the vertebræ, if there is a reasonable probability that the injury is due to hæmorrhage,[4] operation is advisable, but in all other cases of this nature we cannot hope to do good save where the injury is below the level of the first lumbar vertebræ. In such cases laminectomy is an eminently valuable surgical procedure." Mr. Thorburn

[1] J. Hutchinson, *Lond. Hosp. Rep.*; Thorburn, *loc. infra cit.* It will be noticed that permanent compression is a very different thing from irreparable injury. The latter is present, only too frequently.

[2] *Surgery of the Spinal Cord*, 1889, p. 160; *Brit. Med. Journ.*, 1894, vol. i, p. 1348.

[3] *Loc. supra cit.*

[4] Mr. Thorburn thinks that the following would be the most advisable steps in these very rare cases: A laminectomy at the seat of injury, and an endeavour to arrest the hæmorrhage and to give exit to the blood; this procedure being combined in the first instance with paracentesis of the meninges in the lumbar region after Quincke's method (*vide infra*), and this failing, a secondary laminectomy at the lower part of the spine.

advocates surgical interference here on the following grounds: (1) "We may here expect a regeneration of the nerve roots, the physiological evidence being strongly in favour of such regeneration, and not against it, as in the case of the cord. (2) The absence of spontaneous recovery in such cases in itself indicates the presence of a mechanical obstacle, such as permanent compression by bone, blood-clot, or cicatrix, otherwise we should expect the roots of the cauda equina to recover, as other peripheral nerves after severe injuries." For my own part I should only be inclined to interfere where the following conditions are present: A history of a direct injury; mobility and displacement, laterally or downwards, of the spinous process; great local tenderness; the usual symptoms of swelling, &c.; and paraplegia less marked than usual.

Those, on the other hand, who advocate surgical interference do so on the following ground: Dr. J. W. White[1] believes that fracture of the laminæ and spinous processes, and therefore relievable pressure on the spinal cord, will not be found so rare as has been usually believed. I fear that the weight of pathological evidence is all the other way. Dr. Weeks[2] considers that "the surgeon should perform laminectomy in every case, if the condition of the patient is such as to justify any operation, regarding the operation in the first instance as an exploratory one. The hope of restoration of function in those cases in which the cord is not irretrievably injured depends on the promptitude with which the cause of compression is removed; and, however small the number of cases in which benefit is to be looked for, I hold that even those few justify one in immediate operation. Laminectomy is not a difficult operation, since the soft parts are always found torn and quite detached from the bone, and the introduction of cutting instruments under the laminæ is very easy from the displacement present."

One case only is given, a very interesting one as far as it goes, as it occurred in a patient of 70, and the laminectomy exposed a fracture of the laminæ of the third and fourth cervical vertebræ. Very few details are given of the patient's condition—the left upper and lower extremities appear to have been chiefly affected—or of the operation. Two and a half months later there was some improvement in the motion of the left arm and hand, the patient could walk short distances by being supported on either side, and the action of the bladder had become normal.

Dr. Mixter and Dr. Chase, of Boston,[3] also advocate operative interference. Two cases are given suggesting a total transverse lesion of the lower cervical cord. One patient died in about twelve months from cystitis and pyelo-nephritis. The other recovered sufficiently to engage in business again. The authors follow Dr. Walton[4] in advocating laminectomy because there are no typical infallible symptoms from which it can be asserted that the cord is crushed beyond a certain degree of repair. While evidence of degeneration may persist after a laminectomy, the improvement which followed in the second case suggests that an "increased transmission of impulses takes place along the remaining scattered fibres; the analogue of which is found in the increase of functions occurring in the kidney after unilateral nephrectomy, showing the power of nature to accommodate herself to adverse conditions."

I remain of opinion that where *a large number of cases of laminectomy, carefully reported,* are placed before the profession, the balance of patho-

[1] *Ann. of Surg.*, July 1889. [2] *Trans. Amer. Surg. Assoc.*, 1901, p. 319.
[3] *Ann. of Surg.*, 1904.
[4] *Journ. of Ment. and Nerv. Dis.*, vol. xxix, 1902.

logical evidence will be against operation. A few isolated cases in which a varying degree of recovery has followed may show that where the condition of the patient and the surroundings are favourable, interference in skilled hands with the object of exploration is justifiable. Beyond this we cannot go. Few will accept the statement of Dr. Weeks that in these cases "laminectomy is not a difficult operation." Even if the tearing of the soft parts facilitates, as he claims is always the case, the preliminary steps of the operation, such injury facilitates the introduction of infection, and, a little later, the difficulties in restoring irregularities of the vertebræ—I refer especially to their bodies—may be enormous. If operation be undertaken, it is clear that this should be as soon as the patient has recovered from the primary shock: if possible within the second twenty-four hours. While the Röntgen-rays, if available, should always be employed, their use is, often, unsatisfactory.

B. *Penetrating Wounds of the Spinal Cord.* Mr. Thorburn[1] shows that while the percentage of recovery is good as to life, complete recovery of function is uncommon, owing to the little power of recovery of function after a destructive lesion of the spinal cord in man, especially in adults. He would also regard as useless the operation of suture of the pia mater as proposed by Chipault, and points out that it may be harmful not only by necessitating manipulation of the injured cord, but also by confining effused blood and serum, and thus increasing the pressure upon those parts which have escaped section. With the nerve roots, on the other hand, which are capable of repair, operation and suture would be quite justifiable.

C. *Operative Interference in Injuries of the Column and Cord from Gunshot Injuries.* G. H. Makins, C.B., our most recent authority,[2] is very emphatic here. "In no form of spinal injury is this less often indicated, or less likely to be useful. It is useless in the cases of severe concussion, contusion, or medullary hæmorrhage which form such a very large proportion of those exhibiting total transverse lesion, and equally unsuited to cases of partial lesion of the same character. Extra-medullary hæmorrhage can rarely be extensive enough to produce signs calling for the mechanical relief of pressure: the section of the cord cannot be remedied. In one case with signs of total transverse lesion, in which a laminectomy was performed, no apparent lesion was discovered, and this would frequently be the case, since the damage is parenchymatous."

Only three indications for operation exist. "(1) Excessive pain in the area above the paralysed segment; operation is here of doubtful practical use, except in so far as it relieves the immediate suffering of the patient. (2) An incomplete or recovering lesion, when such is accompanied by evidence furnished by the position of the wounds, pain and signs of irritation, of pressure from without, or possibly palpable displacement of parts of the vertebræ, that the spinal cord is encroached upon by fragments of bone. (3) Retention of the bullet, accompanied by similar signs to those detailed under (2).

"In both the latter cases the aid of the X-rays should be invoked before resorting to exploration.

"Operation, if decided upon, in either of the two latter circumstances, may be performed at any date up to six weeks: but if pressure be the

[1] *Loc. supra cit.*

[2] *Surgical Experiences in South Africa*, 1899–1900, p. 340.

actual source of trouble, it is obvious that the more promptly the operation is undertaken the better."

D. *Cases of Inflammatory Disease, e.g. Pott's Curvature.*[1] Interference here will be but very rarely called for, as we have abundant evidence that paralysis, even when of long duration, has a marked tendency to recovery, if the treatment by absolute rest in the recumbent position is vigorously enforced.[2] Where a sufficient trial of this has really failed, operative interference is justifiable if there be no evidence of tuberculous disease elsewhere or infected sinuses. Dr. De Forest Willard ("Tubercular Conditions of the Spine requiring Surgical and Mechanical Relief")[3] thus sums up on this point: "Laminectomy for paraplegia is advisable only after long continued and patient treatment from one to two years, since the prognosis, especially in children, is favourable and good powers of locomotion may be confidently expected. The operation is justifiable in selected cases where loss of motion and sensation are progressively worse and the symptoms threaten life." The anatomical difficulties and risks of laminectomy are well given in this candid and practical paper.

Mr. Thorburn[4] gives the following **indications** and **contra-indications** for operation. **Indications**: (1) "Assuming the prognosis to be thus favourable, we are never called upon to perform laminectomy save under certain special conditions. It will not be argued that the recovery after laminectomy is more complete than that produced by Nature, and experience shows that relapses also are only too common after operation. The indications which appear to me to point to the necessity for operations are these as follows: A steady increase in symptoms in spite of favourable conditions and treatment. The presence of symptoms which directly threaten life. Thus, in my second case, the secondary chest troubles were very grave.[5] Intractable cystitis would fall into this category.

[1] Reference should be made, in addition to the writings quoted above, to the following: (1) In cases of injury, Macewen, *Brit. Med. Journ.*, 1888, vol. ii, p. 308; Keetley, *ibid.*, p. 421; Duncan, *Edin. Med. Journ.*, 1889, p. 830; E. Hart, a case of M. Pean's, *Brit. Med. Journ.*, 1889, vol. i, p. 672; H. W. Allingham, *ibid.*, p. 838; Clipault, *Gaz. des Hop.*; *Arch. Gen. de Med.*, 1890; *Rev. de Chir.*, 1890, 1891, and 1892; these papers are now embodied in Clipault's work on the Surgery of the Nervous System; Schede of Hamburg, *Ann. of Surg.*, 1892, vol. ii, p. 230; Wyeth, *ibid.*, August 1894; Biddell, *Med. and Surg. Reporter*, March 30, 1895; Lejars, *Gaz. des Hôp.*, June 2, 1884; Arnison, *ibid.*, May 1895. (2) In cases of Pott's curvatures, Macewen and Duncan (*loc. supra cit.*); Weight, *Lancet*, July 14, 1888; W. A. Lane, *Brit. Med. Journ.*, April 20, 1889; *Lancet*, July 5, 1890; Abbe, *New York Med. Journ.*, November 24, 1888; Kraske, *Centr. f. Chir.*, 1890, Heft 25; Dr. S. Lloyd, of New York, *Ann. of Surg.*, 1892, vol. ii, p. 289; Bullard and Barrell, *Trans. Med. Orthop. Assoc.*, vol. ii, p. 241. Several of the above cases have been reported so soon after the operation that their value would be much increased by the authors giving later details. (3) In cases of new growths, Dr. Gower's and Sir V. Horsley's paper (*loc. supra cit.*) and the appended table. See also Dr. J. W. White's paper (*loc. supra cit.*), and his table of the most obvious diagnostic points, p. 32; Starr, "Tumour of the Spinal Cord," *Amer. Journ. Med. Sci.*, June 1895; and Patnam and Collins Warren (*Amer. Journ. of Med. Sci.*, October 1890).

[2] "Most of the 'cures' reported as results of laminectomy are merely examples of *post hoc, ergo propter hoc* reasoning. I have read the reports of many, and have little doubt about it. The exceptions include the cases in which laminectomy has led to the liberation of pus and the exposure and erasion of pre-vertebral foci" (Keetley, *Orthop. Surg.*, p. 476).

[3] *Ann. of Surg.*, October 1905, p. 514.

[4] *Loc. supra cit.*

[5] Dr. Parkin, of Hull, in a valuable paper (*Brit. Med. Journ.*, 1894, vol. ii, p. 700), illustrated by cases of laminectomy for spinal caries, mentions a case aged 9, admitted for cervical caries, cyanosis and bronchitis. As the condition became more critical, the sixth cervical spine was removed. The cord was found compressed and bent by a mass of bone and fibrous tissue, the remains of the fourth and fifth vertebræ. When the cord was freed, pulsation returned. Very great benefit followed on the operation, but the child died nearly three months after of tubercular meningitis, thought to be due to a caseating gland found at the necropsy. No evidence of caseation or recent caries was found in the vertebræ.

but it is by no means common, and we can hardly agree with those who hold that the condition is in itself incapable of spontaneous recovery.

"The persistence of symptoms, in spite of complete rest,[1] is the indication which has been most commonly adopted, but, as we have already seen, such symptoms may persist for very long periods and then yield to absolute rest. It is, however, not improbable that, in a few cases, cicatricial pachymeningitis, or rather peri-pachymeningitis, may remain after the original pressure-lesion has ceased to act, and may thus keep up paraplegia until the constricting tissue is removed.

"(4) In posterior caries (that is, in caries of the arches of the vertebræ) operation is clearly indicated, as here we can readily both treat the paraplegia and remove the whole of the tuberculous tissue. Two cases of this nature are recorded by Abbe and by Chipault respectively, and both proved highly successful.

"(5) In my fifth case, the existence of severe pain, which was rapidly exhausting the patient, was regarded as an indication for surgical interference.

"(6) Lastly, children as a rule yield better results than do adults, so that, other things being equal, childhood may also be regarded as an indication for operation.

"**Contra-indications.** The presence of active tuberculous changes in other organs. Macewen holds that we should not operate when there is pyrexia, which is almost tantamount to saying that we should not operate in presence of active tuberculosis. If, however, the pyrexia were clearly due to cystitis, then we might regard it as an indication for, rather than against, interference. Again, general meningitis (although fortunately very rare) will at times obviously be present and will probably prove fatal whether we operate or not."

For chronic spinal meningitis Sir Victor Horsley[2] recommends laminectomy with irrigation and drainage of the spinal theca. He bases his advice on the records of twenty-one operations for this condition. As many of these cases are syphilitic salvarsan should be tried first. Spiller[3] recommends operation for a circumscribed serous spinal meningitis, which closely simulates growth as the collections of fluid in the pia-arachnoid compress the cord. The drainage of the fluid appears to be satisfactory.

E. *Cases of New Growth.* It is in the intra-dural variety of these, when the level of the growth can be correctly estimated, that laminectomy is most decisively indicated. Sir V. Horsley[4] has here, as in so many other instances connected with the surgery of the central nervous system, operated with brilliant success.

The patient was one of Dr. Gower's, aged 42, and his chief symptoms were complete paralysis of the lower limbs and abdomen, the former being frequently flexed in clonic spasms, the pain accompanying these being extremely severe. There was loss of tactile sensibility as high as, and involving the distribution of the fifth dorsal nerve. The bladder and rectum were completely paralysed. The growth

[1] Readers with careful and well-balanced minds will not fail to note on reading the accounts of many of these cases, published as successful cases of laminectomy for spinal caries, that many of them before being submitted to operation, had only been treated by rest for a few days or weeks, "the mother having full directions to keep the child in the same horizontal posture." In other cases, after a brief period of in-patient treatment the children have been sent out in Sayre's jackets to attend as out-patients.

[2] *Brit. Med. Journ.*, February 29, 1909.

[3] *Amer. Journ. Med. Science*, January 1909.

[4] *Med. Chir. Soc.*, vol. lxxi, p. 383.

proved to be an almond-shaped fibro-myxoma resting on the left lateral column, in which it had formed a deep bed, and adherent to the fourth dorsal nerve. The patient recovered perfectly, the report being continued up a year after the operation.

Dr. H. Cushing[1] records a case of "intra-dural growth of the cervical meninges." The history before and after the operation is most fully detailed. Summaries of ten other cases of intra-dural growth successfully operated upon are also given. H. Harte of Philadelphia gives a full list of cases in which laminectomy was performed for intra-spinal "tumours." These are briefly but instructively analysed as to the nature of the condition found and the mortality. This he finds to be nearly 17 per cent. He holds that it should be capable of reduction to 30 per cent. Since then it has been reduced below 20 per cent. in the published cases.

An interesting case of extra-medullary tumour is recorded by Clark.[3] The tumour was successfully removed by Hey Groves, who points out that the site of such a "tumour" is indicated by pain, paraesthesia, paralysis and wasting of muscles occurring in this order at the segment corresponding to the lesion and followed by spastic paralysis of the parts below the lesion at a later date."

In recent years operations for spinal tumours have multiplied with great rapidity, and increasing experience shows that they are very successful when undertaken at an early stage of the disease. Potel and Vest[4] have added to our knowledge. For growths invading the spinal cord or growing in the vertebrae, nothing radical can be done as a rule, but laminectomy may relieve pain and pressure on the cord. When the pain is very severe, the paths of conduction in the anterior lateral columns of the cord may be divided through a small laminectomy some distance above the growth.

For extra-vertebral growths there is more hope, especially in the *extra-medullary*, for these rarely recur after complete removal. They are mostly fibromata or fibro-sarcomata or endotheliomata of low malignancy. They are nearly always well defined, small and solitary. More than half of them are found in the dorsal region. They are about equally common inside and outside the spinal theca.

Whatever part they occupy, these tumours, as a rule, give rise to unilateral pain along the course of the spinal nerve, whose root is affected or compressed, and this serves as a very good indication of the site of the growth. Later pressure upon one side of the cord causes weakness on the same and loss of sensation on the opposite side of the body below the growth. Later the severe compression of the cord causes spastic paralysis of the parts below on both sides, with exaggeration of the reflexes, and later still the sphincters become paralysed, and sensation is partly lost.

Intra-medullary tumours are far less common, and are solitary gliomata, which are encapsuled and removable in over half of the cases. They cause swelling and loss of pulsation of the cord. As they grow in the central grey matter, they cause vague symptoms consisting chiefly of extending atrophic paralysis and loss of sensation to pain and temperature without tactile anaesthesia.

It is difficult and very important to determine the exact level of the

[1] *Ann. of Surg.*, June 1904. [2] *Ibid.* October 1905, p. 514.
[3] *Brit. Med. Journ.*, 1912, vol. i. 175.
[4] *Rev. de Chir.*, 1913, vol. i. p. 713, vol. ii. p. 477.

tumour, for if the latter causes no root symptoms, the signs of compression of the cord may mislead. Then a growth in the dorsal cord may not cause any appreciable local irritation but only weakness and paræsthesia of the legs. Therefore the tumour is often sought too low. The first pains being due to root irritation give a good indication of the site, but it must be remembered that the nerves issue from the spine at a variable distance below the origin of their roots from the cord. Thus in the cervical region the nerves issue one vertebra below their root origins, in the dorsal region from two to three vertebræ below, and the lumbar and sacral nerves all have their origins near the lower end of the cord, which terminates opposite the first lumbar vertebra.

The upper border of disordered sensation is a very valuable guide, but as several nerve-roots supply every piece of skin, the level of the tumour is sure to be a little above the exact level of the segment indicated by the altered sensation. Atrophy of muscle also affords a valuable clue, but it is difficult to find it in the dorsal region. If a tumour is not found at the exploration, a silver probe should be passed up, first outside and then inside the theca, and this may discover it.

Operation of Laminectomy. Asepsis must be maintained and every precaution must be taken against shock before, during, and after the operation. As the patient must be placed, as far as is safe, in the prone position, pressure must be taken off the chest by the use of small pillows, and the operator must be prepared for the need of rolling the patient over from time to time, especially in those cases where the abdominal muscles are paralysed. Far better and safer is it to adopt intratracheal insufflation of ether whenever this can be adopted. A longitudinal[1] incision is made down to the spinous processes, with its centre opposite to the site of the supposed displacement or disease. The deep fascia having been divided a little to either side of the spines and also transversely at the upper and lower angles of the wound, the tendinous attachments of the muscles are cut from the spine, and the muscles completely detached from these processes, the laminæ, and from the transverse processes as far as is necessary, by the edge of a short, stout scalpel or a chisel, the spinous processes being used as a fulcrum. The use of a blunt instrument is more likely to lead to some sloughing, especially where the structures separated are largely tendinous. To prevent hæmorrhage forceps are quickly applied to the chief points, and sterilised pads out of sterile saline solution at a temperature of 110° are tightly packed by retractors into the incision on one side of the spine, while the operation is proceeded with on the other. This will best meet the chief bleeding, which is very free for a time. Sterilised adrenalin (1—1000) should be at hand. Efficient compression will usually suffice. Any vessels that require it being tied, and the muscles held back with retractors, any remaining muscular tissue is scraped away and the periosteum reflected with a suitably curved elevator. In cases of tuberculous disease, where access is desired to the bodies of the vertebræ rather than to their posterior processes and the spinal cord, the operator may desire to make his attack postero-laterally through the transverse processes and pedicles rather than through the spines and laminæ. In these cases especially it will be well for the operator to refresh his memory by having the corresponding part

[1] A flap, with its base in the middle line or to one side, is recommended by some, but, not admitting of ready enlargement, can only be suitable to those cases where the nature and site of the lesion are exactly known.

of the column in a dry state, kept at hand by an assistant (Keetley). In the one case the spinal canal is skirted, in the other it is entered. But to obtain free access, it is often advisable to combine the two routes in tuberculous cases. Two or three spinous processes, if unfractured, are then cut off close to their bases with powerful bone-forceps with jaws at different angles. The laminæ may be next removed by spinal saws, aided by a trephine, or the opening made by this instrument may be enlarged, as in the skull, by bone-forceps. Sir V. Horsley has devised bone-forceps well adapted to working at the bottom of a deep, steep wound-cavity.[1] Dr. W. S. Bickham, in a very instructive article on the technique of operations on the vertebral column,[2] recommends strongly Doyen's saw for removal of the laminæ and spinous processes. This is a strong Hey's saw with an adjustable guard. The guard of the saw is set at 10 mm., which will give a sufficient cutting edge to pass completely through the laminæ at any portion of the spine, provided the section be made well within the laminæ proper, and at a right angle to their surface. It is usually impossible to complete the section of one side with the saw in one position, as the proximal end of the saw will not travel the full length of the wound satisfactorily. The surgeon must divide the upper part of the laminæ on both sides, sawing from below upwards, and then walk round the table and complete the sections by sawing in the reverse direction. The usual flat probe tests the depth of the section. Partial division of the laminæ above and below those to be removed is unavoidable, and harmless (Bickham). A chisel and mallet may be used along an already made saw-line, to complete the section; but even here the vibrations may be hurtful. Further, unless a groove is first made with a saw, the line of the chisel is liable to be irregular. When the lumen of the canal is narrowed, this instrument becomes a dangerous one. Where the arches and the dura may be adherent, the bone must be removed with great caution; "picked away piecemeal," Tubby.[3] In the case of fracture, any loose bone will, of course, be tested and removed by sequestrum-

FIG. 404. Laminectomy for fracture dislocation of cervical spine. Three laminæ have been removed, the cord within its membranes displaced, and the prominent anterior superior angle of the vertebra below the dislocation is being chipped off with forceps.

[1] The surgeon should take the trouble to be provided with the necessary instruments. The ordinary saws and forceps are quite unfitted for removing the laminæ, and in the case of the cervical spine, may, by prolonging the operation and pressing on the cord, bring about a fatal result, as occurred in one case which came to my knowledge. Hæmorrhage from the bones should be arrested by packing applied as above, or (Harte, *loc. supra cit.*) by Horsley's wax.

[2] *Ann. of Surg.*, March 1905.

[3] *Orthop. Surg.*, p. 74.

forceps. The supra- and inter-spinous ligaments and the ligamenta subflava are next divided with blunt-pointed scissors at the two ends of the wound and the isolated segment of bone and ligaments is then partly prised, partly dragged out. In cases of fracture-dislocation, attempts may be made by manipulation of the parts now exposed by the wound, combined with extension and rotation, to rectify the position. The dura mater, covered with peculiar vascular fat, is next exposed. At this stage, if the opening be too narrow, it must be enlarged with rongeur-forceps and gouge. If the operation is to be completed in one sitting (p. 1001), the next step is usually to expose the cord and membranes. The latter are generally found covered by a varying amount of fatty tissue containing veins. This layer should be quickly divided, exactly in the middle line with sharp scissors, and the two halves packed to one side with pledgets of sterilised gauze to meet hæmorrhage. Irrigation with hot, sterile saline solution may also be tried. The dura mater is then examined. If no pulsation be present, compression or increased tension suggest themselves. Where it is needful to open the membranes, in the case of a growth, or the presence of blood, or to inspect a damaged cord, this step is best effected by picking up the dura mater with two pairs of forceps (one of these is held by an assistant), and then dividing the dura-arachnoid between these with scissors. Opening the sub-dural and still more the sub-arachnoid space will, of course, increase the risk of infection from the escape of fluid, and is therefore not a step to be undertaken lightly. Thus the dura should only be opened when fluid such as blood is present within, when the condition of the cord requires investigation, when sufficient mischief is not found outside, or when an intra-dural growth exists. This step is especially to be avoided in tuberculous cases, from the risk of meningitis (Chipault). Cerebro-spinal fluid is carefully mopped away, and if the spine is horizontal and the head is lowered, the flow usually soon ceases. If needful, the flow must be arrested by a small pledget of gauze. Where the anterior surface of the cord or the posterior aspect of the body of the vertebræ needs investigation, it is possible by means of an aneurysm-needle to displace the cord partially. If during this step it is really needful to divide one or two nerve-roots, these should be subsequently united by suture.[1]

In a few cases the cord itself has been sutured like a divided nerve, the stitches taking up the membranes and the cord itself. Such cases are recorded by Dr. Harte and Dr. Stewart, and Dr. Estes,[2] and by Dr. Fowler.[3] In this case the careful report is continued up to two years after the injury. The results are encouraging, especially in two of the cases.

In cases of *caries*, dense scar tissue, granulation tissue, pus, or a tuberculous mass may present themselves when the dura mater is exposed. In some it will be sufficient to take away the diseased material, till pulsation of the cord reappears; in others the tougher leathery substance must be snipped away with scissors till the cord is exposed with a surface made as smooth as possible, and it is clear that,

[1] Dr. Fowler stated (*loc. infra cit.*) that: "Spiller and Frazier found that after division of a posterior root in the dog, followed by immediate suture, regeneration occurs, and that regeneration into the cord does not occur."

[2] *Trans. Amer. Surg. Assoc.*, 1902, pp. 28, 44.

[3] *Ann. of Surg.*, October 1905, p. 507.

if not pulsating, it is not constricted. Any carious bone that is within reach will, of course, be removed by the sharp spoon. If, as is not unlikely, the mischief, *e.g.* tuberculous caries, abscess and granulation tissue, lie in front, this must be got at, if possible, by drawing the cord from side to side with an aneurysm-needle, and cautious removal of part of the transverse processes and adjacent bones (p. 995). When all diseased bone, granulation tissue, &c., have been removed with the

Fig. 405. Laminectomy for extradural tumour.

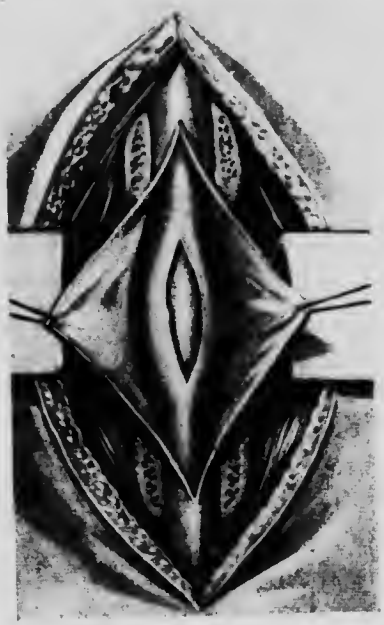


Fig. 406. Intramedullary tumour. The cord has been incised to allow the growth to be extruded. (After Hey Groves, *Med. Annual.*)

sharp spoon, a small flushing gouge, or gauze mops, iodoform emulsion may be applied, and the greater part of the wound closed: drainage, preferably by means of gauze, should, however, be provided for twenty-four or forty-eight hours, as oozing may be considerable.

In the case of *growths* the intra-dural ones hitherto operated upon have been usually met with on the postero-lateral aspect of the cord. A capsule, more or less complete, is generally present. It is to be noted that even when the correct level has been exposed, growths of the cord are sometimes difficult of recognition.[1] Such a case has been alluded to at p. 992. This fact is well illustrated by the case which forms the basis of Dr. H. Cushing's paper.[2] "Fluid escaped in considerable

[1] If no growth can be found in the region exposed, the surgeon should not hesitate to remove the spines of three, four or five of the vertebræ higher up. The chances of an error in diagnosis are much less than those of failing to find the tumour through timidity in exploration. Of course the extent of the operation must be governed largely by the condition of the patient; and, in case of collapse, the operation should be concluded after a day or two, if possible, when reaction has occurred (Harte, *Ann. of Surg.*, October 1905).

[2] *Loc supra cit.*

amount from the sub-dural space. The dura was then incised the full length allowed by the exposure, and on holding apart the edges of the membrane the thin transparent arachnoid bulged into the opening like a distended bubble.[1] This was pricked, and the fluid spurted from the opening in jets corresponding with the cardiac and respiratory rhythm. Not until the contents of the sub-arachnoid space were thus evacuated, and the transparent membrane had settled closely over the cord, was it apparent that there was some underlying abnormality. The arachnoid

Fig. 407. Hemilaminectomy for division of posterior nerve-roots. (Hey Groves, *Med. Annual.*)

was then incised, and lying on the left side of the cord was seen an oval growth of dusky purplish colour." This, removed by "gentle manipulations" and "shelling out," proved to be a fibro-sarcoma. The patient made an excellent recovery, and, three months later, was able to return to his work. In this case to facilitate removal of the growth, one posterior nerve-root was divided.[2] Where such a root is infiltrated it must be sacrificed. Elsberg[3] records the successful removal of several intra-

[1] Dr. H. Cushing observes that it has several times been noticed in these cases that the meninges below the growth are greatly distended with fluid (chiefly sub-arachnoid) under an increased tension, the growth, as it were, acting as a cork to the spinal flask in which the fluid continuously accumulates.

[2] This was believed to be the seventh cervical. The loss of sensation which followed is described with the full detail which abounds in this excellent paper.

[3] *Ann. of Surg.*, 1912, vol. i. 217.

medullary tumours. In the first stage the cord is incised over the tumour with the result that the latter is extruded and is more easily removed a week later.

For Resection of Posterior Nerve-Roots. Mr. Hey Groves[1] admirably describes the technique of posterior root resection as follows:

"Attempts have been made in three directions to minimise the length and danger of the operation. Guleke divides the nerves outside the dura. This may be suitable for the cervical and dorsal regions,

Fig. 408. Hemilaminectomy for division of post nerve-roots. (Hey Groves, *Med. Annual.*)

but in the lumbar and sacral regions the roots pierce the dura so far from their origin, that it would involve a greater difficulty than that which it seeks to overcome. The author of this article[2] and Wilms and Kolb[3] have recommended a procedure by which the lumbo-sacral nerves are attacked at their origin from the lower end of the cord, instead of at their exit from the spinal canal. The accompanying Figs. (407 and 408) illustrate the field of operation for both the cervical and lumbo-sacral regions. In the former a hemilaminectomy of the fifth, sixth, and seventh cervical, and first dorsal vertebræ serves to expose the posterior roots from the fifth cervical to the second dorsal inclusive, and by gentle

[1] *Med. Annual*, 1913, p. 454.
[2] *Lancet*, 1911, vol. ii.
[3] *Munch. Med. Woch.*, 1911. 1961.

traction on the cord the same roots on the opposite side can be dealt with. In the lumbo-sacral region, laminectomy of the last two dorsal and first two lumbar vertebræ gives access to all the lumbar and sacral roots at their junction with the cord. The determination of the exact roots can be made by counting upwards, it being borne in mind that the lowest root of considerable size is the third sacral. Wilms and Kolb suggest that it is unnecessary to count the roots, and they recommend division of rather more than half of all the rootlets composing each root." And later [1] he writes:

"In operating for spastic contractions of the leg, Foerster now holds that five roots ought to be cut: the usual ones are the second, third, and fifth lumbar, and the two upper sacral. The fourth lumbar is left, because it guarantees the extensor reflex of the knee which is so very necessary for standing and walking. Unfortunately, there is some variability in this phenomenon, and the second or third lumbar may be the important root instead of the fourth; so that now Foerster always assures himself of this point by electrical stimulation of the roots at the time of the operation.

Fig. 409. Forked end of ligamentum denticulatum with first lumbar nerve just below it. (After Hey Groves, *Med. Annual.*)

"Foerster himself still prefers the identification of the roots at their exit from the dura, which involves the removal of all the lumbar laminæ. But it has been urged by various authors that this is quite unnecessary, because all the lumbar and sacral roots can be exposed by a laminectomy of the last dorsal and first two lumbar vertebræ. The objection to this is that the filaments of the posterior roots lie so near together that they cannot be accurately counted. Elsberg [2] has made a valuable contribution to the solution of this problem. He has pointed out that the ligamentum denticulatum terminates by a forked end just opposite to the first lumbar nerve, so that this identifies the highest of the series (Fig. 409). Now as the last nerve of any considerable size to be given off from the conus medullaris is the third sacral, we have a means of recognising the last of the series also, and it ought therefore to be easy, if all the posterior nerves, from the first lumbar to the third sacral, are lifted up on a director, to enumerate them accurately."

Treatment of the Wound. To wash away clots and check oozing, flushing with hot sterilised saline solution may be employed, or a solution of adrenalin made use of. From the extent and depth of the wound and the condition of the muscles, drainage by at least a strip of sterilised gauze is indicated. When the theca has been opened, it must be very accurately closed with catgut sutures so as to prevent leakage of cerebro-spinal fluid. The muscles are brought together with buried sutures of catgut. In a few cases the hæmorrhage has been so severe as to necessitate packing the wound. Where there is much oozing the first dressings will require changing at the end of twelve hours, and subsequently,

[1] *Med. Annual*, 1914, p. 525.
[2] *Amer. Journ. Med. Sci.*, 1912, vol. ii. p. 799.

perhaps, once in two days. The skin should on these occasions be carefully resterilised. Efficient support should be supplied by sand-bags. A plaster of Paris jacket should be applied as soon as possible. The application of this at the first considerably prolongs the time of the patient being on the table, and where much oozing takes place, may interfere with this being efficiently dealt with. The necessity remains of after-attention to such conditions as cystitis, or the most successful operation will be brought to nought.

Causes of Failure and Death after Laminectomy. Many of these will have been made clear by the above given details: (1) Shock. Here, as in the case of the brain, the question of completing the operation in a second stage will sometimes arise. As I have already stated (p. 995), the failure of the surgeon to supply himself with proper instruments may lead to needless prolongation of the operation and pressure on the theca, which, especially in operations on the cervical region, may help to bring about a fatal result. (2) Hæmorrhage. This has been fully alluded to: the extra-dural plexus appears to be usually obliterated in cases of Pott's curvature. According to Chipault hæmorrhage is much more serious in the neck, since death has resulted three times from a lesion of the vertebral artery. (3) Respiratory trouble, partly due to the prolonged anæsthetic. In one case[1] the respiration became much embarrassed towards the end of the operation; this, continuing till the patient's death three days later, was attributed to injury to the phrenic nerve with an exploring needle. The dura mater, thickened and adherent to the bones, had been thus explored after removal of the third and fourth cervical arches which were carious. (4) Infective complications. (5) Tuberculous or other secondary deposits elsewhere. (6) Temporary improvement followed by a relapse.

TAPPING THE SPINAL THECA

The following are **the chief indications** for its employment. (i) Pressure of the cerebro-spinal fluid on the nerve centres in hydrocephalus (Quincke), growths, and effused blood. In the case of growths of the brain temporary relief of headache has followed, but death has taken place suddenly in several cases, owing to the withdrawal of the fluid having allowed the growth to make pressure upon the medulla. In tuberculous meningitis it has been used as a means of diagnosis (Quincke). It has also lessened the headache: in the epidemic cerebro-spinal form puncture has occasionally withdrawn pus. (ii) As a means of diagnosis in different forms of meningitis, serous, purulent and tuberculous[2] (Quincke). (iii) In the treatment of tetanus. In my own mind this, together with intra-neural injections, is the most scientific and promising method of dealing with this terrible disease. American surgeons from their enormous experience[3] have shown the way here. The treatment must be early, and, in many cases, prophylactic. "It has been well said that a patient who is having tetanic symptoms is not beginning to have tetanus he

[1] Deaver, *Inter. Journ. Med. Sci.*, December 1888.

[2] Fiebringer found tubercle bacilli in 27 out of 37 cases of tubercular meningitis, one of which is stated to have ended in recovery (*Berlin Clin. Woch.*, November 13, 1893).

[3] Thus a leading article (*Journ. Amer. Med. Assoc.*, August 29, 1903) shows that out of the casualties of the Fourth of July celebration of that year alone, 466 ended fatally. Four hundred and fifteen cases of tetanus occurred, and it is believed that this list is incomplete.

is beginning to die from it." The intraspinal injection has been successful when accompanied by intraneural ones into each of the trunks of the brachial plexus, each being repeated, the intraneural one by reopening the incision made. It is well to try and scratch some of the nerves in the cauda equina.[1] Any wound present should be thoroughly disinfected and drained. The experimental work of Marie, Meyer and others and the results prove this method to be more logical than intracerebral injection, simpler, and less dangerous.

Operation. The interval between the second and third lumbar vertebræ may be found in thin patients by counting downwards from the twelfth dorsal vertebræ. In stout or muscular patients a line drawn between the highest points of the iliac crest usually traverses the upper edge of the fourth lumbar spine when the column is flexed. It is better, even in children, in order to secure the needful rigidity, to have a special needle with a stylet. Barker's syringe and needles are figured below, and the details of technic are described under Spinal Analgesia.

When the fluid is being withdrawn to relieve tension, the operator must be guided by the pulse, any tendency to syncope, or pain in the head.

Albertin [2] reported a most interesting case, which serves to illustrate the usefulness of this measure in relieving intraspinal pressure in certain cases:

A man fell from a window, striking his knees and then his back. Paraplegia was the immediate result, the reflexes were absent, and there were large areas of cutaneous anæsthesia. The sphincters were, however, unaffected. Fourteen days later Albertin inserted a trocar into the spinal canal in the lumbar region, and drew off one ounce of blood-stained fluid. Forty-eight hours later the reflexes had returned, and from this time slow improvement took place, so that two weeks later the patient could walk with crutches. The final result is not given.

SPINAL ANALGESIA

This valuable method of inducing analgesia by the direct action of drugs upon the spinal cord and nerve-roots was introduced by Corning of New York, in 1885. Since then it has been gradually improved by many enthusiastic workers in America and on the Continent. Its adoption by British surgeons was somewhat delayed by reports of bad results abroad, but Barker, Chiene, Leedham-Green, McGavin, Dean, and others have shown that there is very little danger attached to it when used with care, and that it is eminently satisfactory in suitable cases. To Barker especially we owe a debt of gratitude for perfecting the technique and for his able advocacy based on his published results. At the present time the method is widely used and increasingly appreciated all over the world.

Indications. Briefly it may be said that spinal anæsthesia is indicated *for operations below the umbilicus, when an inhalation anæsthesia is considered unusually risky and a local analgesia is not likely to be sufficient.* In spite of Jonnesco's teaching that safe anæsthesia can be obtained as high as the vertex by the addition of a little strychnine to the spinal analgesic, few surgeons or anæsthetists believe spinal analgesia by itself to be satisfactory for operations above the umbilicus. In some operations in the upper abdomen the addition of a very little general anæsthetic

[1] Rogers, *Journ. Amer. Med. Assoc.*, May 14, 1903.
[2] *Lyon. Méd.*, October 8, 1899.

is sufficient, and here the spinal anæsthesia is valuable in diminishing shock.

Thus spinal anæsthesia is especially valuable for operations below the umbilicus when

(1) Any respiratory or circulatory disease makes a general anæsthetic more dangerous than usual either at the time or later from bronchitis, &c. Also when the kidneys are diseased or the small arteries atheromatous as in senile and diabetic gangrene.

(2) When great shock is expected as after severe injuries and operations for such injuries to the lower limbs. The prompt injection of stovaine into the spinal theca undoubtedly diminishes or prevents shock in these cases. The same is true for severe pelvic operations, especially excision of the rectum.

(3) When full relaxation of muscle is valuable as for prostatectomy, most pelvic operations, and those for hernia.

(4) Where vomiting during or after the operation is undesirable and especially dangerous, as in strangulated hernia and intestinal obstruction.

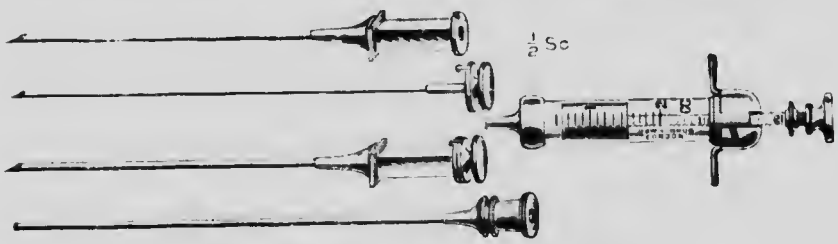


Fig. 410. Barker's Syringe and Needles. (Down.)

(5) Where consciousness during the operation is desirable, as when the patient has a great fear of a general anæsthetic, or the surgeon wishes to consult him after the examination or exploration.

(6) When an anæsthetist is not available in emergencies. Then the surgeon can work single-handed with safety and without anxiety.

The method is not very safe when the Trendelenberg position has to be adopted. There are some enthusiasts who prefer spinal anæsthesia for all operations below the navel, but the writer prefers to reserve it for selected cases, believing that a general anæsthetic is, as a rule, more satisfactory. It is probable that even the spinal enthusiasts would hail general anæsthesia with joy if it could be brought before them now as a new and daring innovation.

Tyrrell Gray[1] has shown that spinal analgesia, especially stovaine and dextrine, is very valuable and safe for children, in whom it lessens shock to a marked degree.

Preparation, Solution, and Instruments. It is necessary to empty the bowels satisfactorily, for the sphincters are paralysed by the analgesic. It is wise for the patient to take only light food before the operation. Many drugs have been tried, and some of these have proved to be dangerous. On the whole, Barker's solution of stovaine is the most satisfactory. This consists of stovaine and glucose each ·05 grm. in 1 c.c. of water. Billon, of Paris, supplies the sterilised solution in capsules of 2 c.c. McGavin recommends a dose for an average healthy adult,

[1] *Brit. Med. Journ.*, 1909, vol. ii. pp. 913, 991.

·05 grm. for feeble, exhausted patients, and ·04 grm. for operations below the groin. The solution is a little heavier than cerebro-spinal fluid and is nearly isotonic with it. The Barker syringe and needles are the best (*see* Fig. 410). The needles are hollow and fitted with a stylet and a cannula, the latter a little longer than the needle. These are well boiled in water containing no soda or other alkali.

Position. The best position is the lateral one, the patient lying on the side to be operated upon, with the thighs and back well flexed. The back is carefully cleaned with acetone, ether, or ether soap and methylated spirit. The anæsthetist's hands are prepared as for every operation. The pelvis is slightly raised, and the interval between the second and third lumbar spines is found, and ethylchloride is sprayed on this spot for a few seconds. The needle containing its stylet is entered in the middle line between the spines, and thrust directly forwards for about two inches, when it is withdrawn and the needle is pushed on until the cerebro-spinal fluid begins to issue. When about 5 c.c. of this has escaped, the cannula fitted in the syringe containing the solution of stovaine is inserted, and the latter is gently injected. The needle is then withdrawn and the patient's head is raised by a pillow. After a minute or two the patient is rolled on his back. The head is always kept well above the level of the dorsal spine. Almost immediately the knee-jerks vanish and anæsthesia rapidly spreads up so that it reaches to or above the umbilicus in five to ten minutes. Then the pelvis is lowered and the operation commenced. If the analgesia is imperfect a second injection of one-half the original dose may be given. A sterilised towel on a frame prevents the patient seeing the operation, and, if considered necessary, his ears may be plugged with cotton-wool. As a rule, however, it is well for an assistant to engage him in conversation, and to give him a drink of water if he complains of thirst or nausea. Occasionally faintness, pallor, and sweating are noticed, and sometimes there is a little vomiting. The analgesia lasts on an average about fifty minutes, but its duration varies from twenty to ninety minutes (McGavin). A number of patients have a headache and backache after the operation, and nearly all have a rise of temperature up to 101, subsiding on the second or third day.

Precautions after the Analgesic. No hot bottles must be placed near the patient's legs until the analgesia has completely disappeared. A perineal pad should be worn until the power of the sphincter ani returns, and retention of urine must be prevented.

Advantages. Very little preparation or starvation is required before the anæsthetic, and vomiting, shock, and other sequelæ are rare after it. The patient finds it very pleasant to be able to eat, drink, or smoke immediately afterwards.

The Disadvantages of Spinal Analgesia

(1) Occasionally it fails to produce a sufficient degree, extent or duration of analgesia. An average of fifty minutes is hardly long enough for some extensive and difficult operations in the pelvis. A failure to secure good analgesia is often due to errors of technique preventing some of the solution reaching the spinal theca. In other cases failure is attributed to idiosyncrasy to the drug or to a low pressure of the cerebro-spinal fluid. With increasing experience the failures become fewer.

(2) According to Crile the blood-pressure falls sometimes to a dangerous degree owing to the loss of the vaso-motor tone in the anæsthetic area, for vaso-motor impulses are blocked by the analgesia with the result that the vessels of the abdomen and legs dilate. An injection of pituitary extract before the operation is sometimes used to diminish the fall of blood-pressure.

(3) It does not prevent mental shock, as the patient is conscious and often suffers from fear, and sometimes is depressed by excitation of the special senses, which are keener than ever. This makes spinal analgesia alone somewhat unsuitable for very nervous people, especially women about to undergo gynæcological operations. The special senses can be blocked to some extent by covering the eyes, by plugging the ears with moist cotton-wool, and by conversation, or by an injection of morphine ¼ gr. an hour before the operation.

(4) A toxæmia sometimes develops a few minutes after the injection. This is sometimes attributed to idiosyncrasy to the analgesic, and sometimes to the addition of adrenalin to the solution, which should be avoided.

(5) The mortality is still a little higher than that of ether.

(6) In a few cases post-operative complications, mostly due to errors of technique, have ensued, such as paresis or pains in the legs from injury of the cauda equina, or hæmorrhage into the spinal canal or theca. Gangrene of the legs has also been mentioned. Some headache and pyrexia are usual, and sometimes these are troublesome.

Asphyxia may occur when a very high level of anæsthesia is attempted. When symptoms develop artificial respiration must be carried out, strychnine injected, and an ounce of cerebro-spinal fluid allowed to escape through a lumbar puncture.

ANOCI-ASSOCIATION

As a result of his brilliant experimental work, Dr. Crile has introduced anoci-association into surgery, and the following account of technique is taken from his book on this subject.[1]

MORPHIN AND SCOPOLAMIN

"To mitigate the pre-operative dread and to facilitate the induction of anæsthesia, a solacing dose of morphin and scopolamin (usually morphin, $\frac{1}{6}$ gr., scopolamin, $\frac{1}{150}$ gr.) is given an hour before the operation to all patients excepting the aged, the very young, and those whose feeble condition contraindicates the use of these narcotics. The use of morphin serves the double purpose of diminishing the pre-operative psychic strain and of actually preventing, to some extent, the damage to the organs of the kinetic system by the trauma of the operation. Laboratory experiments have shown that in morphinised animals subjected to trauma, the changes in the cells of the brain, the suprarenals, and the liver are less than in traumatised animals without this protection.

"That deep morphinisation will almost completely prevent shock has been abundantly proved in both the laboratory and the clinic.

"The protective effect of morphin is remarkably exhibited also in those

[1] Dr. Crile and Dr. Lower. *Anoci-Association*, pp. 113, 115, 121

cases of exophthalmic goitre in which some exceptional local condition causes a break in the complete *anoci-association* of the patient, as a consequence of which the pulse and respiration increase markedly during or after the operation. In these cases, if morphin be given in repeated doses until the respiration and pulse are held stationary or fall, the dangerous exhaustion of the patient will be avoided. The morphin may be given at any time during or after the operation when it is seen that the patient's energy is being expended at too rapid a rate.

"Morphin is especially useful also in those cases of acute infection in which emergency operations must be performed. In such cases morphin affords a double protection—it protects the brain against both the infection and the operative trauma, the effects of which are increased, because during the activations of a toxin the brain thresholds are greatly lowered. Here also morphin should not be given in one dose, but in repeated doses until the physiological effect is produced. This point will be indicated by the reduction of the respiration to the normal rate or less.

"In brief, by proper use, morphin to a large extent controls the metabolic processes. It should be added that it is not our intention to suggest an increase in the use of morphin in average cases, but to emphasise its usefulness when employed in physiologic dosage in certain exceptional cases. . . ."

NOVOCAIN

"Every division of a sensitive tissue—that is, of a tissue supplied with nociceptors—is preceded by the injection of novocain in 1 : 400 solution. This is used routinely in all parts of the body, in all ages, in the debilitated and in the strong, in small and in extensive operations under all sorts of conditions. There are certain salient points to be observed in its use : the tissue to be divided should be completely infiltrated—no nerve filament should be omitted. One might think of the novocain as a stain and consider that only the stained parts are ready for the knife. The infiltrated parts should be subjected immediately to pressure, as firm pressure with the hand greatly increases the efficiency of the anesthetic and the extent of the anesthetised area.

"It is well to make the first infiltration between the superficial and deep layers of the skin in such a manner as to cause a pig-skin appearance. This is facilitated by putting the skin on tension, and then while making the injection, pushing the needle along *in* the skin parallel to the surface.

"Experience in operating under local anesthesia alone is almost essential for learning how to use novocain infiltration effectively, for the conscious patient promptly protests if the infiltration is incomplete. As a result of an abundant experience with conscious patients, the surgeon, even when operating on anesthetised patients, will automatically plan the infiltration and handling of the viscera in the manner which would cause the least response were his patient conscious.

"It is obvious that the anæsthetic solution should be most carefully prepared and sterilised. In our clinic this is done as follows : Normal saline solution is prepared with distilled water and boiled for twenty minutes. A sufficient number of novocain crystals are added to make a 1 : 400 solution which is then boiled for ten minutes on two successive days.

"Novocain when properly injected anæsthetises the part immediately; the anæsthesia lasts for approximately an hour; and it presents no interference to the healing of the wound."

QUININ AND UREA HYDROCHLORID[1]

"To minimise post-operative discomfort, especially in abdominal operations, quinin and urea hydrochlorid in a ⅛ to ½ per cent. solution is injected *at a distance* from the wound. The effects of this local anæsthetic last for several days, so that by its use the patient is protected from noci-impulses from the operative field until the healing process has well begun. This local anæsthetic can be safely used in all cases in which no infection is present, but is unsafe in the presence of infection because it to some extent diminishes the resistance of the tissues. Quinin and urea hydrochlorid usually cause some œdema of the infiltrated part which may last for weeks, but which ultimately disappears. The solution used at Lakeside Hospital is prepared by boiling distilled water for twenty minutes; adding a sufficient number of sterile quinine and urea tablets to make a solution of the required strength and boiling again for ten minutes.

"Moynihan has devised an excellent syringe having a long obtuse-angled needle by means of which the quinin and urea hydrochlorid may be injected *at a distance* from the incision so that the entire operative field will be anæsthetised for two days or more after the operation, while the wound itself is not exposed to the irritation of the quinin and urea."

GENTLE MANIPULATIONS: SHARP DISSECTION

"The phylogenetic facts upon which the kinetic theory of shock is founded indicate the necessity for the use of the gentlest manipulations throughout the operation. In this respect the surgeon should at all times govern his movements as he would if the patient were to be conscious of each step in the operation. Pulling, tearing, and crushing manipulations awaken phylogenetic noci-associations with consequent activation for defence, and exhaust the organs composing the kinetic system, especially the brain. In addition actual coincident trauma is produced by traction in the tissues beyond the zone which is protected by the infiltration of the local anæsthetic. On the other hand the division of the tissues with a sharp scalpel is a form of injury which awakens less phylogenetic association and, in addition, produces the least amount of damage to the tissues. Gentle manipulation and sharp dissection by producing the least amount of tissue injury in turn necessitate the minimum amount of healing. *Clean-cut wounds give the least post-operative discomfort.* It should be borne in mind also that trauma, by diminishing their vitality, predisposes the tissues to infection. For every reason, therefore, the tissue trauma should be as slight as possible."

Comment. The principles underlying anoci-association are sound and excellent, but the practice and much of the technique recommended by Dr. Crile has been adopted by most surgeons for a long time. Morphin and scopolamin or some similar sedatives given before the anæsthetic has been in general use for years, and the adoption of nitrous oxide with

[1] The anæsthetic properties of this drug were discovered by Thibault, of Scott, Arkansas.

or without ether instead of chloroform has been attended with excellent results. In my experience, however, shock has been extremely slight and rare after abdominal operations in recent years. Moreover post-operative discomfort has been very trivial. Gentle manipulations, quick operating, skilled anæsthesia, good preparation before the operation, and careful but not meddlesome after-treatment have been attended with the happiest results in the large majority of cases. Therefore I have not thought it necessary to adopt the injection of novocain with quinin and urea hydrochlorid as a routine measure. I believe, in fact, that the delay involved in the process and the unpleasant œdema of the tissues more than outweigh the advantages of the method in the majority of cases. For very extensive and somewhat prolonged operations likely to be attended with considerable shock, the method has very much to recommend it.

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