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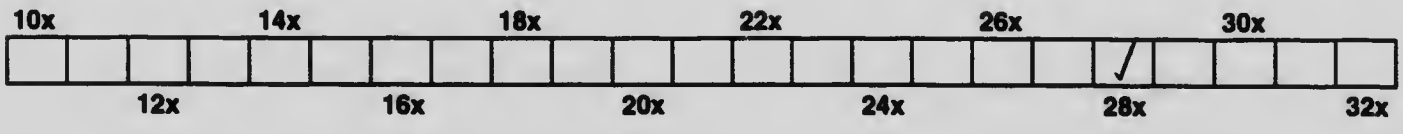

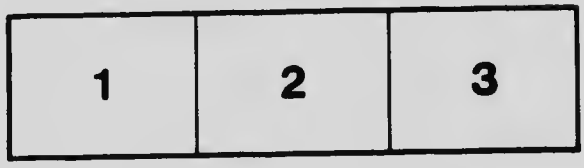

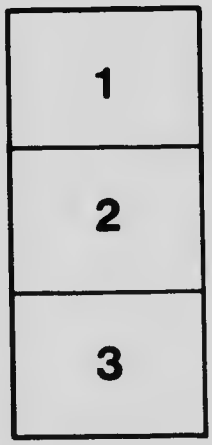

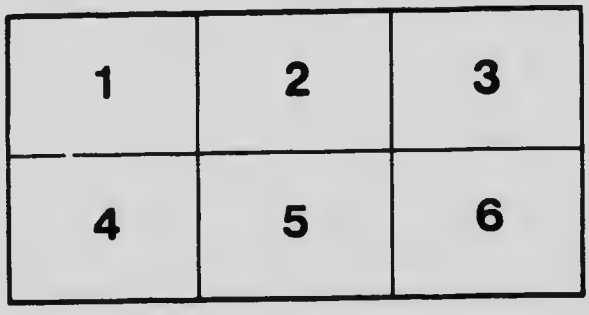

OPERATIVE SURGERY

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The Head and Neck, the Thorax and the Abdomen

BY

EDWARD H. TAYLOR

M.D., B.S. (Dub. Univ.), F.R.C.S.I.

Professor of Surgery in the University of Dublin

Surgeon to Sir Patrick Dun's Hospital

ILLUSTRATED WITH 300 FIGURES FROM ORIGINAL DRAWINGS, MANY PRINTED IN COLOURS

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PREFACE

This work on the Operative Surgery of the Head and Neck, the Thorax, and the Abdomen, differs in certain respects from the ordinary treatise on this subject. No attempt has been made to include an account of all or even the majority of the operative procedures which are performed in these regions, but rather to present in convenient form a description of those which are most frequently required in general surgical practice. A work which would cover the entire domain of the operative surgery of these regions would of necessity require the production of two or more large volumes, but instead of following the ordinary stereotyped plan, I decided to include in one volume an account of those operations which a general surgeon is most likely to be called upon to perform.

The idea of producing such a work originated in connection with the post-graduate courses of medical study in Trinity College, which have been largely attended by surgeons attached to Provincial Hospitals and County Infirmaries, also by officers of the Indian Medical Service, Royal Army Medical Corps, Navy Medical Department, and the Colonial Medical Service. On many occasions I have heard a wish expressed for a work of this kind, and it was with the hope that I might be able to meet such a want that I undertook to add still another to the already long list of treatises on this subject.

In the description of the various operations I have followed a definite plan, viz., to arrange the description in successive stages from the first incision up to the introduction of the sutures, as I believe such an arrangement will prove helpful in enabling those who are not constantly engaged in operative work to follow out the various stages without difficulty. In all cases I have described the operations as I perform them myself, and in certain cases where a choice lay between different methods I have selected that which I have found by experience to be the most satisfactory.

The illustrations, with one or two exceptions, are original, and have been prepared under my direct supervision. Many have been drawn from stereoscopic photographs, taken in the operation theatre. I have found this an excellent method for producing illustrations both accurate in the matter of detail and giving a clear representation of the requirements of modern surgical technique. The figures which are for the most part, if not altogether, anatomical have been prepared from special dissections made in the Surgical Department of Trinity College. As many of the figures represent successive stages in the more important operations, I have provided each with a short explanatory note, indicating the special points which each figure is meant to represent. In this way the study of the figures alone should prove more helpful and instructive.

The illustrating of the work has been carried out for the most part by Mr. James T. Murray, of Edinburgh, whose reputation as an anatomical artist is so well known. I cannot speak too highly of the great skill and earnestness with which he devoted himself to his work.

It would be impossible for me in these short prefatory remarks to express my indebtedness individually to those of my surgical brethren from whose work I have derived help and acquired new ideas. I have, however, so far as was possible, alluded to the sources of my indebtedness in the text. At the same time I cannot refrain from stating how much I owe to my brilliant American *confrères*, who are doing, and have done, so much to advance our knowledge in the field of surgical science and to attain a higher degree of perfection in the details of operative technique.

In the preparation of the section which deals with gastro-intestinal surgery I have received valuable assistance from Mr. Adams McConnell, F.R.C.S.I., and Mr. R. A. Stoney, F.R.C.S.I., has likewise been most helpful in the preparation of the section devoted to operations upon the kidney. The subject of anæsthetics and their modes of administration has been entirely written by Mr. McConnell. I am indebted to Sir Robert Woods for valuable suggestions in connection with the operations upon the larynx, and to Mr. T. O. Graham, F.R.C.S.I., for revising the operations in the mastoid region and those which concern the maxillary sinus. My best thanks are due to Mr. William Pearson, F.R.C.S.I., for his able help in the revision of the proofs while the book was passing through the press.

I cannot speak too highly of the manner in which Messrs. J. & A. Churchill have carried out all the details relative to the publication of the work and for the ready attention which they have always given to my suggestions.

77, Merrion Square,
Dublin
July, 1914.

EDWARD H. TAYLOR.

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SECTION I

SURGICAL TECHNIQUE

WOUND INFECTION.—The avoidance of wound infection is the most important end to be achieved in operative surgery. By wound infection is meant the entrance into the tissues of micro-organisms capable of exciting local inflammation with pus formation, and possibly entrance into the general circulation, producing a generalised infection or bacteriæmia. It is beyond the scope of this work to enter into a detailed account of the micro-organisms which excite wound inflammation; such information must be obtained from one of the numerous works on bacteriology. It will suffice to enumerate those which are more commonly found in infected wounds and cavities: they are *Staphylococcus pyogenes aureus* and *albus*, *Streptococcus*, *Pneumococcus*, *Bacillus coli communis*, *Bacillus typhosus*, *Gonococcus*, and *Bacillus pyocyaneus*.

When a wound is inflicted under circumstances which enable the tissues to be protected from the ingress of organisms, it is termed *aseptic*. The term "sepsis" is usually employed to indicate infection of wounds by pus-producing organisms; such wounds are termed *septic* or *infected*, and with these the process of healing is interrupted by inflammation of varying intensity, resulting usually in pus formation and destruction of tissue.

SOURCES OF WOUND INFECTION.—The sources of wound infection are numerous, but the following, as given by Kocher, are the most deserving of mention, viz., (1) infection by air, (2) contact infection, (3) implantation infection, (4) lesion infection, (5) auto-infection.

Air Infection.—Organisms mixed with dust may be carried in large numbers in the air, especially if strong currents are set up and the air is in motion. It is obvious that the degree to which air might be contaminated with bacteria-laden dust will depend upon a variety of circumstances. With ordinary precautions, however, it is not likely that the air may be regarded as a serious source of infection. Undoubtedly some bacteria are deposited in the form of dust upon every wound, but not in sufficient quantity as a rule to result in wound disturbance.

Contact Infection.—This is the most fruitful source of wound infection. Organisms may reach the wound from the hands of the operator or his assistants, the patient's own skin, instruments, dressings, sponges, in fact anything that may come into direct contact with the wound surfaces. The methods of disinfection at present in vogue are mainly directed towards preventing infection of this kind.

Implantation Infection.—Materials such as ligatures and sutures, which are purposely left in the wound, may be the means of introducing micro-organisms. In the absence of all extraneous material, healthy, cleanly cut tissues are capable of healing *per primam*, even though some organisms may have gained entrance during the course of the operation. The tissues are capable of dealing with these up to a certain extent, but they fail if the wound contains buried sutures or ligatures. Kocher lays stress on this point and recommends that silk when introduced into a wound should be impregnated with an antiseptic, and not merely aseptic, so that the effects of micro-organisms may be counteracted.

Lesion Infection.—In order that wounds should heal *per primam*, it is of importance that their vitality should be ensured, and that their capacity for resistance should be unimpaired. Anything which is calculated to lower or destroy their vitality should be avoided, such as rough handling, the application of ligatures to large masses of tissue, or the long application of clamps or hæmostatic forceps, tearing of tissues or excessive use of antiseptics. The presence of organisms in wounds with damaged or devitalised tissues would be calculated to induce septic changes.

The presence of detached or poorly nourished tags of tissue, inadequate drainage, traumatism by rough handling, irregular incisions, and irrigation of wounds with caustic solutions which produce superficial necrosis interfere with wound repair.

Auto-infection.—Infection of a septic or pyogenic character involving some of the deeper tissues, and in the absence of an open wound, is usually explained on the hypothesis that the infective organisms have reached the part by way of the blood stream and have found there a suitable nidus; the acute form of osteo-myelitis in young subjects is generally accounted for in this way. It is reasonable to assume that in some rare instances operation wounds may become infected in the same manner.

DISINFECTION.—The term "disinfection" includes the various measures employed to counteract the influence of living micro-organisms by inhibiting their action or destroying them completely. A germicide is an agent which possesses the power of destroying micro-organisms. The term "sterilisation" implies the process whereby complete and permanent loss of vitality of micro-organisms is brought about. True disinfection, *i.e.*, the destruction of micro-organisms, is synonymous with sterilisation.

The value of disinfection in wound treatment was first emphasised by Lister, who has been justly styled the father of modern surgery, but it would be utterly beyond the scope of this work to indicate the main facts relating to the introduction of antiseptics by him in 1867 and the discovery by Pasteur at an earlier date of the dependence of fermentation on micro-organisms. The term "Listerism" has come to be regarded as synonymous with the treatment of wounds by disinfectants of a chemical nature, *i.e.*, antiseptics. For two decades the antiseptic method of wound treatment held supreme sway, and was attended by marvellous results when contrasted with the older methods of wound treatment which were in vogue before that time. Chemical methods of disinfection have gradually become superseded, however, by those of a physical nature, *i.e.*, heat. Sterilisation by boiling water and steam is at the present day the method mainly relied upon throughout the world. At the same time, physical methods cannot accomplish complete sterilisation in surgical work, but are of necessity supplemented by chemical or antiseptic agencies.

In the carrying out of modern surgical technique reliance must be placed on the three great measures for securing surgical cleanliness, viz., mechanical washing, moist and dry heat, chemical disinfectants.

Mechanical Cleansing as applied to the patient and his immediate surroundings is the most useful and important of the methods for procuring sterilisation. It is accomplished by means of soap and hot water, assisted when necessary by the nail-brush, etc. The removal of dirt by washing and scrubbing not only disposes of enormous masses of the bacteria, but prepares the various surfaces so that other methods of sterilisation can be successfully used in attacking the germs which remain.

Chemical Disinfection is accomplished by means of antiseptics. These are mainly of use for the preparation of the skin of the operator and his assistants and of that of the patient. They are of value, too, in the preparation of ligature and suture materials.

Physical Sterilisation by the agency of heat in the forms of dry heat, boiling water, and steam has a very wide application, and is employed as far as possible in the sterilisation of all materials, instruments, appliances, etc., employed in operative work. Sterilised saline solution is used for clean wounds, and has largely replaced fluids of an antiseptic nature for douching and flushing recent or infected wounds and cavities. It does not irritate, is non-toxic, and acts essentially as a mechanical cleanser and a healthy stimulus to the tissues.

ANTISEPTICS OR CHEMICAL DISINFECTANTS.—These are chemical compounds which possess the power of destroying or inhibiting the growth of micro-organisms. They are used in watery or oily solutions, in powders, or in the gaseous state. Their action as destructive agents, *i.e.*, germicides, is perhaps not very great, taking into account the relative strengths at which they are employed. Antiseptic solutions are often credited with greater powers than they possess considering their low degree of concentration; under such conditions the most that can be expected of them is to exert a beneficial influence by retarding or inhibiting the growth of micro-organisms.

Antiseptic Powders have little germicidal value. Bacteria are unaffected when surrounded by the strongest antiseptic powder so long as it is dry. On moist septic surfaces powders are likely to cause scabbing and thus impede the escape of septic secretions. Their free application also may result in absorption and toxic symptoms. If used in solutions of a high degree of concentration, antiseptics are decidedly injurious. By their irritating properties they are calculated to lower the vitality or induce necrosis of the tissues with which they come into contact. Bacteria are often hidden away in wound recesses or surrounded by impermeable media, such as coatings of grease, and consequently they are not likely to come under the influence of antiseptic applications.

In order that antiseptics should possess a real disinfecting value in the treatment of wounds, they should be readily soluble and have the power of penetrating deeply, so as to come into contact with all the infective germs; they should be actively germicidal, and capable of acting in a short time; furthermore, they should not form chemical compounds of an inert nature with the fluids and tissues of the body; it is desirable also that they should be non-toxic and non-irritating, but unfortunately no antiseptic combining all these valuable qualities has yet been discovered.

Some antiseptic compounds have their utility largely minimised by the fact that they act injuriously on metal instruments, leading to corrosion, for example, corrosive sublimate, iodine, biniodide of mercury, etc. Another disadvantage possessed by many antiseptics is that they are highly toxic and by reason of their capacity for

rapid absorption are apt to induce serious consequences if used without due discrimination; among those the toxic properties of which are deserving of note are carbolic acid, corrosive sublimate, iodoform.

The following antiseptics are those which we usually employ in ordinary surgical work:—

Carbolic Acid. This compound, obtained by the distillation of coal tar, was largely used in the earlier antiseptic era. It is very volatile, however, and for this reason it loses much of its value as an antiseptic. Applied locally in the form of moist dressings, it may lead to gangrene of the tissues by inducing a copious exudation and the formation of arterial thrombi. It is highly toxic, and in former years poisoning by carbolic acid was by no means uncommon. When absorbed it is excreted by the kidneys, and may give rise to a green brown or smoky colour of the urine (carboluria). When applied locally in a concentrated form it exerts a decidedly anæsthetic action upon the tissues, skin, and mucous membrane. If very strong, it acts as a caustic.

Liquefied carbolic acid is sometimes employed for disinfecting foul sores and phagedenic ulcers, or for swabbing over recently divided tissues in the course of certain operations, such as the removal of tissues the seat of tuberculous disease, caseating glands, sinuses, and septic cavities. Its application in recent wounds should be followed by gentle swabbing of the parts with alcohol, so that any excess of the acid may be removed. Its action, however, in this form is quite superficial as it causes coagulation of the albumin of the tissues with which it comes in contact.

Carbolic acid in solution is still extensively employed, the usual strength of stock solutions being 5 per cent., *i.e.*, 1 in 20 carbolic acid. This solution may be diluted to varying degrees. A solution of 1 in 40 is sometimes employed for instruments during operation, in which case each instrument should be rinsed in saline before its insertion into the wound. It also forms a useful preserving medium for ligatures after previous disinfection.

The following coal tar derivatives are also useful antiseptics:—

Lysol.—As obtained commercially this is a brownish fluid strongly alkaline in reaction and with a syrupy consistency. It is a solution of tar oil and other bodies allied to carbolic acid in potash soap. It is freely soluble in water, and in solutions of 1 or 2 per cent. has an undoubted value for cleansing the skin in cases of accidental injury. This is probably its most useful property. Its actual value as an antiseptic is apparently not very great unless employed in a concentrated form, but it is then very irritating. Lysol is not suited for washing away purulent discharges, as its action on pus is similar to that of an alkali, converting it into a slimy substance.

Cyllin and **Creolin,** which are practically identical, are compounds which consist of tar oils (cresols) saponified with resin and alkali. They are represented by a fluid of a dark tarry consistency and a rather unpleasant odour. Solutions in water have a white or creamy appearance. In making such solutions cold water should first be added.

Cyllin and creolin are of decided value as disinfectants and antiseptics, and are usually employed at a strength of 1 or 2 per cent.; they are also of value as deodorisers. They are to be recommended for douching infected and suppurating cavities in strengths of 1 to 2 drachms to a pint of water, as their toxicity is slight. For septic wounds and cellulitis involving the extremities they are excellent when employed in the form of a hot antiseptic bath for half an hour or more three or four times a day.

Corrosive Sublimate or Perchloride of Mercury. This is a powerful antiseptic, but at the same time an intensely irritant poison. In strong solutions, 1 in 1,000, it is very irritating to the skin and tissues. In the presence of albumin it forms an insoluble albuminate, and consequently its antiseptic value under such circumstances is very much diminished. In spirituous solutions it appears to be of use mainly in disinfection of the hands and skin, 1 in 2,000 and 1 in 4,000 being the ordinary strengths employed. It is a useful medium also in which to preserve ligatures of silk and such like materials.

Alarming signs of toxæmia, such as severe colicky pains, vomiting, and salivation, have followed the employment of solutions of corrosive sublimate for irrigating purposes. In portable form it is procurable as "soloids," one of which dissolved in a pint of water makes a solution of 1 in 1,000. A concentrated solution (10 per cent.) in glycerine and water may be carried in the surgeon's bag. Two fluid drachms of this added to a pint of water makes a solution of 1 in 1,000.

Harrington's solution contains corrosive sublimate as its active antiseptic ingredient; it is made up as follows: 640 c.cs. commercial alcohol (90 per cent.), 60 c.cs. hydrochloric acid, 300 c.cs. water, 0·8 grm corrosive sublimate. This solution possesses a very high antiseptic value and is probably one of the most efficient skin-sterilising agents in use at the present time. It is irritating to the skin, however, and is calculated to cause a slight inflammatory reaction if applied to sensitive parts such as the face, the vulva, or the scrotum and penis. In spite of this drawback, its use as a skin disinfectant is attended by excellent results.

Biniodide of Mercury (Potassio-mercuric Iodide).—This is a very valuable and powerful antiseptic, and has largely supplanted corrosive sublimate in general use. It possesses the following advantages over the sublimate: it is apparently a more powerful antiseptic; it does not coagulate albumin; it is less injurious to the tissues and less irritating to the skin. Furthermore, it is not so injurious to instruments, it is less toxic, and penetrates wound recesses more readily.

Biniodide can be obtained in the form of "soloids" coloured with eosine. One "soloid" in a pint of water makes a solution of 1 in 1,000. A spirituous solution of biniodide is largely used as a skin disinfectant. Two soloids are dissolved in 5 fluid ounces of distilled water, and the solution added to 15 fluid ounces of methylated spirit or duty-free spirit; the resulting solution contains approximately 70 per cent. alcohol.

Solutions of biniodide in the strength of 1 in 500 spirit are used mainly for the purpose of disinfection of the skin and hands and by some surgeons for the preservation of ligature materials.

Alcohol, or rectified spirit (90 per cent.), is largely employed in surgery at the present day, and is regarded as a cleansing agent and an antiseptic of the highest value. In the pure state it has little, if any, antiseptic value, but when mixed with water until the proportion of spirit reaches 70 per cent. it assumes a high degree of bactericidal power. It also has a useful physical action: it hardens the superficial epidermis, and thus diminishes the likelihood of organisms working loose from the deeper parts of the skin during the operation.

Methylated Spirit is a mixture composed of ninety parts rectified spirit (90 per cent. alcohol) with ten parts of wood spirit. In addition there is added a small amount of mineral naphtha, or petroleum oil, which causes watery solutions of methylated spirit to assume a turbid appearance. Although this is objectionable when solutions are

used for surgical purposes, yet their value for disinfecting purposes is not diminished thereby. What is known as duty-free methylated spirit is devoid of petroleum oil. It is equally efficient as 90 per cent. alcohol, and can be obtained at a much lower cost.

Formalin as supplied commercially is a solution containing 40 per cent. formic aldehyde gas dissolved in water. In its concentrated form formalin is a powerful caustic and hardening agent; in weak solutions (1 to 2 per cent.) it is antiseptic. As the gas is very volatile, watery solutions rapidly lose their strength if exposed to the air. The fumes of the gas are very pungent and highly irritating to the mucous membrane of the nose and eyes.

Iodine as an antiseptic agent possesses a very high value. In solutions of 1 drachm of the tincture to a pint of water it is useful for irrigating infected wounds and suppurating cavities. It does not exert an irritating or injurious influence upon the tissues, but seems to act beneficially by promoting increased vascularity and a higher degree of tissue activity. In this way it possesses a valuable additional power to that of an antiseptic.

Tincture of iodine has come very generally into use as an antiseptic in the disinfection of the skin. In the case of recent wounds it has been found that the application of the tincture to the surrounding integument is capable of effecting a very satisfactory degree of disinfection without any preliminary cleansing with soap and water. When used in emergency wounds it is better not to make any attempt to cleanse the skin first with soap and water, but to rely entirely on the tincture as its action is much more effective if the epidermis has not been previously softened by the water.

In the preparation of the patient's skin for operation the usual procedure is to cleanse the area concerned with soap and hot water, followed by ether and alcohol, on the night preceding. A dry sterile dressing is then applied. This is removed next morning, and the entire area is painted over with tincture of iodine and another dry sterilised dressing applied. Just before the operation, when the patient has been anæsthetised, the dressing is removed and the skin painted a second time with the tincture.

Some surgeons consider the above preliminary disinfection unnecessary. The skin is merely treated by the ordinary rules of cleanliness, and the only further preparation consists in the application of the tincture of iodine immediately before the commencement of the operation. For rough cutaneous areas, where disinfection may be difficult, the liquor iodi (B.P.) may be substituted for the tincture with advantage.

Iodine is extensively employed at the present day in the preparation of catgut (p. 9).

Iodoform is met with as shining yellow hexagonal crystals with a penetrating disagreeable odour or as a fine powder. It is but slightly soluble in water, but dissolves rapidly in ether (1 part in 7) and in chloroform (1 part in 14). For many years iodoform has been extensively employed in surgery on account of its antiseptic properties. Its action in this respect, however, is rather as an inhibitory agent than a germicide. It is incapable of destroying pus organisms, but prevents the formation of toxins in wounds of an infected character. The use of iodoform is attended by certain objections: it has a very unpleasant odour and it is highly toxic, being readily absorbed from wounds and cavities.

Various views have been held as to the way in which iodoform exerts its antiseptic

powers. It is not due to free iodine resulting from chemical decomposition of the iodoform, but apparently to the setting free of di-iodoacetylene, which possesses decided germicidal powers. The chemical changes on which its development depends occur when iodoform is introduced into the joints or cavities or deep wounds from which oxygen is excluded.

In addition to its antiseptic properties, iodoform is a deodoriser and anti-putrefactive agent. Locally it possesses a certain amount of anæsthetic power when applied to the skin, but its continued action is liable to set up irritation and dermatitis with a vesicular eruption.

In its crystalline or powdered state iodoform is sometimes applied to lacerated wounds with decomposing contents.

Gauze impregnated with iodoform is largely used as packing for mucous cavities (rectum, vagina, uterus) and suppurating wounds. As a means of arresting oozing of blood it is undoubtedly of value in the form of tamponnade, but as a drain either for blood or pus it is not of much use. When the gauze becomes soaked with discharge it actually prevents drainage, and acts as a plug, preventing the discharge escaping.

In the form of an emulsion (iodoform, 1 part; glycerine, 10 parts) iodoform is useful when introduced into tuberculous joint cavities or in certain forms of chronic abscess. The greater part of the abscess contents is first allowed to escape through a small incision, and this is closed as soon as the emulsion has been introduced. It would appear that in such cavities the granulation tissue brings about decomposition of the iodoform and the formation of di-iodoacetylene, which is powerfully antiseptic.

Kocher's iodoform and bismuth paste consists of subnitrate of bismuth and iodoform in the proportion of 2 to 1 suspended in a solution of corrosive sublimate, 1 in 1,000. It is a useful application to wounds after certain operative procedures.

Hydrogen Peroxide as obtained commercially consists of a solution of hydrogen dioxide in water, and yields on decomposition 10 volumes per cent. of oxygen gas. It has an undoubted germicidal power, and is of considerable value in the treatment of abscess cavities and wounds with decomposing contents. In the presence of blood, pus, or tissue debris, oxygen is set free, and a rapid effervescence takes place, with the development of a quantity of froth. When the peroxide solution is introduced into a cavity containing decomposing blood clot, pus, or necrotic tissue it rapidly penetrates into all recesses, with the result that as effervescence proceeds the clot or necrotic tissue is broken up into fragments and carried away in the outgoing current. Irrigation of the bladder with peroxide is of great value after prostatectomy for the removal of clots or purulent discharges, the solution flowing in along a soft rubber catheter and escaping by the suprapubic drainage tube. As a mouth wash when the gums are in an offensive state it is excellent. Swabs of absorbent cotton soaked with peroxide solution (1 part peroxide in 2 of water) are rubbed over the teeth and gums twice daily for a few days before operation, and effect a most remarkable improvement.

Boric Acid is a mild, unirritating antiseptic, but it has little power as a germicide. In solution it is of use as an irrigating fluid for abscess cavities, the mucous membrane of the bladder, rectum, and conjunctiva, etc. Lint impregnated with boric acid moistened with hot, sterilised water is highly beneficial as a dressing for septic sores or infected wounds. A double layer of lint is applied directly to the surface, and over it a piece of waterproof tissue and a pad of absorbent wool.

Sterilised Normal Saline Solution is made by adding a drachm of common table salt

to a pint of water. The amount of the salt in solution is equivalent to that in blood serum, viz., 0·6 per cent., and accordingly such a solution is termed "isotonic." It is only indirectly antiseptic, and is used for the simple mechanical irrigation of mucous membranes, fresh wounds, and serous surfaces. It is mild and soothing and non-toxic. It does not produce any irritation of tissues in aseptic wounds. In septic cases it helps to increase the vitality and therefore the resisting power of the tissues already weakened by pathogenic organisms. It is useful for infusion purposes, and in recent times its enormous value when introduced into the bowel in cases of peritonitis has been fully recognised.

PHYSICAL STERILISATION.—This form of sterilisation is effected by heat and has a very wide range of applicability. It may be carried out by the agency of boiling water or steam.

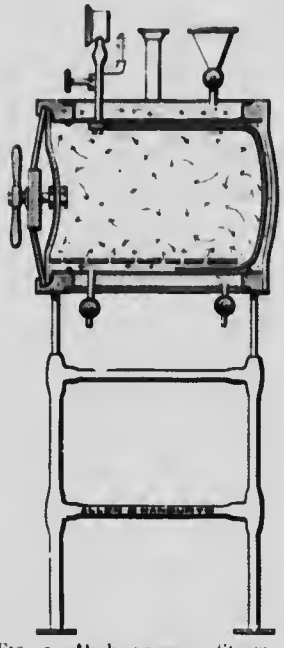

Fig. 1.—High pressure Steam Steriliser. Sectional view.

Boiling Water destroys all pyogenic organisms with absolute certainty in from five to ten minutes; it also destroys their spores. Sterilisation by boiling is especially of use for instruments, ligatures, and various forms of surgical appliances.

In sterilising instruments some carbonate of soda (1 per cent.) is added to the water. Before the instruments are introduced into the steriliser they should be thoroughly cleansed by mechanical means, and the water should have reached the boiling point. The soda prevents rusting of metal instruments, and it is useful also in removing greasy matter. Sharp instruments (knives, needles, etc.) should be protected during boiling.

It is not advisable to add soda to the water employed for the sterilisation of rubber materials (gloves, tubing, etc.); they are boiled in plain water and then placed in sublimate or biniodide solution.

In emergencies, sheets, towels, etc., for surrounding the area of operation, also trays for holding the instruments, may be rapidly sterilised by boiling. Usually, however, these are sterilised by means of steam.

If a special sterilising apparatus is not available, the instruments may be enclosed in a bag or towel and immersed in a vessel of boiling water. All bowls, receptacles, etc., should be boiled before use.

Towels, swabs, sheets, etc., are sterilised in an autoclave containing steam at high pressure for forty to sixty minutes. They should be used as soon afterwards as possible. If not used within a couple of days, the process of sterilisation must be repeated.

High Pressure Sterilisers.—By high pressure is meant from 10 to 15 lbs. of steam to the square inch at 240° F. It is more penetrating and more germicidal than steam at low pressure.

The ordinary high pressure steriliser (Fig. 1) consists of a cylindrical chamber surrounded by a steam jacket, and has attached to it an arrangement for creating a vacuum when required.

The water in the outer cylinder is heated by gas or steam. The steam jacket is half filled with water, and the steam generated is under a pressure of from 10 to 20 lbs. at a temperature of from 230 to 260 F.

The air in the sterilising chamber is exhausted by a vacuum apparatus, and the steam is turned on and allowed to circulate freely from fifteen to thirty minutes, according to the density of the objects exposed, and it is then turned off. The residual steam in the sterilising chamber is removed by a vacuum, and the materials are dried by the heat generated in the jacket. This drying process requires from ten to twenty minutes. By turning a valve filtered air is admitted into the inner cylinder, relieving the vacuum, and the materials are removed dry and sterile.

LIGATURES AND SUTURES.—A great variety of materials has been employed from time to time for ligatures and wound sutures, but many have fallen into disuse. They are broadly divided into two groups, the absorbable and the non-absorbable. Among the former are included catgut and tendon ligatures; the latter embrace silk and allied materials, metallic sutures of silver, aluminium-bronze, and iron wire, silkworm gut, and horsehair.

CATGUT.—When properly prepared this suture material consists almost entirely of the submucous coat of the intestine of the sheep, which, having been cut in suitable lengths and rolled in different sizes, can be obtained commercially in the dry state. Considering its source, it is necessary to submit catgut to a thorough process of sterilisation before employing it for surgical purposes. A great many processes have been recommended, but only those which appear efficient and at the same time simple in detail will be mentioned.

Preparation of Catgut by the Iodine Method (Claudius). The dry catgut in small hanks or suitably rolled on glass reels or slides is immersed in a 1 per cent. solution of iodine and potassium iodide in water and allowed to remain in it for at least eight days (iodine, 1 drachm; potassium iodide, 1 drachm; water, 22½ fluid ounces). It is then ready for immediate use, but before introducing it into the tissues it is advisable to wash away the excess of iodine in normal saline solution. Iodine catgut may be preserved for months in the solution in which it has been prepared, or, if it is desired to keep it for a considerable period, it is better to preserve it in a solution consisting of equal parts of spirit and the watery iodine solution. If the gut is kept in the watery iodine solution, the latter should be changed each month, otherwise the gut will not keep, as the iodine is volatile, and the fibres of the gut undergo disintegration in the water.

Preparation by the Formalin Method (Hofmeister). The main advantage of this method of preparation of catgut is that when the latter has been steeped in a solution of formalin for some time it is found to have undergone some profound chemical change, as the result of which it can withstand boiling for some minutes and is less rapidly absorbed. Consequently it may be depended on to remain in the tissues and retain its tensile efficiency when employed in the form of deep sutures for a longer period than catgut prepared by the iodine method.

The mode of preparation is as follows: The catgut is wound with moderate tightness on cylindrical pieces of wood, glass slides, or metal frames. These are immersed in a solution of formalin—2 per cent. for small sizes, 4 per cent. for sizes above No. 2—and allowed to remain in it for a period varying from twelve to twenty-four hours, depending upon the thickness of the gut. The formalin is washed away in a stream of cold water for twenty-four hours. The gut is next boiled in water for ten minutes

for the finer sizes, for fifteen to twenty minutes if the sizes are large, *i.e.*, over No. 2. The gut is finally placed in a preserving solution, from which it may be used directly when required. A spirituous solution of biniodide containing from 5 to 10 per cent. of sterile glycerine is very suitable for the preservation of catgut. It is prepared as follows (Pearson): One soloid is dissolved in 4 fluid ounces of warm distilled water; 1 fluid ounce of sterilised glycerine is added, and 5 fluid ounces of alcohol or methylated spirit. It may be preserved also in a mixture consisting of corrosive sublimate, 1 per cent.; glycerine, 5 per cent.; alcohol, up to 100 per cent.

Chromicised Catgut is frequently employed for deep sutures as it is slowly absorbed and is capable of lasting from four to six weeks. The usual method of preparation is as follows: The suture material, after having been freed from fat by being washed in ether, is treated in a bath of a 4 per cent. aqueous solution of chromic acid. After remaining in this bath for twenty-four hours it should be dried in a hot air oven.

Catgut as a Suture Material.—The absorbability of catgut is a property which renders it particularly suitable for employment in the form of buried sutures, more especially if the conditions are such that absolute asepsis cannot be assured or in wounds already infected. Should infective processes develop, the buried sutures or ligatures of catgut will become dissolved *in situ* and lead to no further trouble If silk or such like material has been employed, the sutures or ligatures, being non-absorbable, must loosen and become completely detached and removed or extruded along the sinus tracks before healing can take place. Buried silk may be responsible for suppurating sinuses persisting for many months.

The time required for the absorption of catgut varies, depending upon its thickness and method of preparation.

No. 00, No. 000, or No. 000000 iodine catgut is suitable for ligaturing small vessels or for suturing wounds such as that following circumcision. The finer ligatures last for five or six days, No. 2 for ten to fourteen days, No. 3 and No. 4 up to twenty-one days or possibly longer. Formalin catgut resists absorption longer than that prepared by the iodine method, and consequently will be found useful as a suture material for abdominal wounds. The same remark applies to chromicised catgut, which when employed for buried sutures retains its efficiency for a period of four to six weeks.

SILK, LINEN THREAD, AND PAGENSTECHER'S THREAD.—These possess great value as ligature and suture materials, and can be thoroughly sterilised by boiling or by steam. Repeated boiling, however diminishes the strength of silk. Sterilisation by steam under pressure has not the same disadvantage.

Silk possesses great strength, and is very useful for ligaturing stout pedicles or large blood vessels. It readily absorbs fluids by its capillarity, and in infected wounds it is quickly invaded by micro-organisms; for this reason it is likely to become a source of trouble.

Silk in aseptic wounds becomes encapsulated, and as a rule causes no further trouble. It is to be noted, however, that silk and other non-absorbable materials may, at periods quite remote from the time of their application, be responsible for inflammatory trouble resulting in abscess or obstinate sinus formation.

Turner's patent plaited suture silk is the variety usually employed for surgical purposes. It can be procured in a large number of sizes, from No. 1 up to No. 14. Sizes below No. 1 are marked No. 0 and No. 00.

Silk, linen thread, and Pagenstecher thread are readily sterilised by boiling in

water for twenty minutes or half an hour. They may be preserved until required for use in an antiseptic solution of biniodide or corrosive, 1 in 500, to which a 5 per cent. proportion of glycerine has been added, or in a 5 per cent. solution of carbolic acid. If these materials are boiled several times, they lose their tensile strength, and undergo marked deterioration. It is advisable therefore to prepare for each operation or each set of operations approximately as much ligature and suture material as will be required.

Although sterilisation of silk and materials of this kind may be effected by boiling alone, yet, according to Haegler, this is not sufficient, because it would appear that the surface of the silk may become infected with bacteria on the mere exposure to air or in manipulations incidental to its introduction into the wound, viz., threading, tying, or passing through the skin. Should such infection of silk occur, it may result in a superficial stitch abscess or in deep suppuration around a buried suture. It is better,therefore, to employ chemical as well as physical methods in silk sterilisation.

Sublimate Silk. Kocher's method for preparing silk is to treat it for twelve hours with ether and for the same period in alcohol to remove the fat. It is then boiled for ten minutes in a solution of corrosive sublimate, 1 in 1,000, and rolled upon sterilised glass spools, slides, or bobbins. It is again boiled in 1 in 1,000 corrosive sublimate immediately before use. A small amount of antiseptic remains in the silk; it is probably incapable of destroying organisms to any extent, but it inhibits their development.

Glass jars to contain sutures should be provided with closely fitting glass covers, and the reels are allowed to remain in these from day to day until used. One jar may contain various sizes of silk, another different sizes of catgut. Just before use the required materials from each jar may be picked up with sterilised forceps and placed in sterilised bowls, and the lengths as required cut off by an assistant wearing rubber gloves.

Pagenstecher thread is employed by some surgeons in preference to silk, especially in gastro-intestinal operations. It maintains a smooth exterior unless after repeated boiling, and it is stronger than the same size of silk.

We usually employ linen thread which is very strong, and admirably fulfils all the requirements of a non-absorbable suture material.

Silkworm Gut is perhaps the most valuable material we possess for skin sutures. It is very strong, with a perfectly smooth surface, does not absorb fluids, is unirritating to the tissues, and can readily be sterilised. It is obtained commercially in lengths of 10 to 14 inches, and the better qualities are graded in three sizes: strong, medium, and fine. It can be obtained dyed in different colours. Silkworm gut dyed black has the advantage of being readily recognised in a wound and more easily removed.

The gut is prepared for use by boiling in weak salt solution; boiling in soda injures it, and renders it brittle. It may be preserved for use in a solution of biniodide and spirit to which some glycerine has been added. Silkworm gut is employed exclusively as a suture material to be removed after its purpose has been effected

Horsehair is a useful suture material for adjusting wounds in the face and neck. Care should be taken to render it perfectly sterile before use.

SILVER WIRE AND ALUMINIUM-BRONZE WIRE. Wire as a suture material is used almost entirely for securing apposition of the fragments in cases of fractured bones. Silver wire was originally employed extensively for securing coaptation of wounds of the soft tissues, and at the present day it has probably no superior as a

suture material for approximating the flaps in the operation for cleft palate (p. 94). It is sometimes used as a subcuticular suture when it is desirable to reduce the resulting scar to a minimum.

Silver Filagree. Silver wire is prepared for use by a thorough scrubbing in soap and hot water; it is then boiled in 1 per cent. sodium carbonate solution for half an hour, or it may be heated in a spirit flame. The flame anneals the wire, and renders it less liable to break when twisted. Filagrees are readily prepared, and they are useful in promoting the consolidation of the wound in certain cases of abdominal hernia, more especially the incisional variety and large umbilical hernias in adults.

SPONGES, SWABS, ETC.—The use of sponges for the removal of blood from wounds in the course of operations and for various other purposes is a subject of considerable importance in surgical technique.

Marine sponges were alone employed for many years, and answered their purpose admirably; but, as with many other details in operative work, the use of these sponges has been gradually superseded by that of gauze with loose meshes. The sterilisation of marine sponges has been regarded as too uncertain and unreliable, although by many this is strongly denied. Gauze material, while largely inferior to the natural sponge as an absorbent and not so satisfactory to manipulate, is now employed almost exclusively by reason of the greater certainty with which it can be sterilised.

The ordinary gauze swab consists of butter muslin folded in a convenient form, all cut edges being turned in so that no loose threads may become detached and left in the wound. The gauze may be merely folded, but it is better that before sterilisation is carried out it should be folded and stitched. These swabs are mainly of use for sponging away blood from wounded surfaces. They are made in different sizes. For ordinary purposes 6 inches by 6 inches is very convenient.

Thick swabs or pads are useful both as absorbing media and for protective packing in the case of operations within the abdomen, or in large wounds elsewhere. It is often desirable to shut off the immediate site of the operation from the surrounding parts or to obtain better access by pushing aside the coils of intestine, appendix, gall bladder, kidney, etc., as the case may be. These pads, from their thickness, retain heat well; and if rinsed out of very hot saline solution, they protect large exposed wounds or protruded viscera in a very admirable way. A thick swab consists of a layer of absorbent wool surrounded by a single or double layer of gauze, or crumpled of gauze folded so as to make a sufficient bulk. They form a suitable dam or wall to prevent the spread of septic material or other pathological fluids into adjacent portions of the peritoneal cavity during operations within the abdomen. These large pads are very effective in preventing the intestines from invading the field of operation.

Under no condition should any swab be introduced within the abdomen unless it is provided with a piece of tape which hangs out of the wound and is secured by a pair of hæmostatic forceps. Small swabs soaked with blood may readily escape detection and are difficult to recognise within the abdominal cavity. Too great care therefore cannot be taken to prevent them from being overlooked and perhaps left behind.

A very convenient form of pad may be improvised by taking a square piece of gauze and a sufficient amount of absorbent wool to make when moderately compressed a bulk approximately the size of a tennis ball. Drawing together the four corners of the gauze converts it into a bag which is secured at its neck by a piece of thread.

Tetra Tissue is the name applied by a French manufacturing firm to a form of cotton fabric made by them. It is supplied in sheets, squares, bandages, surgical apparel, etc., and consists of a varying number of layers of loosely woven or medium texture material. It is very useful for protecting wound margins during the performance of certain operations. Large or medium squares may be employed in relays for maintaining the area surrounding the field of operation sterile.

DRAINAGE AND DRAINAGE MATERIALS. The accumulation of fluids, viz., blood, serum, or pus, in wounds or the cavities of the body may be attended by unpleasant, if not serious, consequences, and accordingly it is desirable that their removal should be brought about by suitable surgical measures. A collection of blood in a wound or cavity may act injuriously in two ways: it may be invaded by septic or putrefactive organisms and undergo decomposition, as the result of which the patient suffers from toxæmia, and suppuration develops in the wound, or, in the absence of infective changes, the accumulated blood keeps the tissues apart and retards healing. Blood collections may undoubtedly become absorbed, but the process takes time. It is needless to state in full the reasons why infective discharges should in all cases be conducted to the surface. Prompt drainage arrests toxic absorption, prevents further destruction of tissue and extension of the infective process.

Drainage may be effected in different ways, but the more usual consist of—(1) tubes of various kinds (metal, rubber, glass), or (2) materials which conduct fluids to the exterior by the action of capillarity: these include gauze drains of various kinds, drains of catgut, etc.; (3) combined gauze and tubular drainage.

Tubular Drainage.—The forms of drainage tubes at present employed are those consisting of rubber or glass. Metal tubes have no special advantage over these, and are seldom employed. Tubes of decalcified bone, at one time loudly extolled, have fallen into disuse, and need no further mention.

Rubber tubing is very useful for drainage purposes. It can be obtained in a great variety of sizes and of varying consistency. Thin rubber tubing is not good as it collapses too readily. Rubber tubes can be cut to any required length, perforated with holes as desired, or split longitudinally or spirally, and they are readily sterilised by boiling. The main disadvantage of rubber tubing is its yielding character, whereby it is liable to be compressed, and its action as a drain partially or completely frustrated. Aluminium drains are useful in situations where pressure by muscular contraction might close a rubber tube, *i.e.*, for suprapubic drainage of the bladder. In selecting rubber tubing for drainage purposes it is advisable to employ a tube of relatively large size in preference to one of narrower bore; on the whole there is a tendency to use tubes that are too small.

Rubber drainage tubes may be improvised from lengths of tubing of the required dimensions, but the difficulty with these is to prevent them from slipping into the cavity or escaping from it completely. Such form of tube may be secured by a suture of catgut or silkworm gut. A suture of fine catgut is sometimes passed through the deeper part of the tube where it lies in the tissues, anchoring it securely in position for a week or ten days, by which time the gut is absorbed and the tube becomes free. This method is frequently employed in the drainage of the gall bladder, or a suture of silkworm gut may secure the tube to the skin for such time as may be necessary. A safety pin passed through the tube close to its outer orifice may be so adjusted as to lie across the wound and prevent the tube from receding. Rubber tubes provided with flanges are very convenient for the drainage of cavities such as the pleura, the peritoneum, or the urinary bladder.

Glass Drainage Tubes have acquired a well-deserved popularity: they can be obtained in sizes to suit all varieties of wounds, they are easily sterilised, and may be used over and over again; but they cannot, as in the case of rubber, be shortened or trimmed to suit individual requirements. This is but a trivial objection, after all, and detracts but little from their general usefulness. They are very applicable to drainage of wound cavities in the neck following thyroidectomy, excision of large masses of glands, wound cavities left after excision of joints, etc.

Gauze Drainage has been extensively employed for many years. Owing to its capacity for absorbing fluids, it was supposed that gauze by the action of capillarity would withdraw fluids from cavities or the depths of wounds and conduct them to the dressings overlying the wound. Various forms of medicated gauze, particularly the iodoform variety, have been utilised; but increasing experience has shown that gauze drains are not satisfactory for the removal of blood or pus. Serous or watery fluids do drain away fairly well, but all gauze drains become inefficient when sodden with pus and their meshes filled and entangled with blood clots. They rather hinder than promote drainage.

The following are the chief methods of carrying out drainage by gauze: (1) One or more strips of gauze, preferably with selvedge margins, are introduced into the wound, and their free ends are secured externally. The cut edges of gauze should not be brought into contact with the tissues, as loose threads are apt to become detached. (2) The Mickulicz tampon. This consists of a bag of plain sterilised gauze, with a piece of tape attached to its interior at its deepest part and extending out beyond the mouth. To introduce the bag, a long pair of forceps passed into its interior seizes it at the fundus, and guides it into position. The forceps are then withdrawn. The interior of the bag is now filled with strips of gauze to the required extent. When the tampon has served its purpose the individual strips are removed from its interior; and, lastly, the bag itself, having been loosened by the liquefaction of the surrounding exudate, is readily removed by drawing upon the tape. For reasons above stated, the Mickulicz tampon is not efficient and therefore not to be recommended as a drain. It may, however, by exerting adequate compression, succeed in arresting hæmorrhage from extensive oozing surfaces or in segregating a septic area within the abdomen from the adjoining non-infected areas.

Mixed Tubular and Gauze Drainage is carried out by means of tubes containing strips of gauze in their interior or by an arrangement of rubber and gauze known as the cigarette drain.

The Dressed Tube. A tube of required length and calibre is taken and either split in a vertical direction from one extremity to the other or cut in a spiral direction. A piece of gauze rolled in the form of a wick is placed in its interior, and emerges for some distance beyond the tube at each end. The split tube should be fairly large, up to $\frac{5}{8}$ inch, and the gauze wick should fit it loosely. In introducing the drain the protruding gauze is placed at the bottom of the cavity or in the immediate vicinity of some sutured viscus or duct from which it is feared that leakage may occur. The other free end of the tube projects for a short distance beyond the level of the skin wound. A suture of fine catgut anchors the tube in position.

The Cigarette Drain is made by taking a square piece of sterilised rubber sheeting,—dentist's rubber dam—of the required size and laying over it a fourfold layer of sterile gauze of the same dimensions. The rubber and gauze layers are rolled up together; and when this has been done, a small strip of the gauze may be

cut away, so as to allow the free rubber margin to come into immediate contact with the rubber roll and be secured to it by a little chloroform or a few points of suture. Such a drain, arranged in the form of a cylinder, presents on cross-section alternating concentric circular layers of gauze and rubber, the circles diminishing gradually in diameter from without inwards.

Gauze, when employed in the drainage of the peritoneal cavity, should always be enclosed either in a split rubber tube or in rubber protective tissue. Plain gauze tends to adhere too firmly to peritoneal surfaces, and its rather forcible withdrawal will be accompanied by discomfort or actual pain to the patient.

CONSIDERATIONS IN OPERATIVE TECHNIQUE.

THE OPERATOR. Aseptic Precautionary Measures. A surgeon who is frequently called upon to perform operations of an aseptic nature must needs take every possible precaution against contamination of his hands by infected matter. He should never touch infected wounds or sores, conduct a rectal or vaginal examination, or examine the cavity of the mouth unless his hand or finger is protected by a rubber glove or finger cot. The importance of these precautionary measures is self-evident. Taken collectively, they come under the heading of what Professor Kocher terms "abstinence from infection."

Hand Disinfection. Most, if not all, of the objects that come into direct contact with the wounds made by the surgeon can be rendered perfectly sterile, *i.e.*, clothing, towels, sponges, ligatures, sutures, instruments. The real source of infection of a wound deliberately made by a careful surgeon whose materials are properly prepared and who uses them carefully is to be found in most circumstances either in the skin of the patient or in the hands of those directly concerned in the operation.

It is assumed that every operating surgeon ensures the general cleanliness of his body by one or more baths daily. The hands require to be more than what is regarded as socially clean or free from visible dirt: they must undergo a careful process of disinfection. No method for ensuring absolute sterilisation of the human skin has yet been devised, but nevertheless very satisfactory results can be obtained by the more approved methods of disinfection at present employed.

The uncertainty attending disinfection of the skin depends upon the fact that the means applicable for promoting it are those of a mechanical and chemical nature. Even after the most thorough mechanical cleansing by hot water, soap, and the nail-brush, the skin of the hands remains infected, as organisms remain hidden away in the natural epidermal grooves and deeper layers of the epidermis, beneath the free margins of the nails and the nail folds, in cracks and fissures of the epidermis, and in the ducts of the sebaceous and sweat glands. In employing antiseptic or chemical disinfectants for the hands, care must be taken that the solutions are not too concentrated, and that the particular antiseptics employed are not unduly irritating, otherwise the skin may be greatly irritated, and the epidermis may become very rough and cracked. A rough epidermis is altogether to be avoided if one's hands are to attain any satisfactory degree of disinfection; indeed, it is doubtful if proper disinfection of the hands can be brought about unless they are maintained in good cosmetic condition.

The following method for cleansing and disinfecting the skin of the hands is that which we habitually employ:

The hands and forearms are washed with soap or soap spirit in warm running

water, and in the cleansing process the nail-brush is freely requisitioned. Care is devoted to the spaces beneath the nails and the nail folds. The same brush should not be used throughout the process, as it soon becomes infected, but there should be two or three brushes available. These, having previously been sterilised by boiling, are preserved for use in a solution of cyllin or biniodide. The cleansing should be carried out in a methodical manner, so that no part of the skin escapes a thorough scrubbing, and the time occupied in the process should not be less than five minutes. Coarse nail-brushes should be avoided, as they tend to render the epidermis rough; brushes with bristles of medium strength are to be preferred.

The skin of the hands and forearms is next scrubbed with swabs soaked in alcohol of 70 per cent. strength, the same care being taken of the nails and to ensure that every portion of skin is dealt with thoroughly. The alcohol acts as a disinfectant, and in addition it hardens and dehydrates the epidermis. The skin becomes shrivelled and the natural furrows become narrowed as a result of the contraction changes in the epidermis.

The hands and forearms are next rubbed over with a solution of biniodide of mercury in spirit (1 in 1,000) or in a solution of corrosive sublimate of the same strength.

Finally, the hands and forearms are rinsed in hot sterilised saline solution and dried in a sterilised towel.

The difficulty and uncertainty in procuring thorough disinfection are due in many cases to previous handling of septic matter and the presence of a rough or cracked epidermis brought about by the use of strong antiseptics.

When the hands have been disinfected as just described, they must on no account during the moments preceding the operation touch anything except what has been already sterilised.

An additional precaution sometimes advisable, especially if the ends of the fingers and nails are not in good cosmetic condition, is to apply some tincture of iodine or compound tincture of benzoin to each digit in turn, allowing it to dry.

RUBBER GLOVES.—The use of rubber gloves in operative surgery is now well established, and their great value fully recognised. The gloves may be sterilised by boiling or by steam. The latter method is probably better as the gloves can be put on dry, the hands having been well dusted with sterilised talc powder. This method has the advantage that no collections of fluid remain within the glove to macerate the epidermis and collect micro-organisms which may escape and infect the wound if the glove is pricked. The danger of infection from this source, however, is probably not great unless the previous disinfection of the hands has been performed in an utterly careless fashion.

A damaged glove should be instantly replaced by another, or in case of a small finger prick an extra glove finger may be drawn over the seat of perforation.

Gloves of cotton were introduced by Mickulicz, but being in no way comparable to rubber gloves as regards the protective security which they afford, they have fallen completely into disuse. The greatest value of rubber gloves depends upon the advantages attending their use between operations in conducting rectal and vaginal examinations, dressing infected wounds, etc. Rubber gloves are even more strongly indicated in septic than in aseptic cases, as it is a serious error on the part of a surgeon to allow his hands to be contaminated by infective matter if it can possibly be prevented. Such contamination renders the subsequent disinfection a matter of great difficulty, indeed, it is doubtful if an efficient degree of hand disinfection can be

brought about if the skin surface has been recently in contact with purulent discharges of an acute septic kind.

The disadvantages attending the slipping surfaces of rubber gloves in abdominal work may be overcome by using sterile muslin. A coil of intestine, the gall bladder, etc., may be securely held if grasped by a folded layer of muslin and not directly by the gloved hand. By some surgeons the difficulty is overcome by wearing cotton gloves in addition to those of rubber.

Operating Attire.—As it is important that everything in the near vicinity of the operation wound should be surgically clean, the external investment of the operator and his assistants should be thoroughly sterilised. The head is protected by a cap of linen or some equally suitable material. It covers the forehead, absorbs perspiration, and prevents particles of dust and loose hair from the head falling into the wound. In the case of nurses it is particularly desirable that the head should be completely covered.

The operating coat should be as long as possible and button at the back. It should reach down to the middle of the legs, and the collar should extend well up on the neck. The sleeves are detachable. A long, light mackintosh apron is worn beneath the coat. In the special pattern of coat which we employ there are two short sleeves provided with running strings of tape. When the coat is put on these short sleeves are made to constrict the arm just above the elbow, so as to cover the rolled-up shirt or vest sleeve. Immediately before the operation detachable sleeves are drawn on and buttoned to the coat sleeves above the elbow and again buttoned at the wrist. Finally, rubber gloves, dry sterilised, are drawn over the hands and the sleeves where they cover the wrists. Complete operating suits may also be worn. This is an ideal arrangement, and has much to commend it. White canvas shoes, white drill trousers, sterilised or freshly washed, and a sterilised white drill jacket complete the equipment. Not alone does such an outfit conform with one's aseptic ideals, but it adds greatly to the physical comfort of the operator when working in the warm atmosphere of an operating theatre.

MASKS.—These are worn when operating by many surgeons. They cover the nostrils and the mouth, and are intended mainly to prevent particles of saliva from being projected from the mouth into the wound in talking. That infection may reach a wound in this way there cannot be the least doubt, and the numerous experiments which have been conducted with a view to proving the possibilities of micro-organisms being projected from the mouth in the course of speaking need not be detailed here. Masks certainly help to diminish the chances of wound infection from this source. At the same time it is probable that the wearing of masks during the performance of operations may be dispensed with if the operator is careful not to speak or converse while his mouth is directed towards the wound or to breathe with open mouth, and if he takes due care that his teeth are quite free from decay, and his mouth in a thoroughly clean condition. For the reasons just given it is not advisable that surgeons suffering from nasal or bronchial catarrh should undertake operations unless provided with a suitable mask. Surgeons with beards also had better wear masks.

THE PATIENT.—General Examination.—No matter how insignificant the proposed operative procedure may be, a thorough preliminary examination of the patient is to be recommended in all cases. The condition of the heart, lungs, and kidneys especially should be noted. Such pathological conditions as valvular disease of the heart,

chronic bronchitis and emphysema of the lungs, chronic interstitial nephritis, diabetes, etc., not to mention many other conditions, might have a very serious bearing in view of operative intervention, or might possibly offer a strong contraindication to its performance. An examination of the blood, too, is advisable in order to determine, for example, its richness in hæmoglobin and the relative proportions of its corpuscular elements. A leucocytic count may shed valuable light upon the capacity of the patient to withstand an operation of magnitude.

Before Operation.—As a rule it is advisable that the patient should be kept at rest for twenty-four hours or more before the operation, so as to bring the heart into a quiet state and calm the circulation and allow the various preparatory measures recommended below to be carried out efficiently.

General Cleansing and Skin Disinfection.—The general skin surface, including the hairy scalp, is subjected to a thorough mechanical cleansing with soap and warm water. In the case of the poorer classes and in general hospitals this mechanical cleansing by warm baths is particularly necessary, and the process may have to be repeated more than once before a satisfactory result can be achieved.

The disinfection of the skin in the area of the operation and its vicinity must be done with thoroughness. The area included in the process should be a wide one. When possible the process is commenced one or two days before the operation. The skin is well washed with soap or soap spirit and hot water; hairs too, if present, are removed. Especial attention should be paid to the umbilicus, the axilla, the groin, and the perineum when one of these regions lies close to the site of operation. After this washing process the skin is dried with a sterile towel, and ether, followed by alcohol (70 per cent.), is applied to the entire area. Finally, a compress of biniodide, 1 in 2,000, is laid over the surface and retained by a suitable sterilised dressing. On the morning of the operation this dressing is removed, and the entire surface is painted over with tincture of iodine, after which a sterile dressing is applied. After the patient has been anæsthetised this preparatory dressing is removed and the skin once more painted with tincture of iodine.

If the skin is rough and cracked, its thorough disinfection is not readily effected. In such cases the application of the liquor iodi (B.P.) is highly advantageous. Some patients' skins will not stand a vigorous preparatory treatment as it may cause an irritative dermatitis and completely defeat the purpose for which it was intended.

The Mouth.—The state of the patient's mouth is a matter of pressing importance as it is very often in a highly septic condition. All decaying stumps and loose teeth demand removal, deposits of tartar are scaled away, and the teeth generally are made as clean as possible by means of water and soap. Swabbing the gums and teeth twice or three times daily with equal parts of peroxide of hydrogen solution and water effects a very excellent degree of cleansing. Antiseptic mouth-washes are to be employed in addition. For this purpose carbolic acid (1 in 80) cyllin (1 in 100), or listerine, will be found useful.

Feeding.—Before operations of moderate severity, and excluding those in connection with the intestinal tract, the patient may have ordinary diet up to the day before the operation. Food of a light and easily digested nature should then be given, such as soups, fish, and milky foods, as these are readily assimilated and do not leave a bulky residue in the bowels.

When the operation concerns some of the abdominal viscera, especially the stomach

and intestines, suitable feeding may be administered for some days beforehand. Dr. Harvey Cushing, of Baltimore, has drawn attention to the value of sterilisation of the food before operations on the gastro-intestinal tract.

In the case of an adult no food of any kind should be taken within six or eight hours of the time for the administration of the anæsthetic, excepting a few tablespoonfuls of coffee, a cup of tea, or hot broth, given in the early morning. Stimulants, if necessary, are administered through the rectum. Children, however, will not bear such prolonged starving; four hours' fasting at the most is sufficient for a child under six years of age.

The Bowels.—A thorough evacuation of the bowels before operation is absolutely essential, but at the same time purgation of the patient must be carried out with some degree of discrimination. A practice altogether reprehensible, unless unavoidable for certain reasons, is to postpone the administration of purgative medicine until the evening before the operation. The objections are that the medicine, acting during the night, disturbs the rest of the patient, and is calculated to upset and weaken an individual of nervous temperament. Furthermore, if the operation is directed towards some rectal condition, it may happen that during the procedure the wound is flooded with liquid fæces. It is much better to arrange that after the process of purgation has been carried out a sufficient interval be allowed to enable the bowels to assume a quiescent state. As a rule no purgative medicine should be given by the mouth later than thirty-six hours before operation. A good routine practice is to administer a dose of liquorice powder or a mercurial pill on the last night but one preceding the operation and a saline next morning; this is followed by an enema, and, if necessary, another enema may be administered on the morning of the operation, but it had better be dispensed with if the operation is to be performed upon the rectum, lest some of the enema should be retained and only come away during the course of the operation.

In cases of obstinate constipation it is well to commence with aperients and enemata some days beforehand, so as to ensure a thorough emptying of the bowel.

In operations upon the rectum and large bowel especially the intestinal contents should have been well cleared away two or three days beforehand, peristalsis quietened, and the septicity of the contents reduced as much as possible.

Antiseptics by the mouth are possibly beneficial in allaying intestinal fermentation and putrefaction. Those which appear most efficient are salol and salicylate of bismuth. We usually employ the latter before operating upon the colon and rectum.

Protection from Cold.—The means employed for preventing loss of heat from the patient's skin during the operation should be adequate. Chilling of the surface of the body increases shock and favours pulmonary complications, especially bronchitis. In public institutions and well-equipped private hospitals the operating theatres are suitably heated to 70° or 75° F. before the operation commences. The patient's lower limbs are encased in thick woollen stockings, reaching up to the groin, and the trunk is covered by warm blankets, with the exception of the part concerned in the operation. Rubber or waterproof sheeting is placed over the blankets to prevent these being soaked with fluids. Sterilised sheets and towels are placed over all. Protecting towels are arranged around the parts concerned in the operation, and are frequently changed as they become soiled.

The Resisting Power of the Patient.—Attempts have been made to increase the

resisting power of the patient by the injection of antitoxins or suitably prepared vaccines which help to raise the opsonic index.

THE OPERATION.—Protective Arrangements against Infection.—The making of wounds with instruments and hands free from living organisms and care not to allow any object not completely sterilised to come into contact with the wound surface constitute what is meant by aseptic surgery.

Disinfectants and antiseptics are employed in the preparation of instruments and surgical materials, by the surgeon and his assistants, and if such preparation has been thoroughly carried out, the wound may be made and treated until healing has occurred without the use at any moment after the beginning of the operation of antiseptics of any kind.

The means for ensuring sterilisation and disinfection in surgery have been already dealt with. In the course of a properly conducted aseptic operation nothing should be employed in the operation and nothing exposed in the vicinity of the wound unless its sterilisation is beyond doubt. All instruments, ligatures and appliances, bowls, basins and trays are suitably arranged and ready for immediate use. The surgeon, his assistants, and the nurses engaged in the theatre are provided with sterilised coats, gowns, caps, etc., and all wear rubber gloves. The patient, with the exception of the face and the area of operation, is covered with sterilised sheets and towelling.

The patient's head and the anæsthetist may be shut out from the field of operation by a suitable screen.

Strangers and visitors admitted to witness operations are provided with clean coats, not necessarily sterilised, but they do not come into immediate contact with the operator or the operating table. It is a good arrangement whereby all visitors stand behind a barrier some little distance away so as not to hamper the operator or thwart his elaborate precautions against infection of the wound.

Arrangement of Instruments, Ligatures, etc.—A suitable arrangement of instruments and ligatures conduces to the smooth working of the operative details. They are entrusted to an assistant in whose training the operator has confidence. As far as possible instruments are arranged in groups in sterilised trays. They may be used in the dry state or out of a warm antiseptic solution, such as carbolic acid 1 in 80. Cutting instruments, scissors, scalpels, and needles are kept in one tray, hæmostatic and dissecting forceps, blunt needles, retractors, and blunt dissectors in another. Instruments for special operations on the gastro-intestinal or urinary tract, resections, etc., are placed in another. Ligature materials are kept at one side in jars and either taken from these immediately or transferred to sterilised glass or enamel trays just before use.

Sutures and ligatures are cut with a pair of scissors set aside for the purpose, and the cut pieces are kept in a separate dish. No other instruments employed in the operation should be allowed to enter the jar to cut the catgut from the reels. Sutures and ligatures must not be handled with naked fingers. Swabs, towels, sterilised sheets, etc., are entrusted to the theatre sister. Another nurse is available for the preparation and handling of saline or antiseptic solutions.

ANÆSTHETICS AND THEIR ADMINISTRATION.

There is no general anæsthetic universally indicated. Anæsthetics, like instruments, must be adapted to the individual and to the operation. Speaking generally, however, all operations can be performed under ether with greater safety than under

any other anæsthetic. If chloroform were abolished the advance of surgery would be hastened rather than retarded. Chloroform should not be employed if a bottle of ether and a handkerchief are available. We shall consider in this section the administration of ether by different methods, of hedonal and of chloroform, placing these in what we consider to be their order of safety.

ETHER.—For the routine operation we employ the gas-ether sequence administered by the Hewitt or Clover inhaler as follows: With the indicator at zero, about one fluid ounce of ether is poured into the inhaler. The anæsthetist blows through the central funnel to remove the smell of the vapour as much as possible. The gas-bag is moderately filled with nitrous oxide and attached to the inhaler. Having seen that all the parts are complete, and that there is no leakage, the inhaler is applied to the patient's face. If the face piece is too large, the chin is included, and air is not allowed to enter at the side of the nose. The patient is allowed to breathe pure air through the apparatus, and then the gas is turned on. This latter is expired into the air through the open rebreathing valve. When roughly half of the contents of the bag has been used, the rebreathing valve is closed, and the expired air is made to pass back into the gas-bag. The indicator on the inhaler is now moved slowly and steadily from zero towards 1. The speed is regulated by the breathing; any sudden intake of the breath is to be regarded as the signal of an approaching cough, and is due to the ether being turned on too rapidly. About one minute is occupied in reaching 2 on the indicator. The rate is now steadily increased, and "full" is reached in about thirty seconds more. The gas attachment can now be removed, and the rebreathing bag rapidly substituted.

The main points which deserve attention in the induction of anæsthesia are (1) absolute exclusion of air; (2) turning on the ether steadily, not in jerks; (3) beginning slowly and gradually increasing the rate.

In using gas as a preliminary it is not intended to induce gas anæsthesia, but rather to render the larynx more tolerant of ether. It is practically never necessary to use more than one bag full of gas. With the ordinary patient the colour should remain good during the whole period of induction, and the breathing become more perceptibly deeper after the half-way point on the inhaler is passed. With very vigorous or alcoholic individuals some degree of cyanosis is common; but if it be moderate, it is better not to admit air as it would result in the patient partially recovering from the anæsthetic. If, however, the cyanosis persist, the best course will be to pass on rapidly to "full," remove the rebreathing bag—not the inhaler—and allow the patient to breathe air through the ether till the colour improves. Coughing at the beginning of induction is an indication for slowness, towards the end for haste. If the patient struggle, his movements should be restrained by the assistants, but no pressure should be brought to bear on his chest, and access of air should be prevented. If touching the eyelashes does not make the patient close his eyes, the preliminaries of the operation may be begun. The pupil reacts to light at this stage. The anæsthetist need not attempt to induce the conjunctival or corneal reflex: the former is rendered unnecessary by the lid reflex, and the latter is only useful later in the operation and when one is in grave doubt as to the depth of the anæsthesia. It is better not to touch the eye if it can be avoided. If the patient be of a good colour and breathe well, if the lid reflex be absent and the light reflex present, the operation may be commenced. If rigidity persist at this stage, the rebreathing bag is removed for a few respirations. When the patient is obviously under the anæsthetic, but remains rigid, air is indicated. Frequently when the preparation has been faulty, and there is food in the stomach,

the induction is accompanied by congestion of the head and neck and coughing; it is then wise to allow the patient to vomit and then recommence the anæsthetic.

When anæsthesia is well established the jaw should be hooked forward and kept in that position by placing the fingers behind the ascending ramus.

The majority of patients do very well with the bag off and the indicator at full. In the case of weakly individuals and with the majority of women, the indicator may remain at the half-way or three-quarter-way point.

For further details the reader is referred to Hewitt's "Anæsthetics and their Administration."

OPEN ETHER. By this method ether is administered by allowing it to drop on to a Skinner's mask. With it the induction of anæsthesia takes longer, and more ether is consumed, but it gives the best results if skilfully carried out. The method is only a relatively open one, for with strong, vigorous individuals it will probably prove inefficient unless air is excluded to some extent. The mask, covered by several layers of muslin, is placed on the patient's face, and a long strip of muslin is wound round the edge of the mask in order to exclude air. Ether is then dropped on to the mask drop by drop, very slowly at first, then more rapidly. The dropping is carried on continuously, and not in an intermittent manner. As anæsthesia begins the respirations become deep. The course of the anæsthesia is essentially the same as that indicated above.

This method is specially indicated in children, in feeble individuals, and for operations on the neck, but it may be carried out in all cases if so desired.

INTRATRACHEAL INSUFFLATION OF ETHER.—The principle of this method is the introduction of a continuous current of warm, moist etherised air directly into the trachea by means of a catheter passed through the larynx. In America, where intratracheal insufflation is largely employed, many varieties of apparatus are available; in this country those of Crawford, of Dublin, and Kelly, of Liverpool, are both simple and efficient. It is impossible to describe the details of these here, but for fuller information reference should be made to the following articles: Elsberg, *Annals of Surgery*, July, 1910, and February, 1911; Robinson, "Surgery, Gynæcology, and Obstetrics," 1912; Crawford, *Medical Press and Circular*, May, 1913; Kelly, *British Medical Journal*, 1912.

This method is obviously unnecessary for short operations, but it is strongly indicated in operations on the head, neck, and spine (see "Craniotomy and Craniectomy," p. 35).

For operations in the region of the mouth it is specially useful, as the continual efferent stream of air escaping alongside the catheter prevents blood or septic matter from entering the larynx. Intratracheal etherisation is as yet the simplest means of preventing collapse of the lung when the pleura is opened; it therefore widens the scope of thoracic surgery.

We have used this method chiefly in operations on the neck, such as thyroidectomy and the removal of glands. There can be no respiratory embarrassment with this form of anæsthesia, seeing that at any time pure air or oxygen can be passed directly into the trachea, thus preventing over-etherisation and at the end of the anæsthesia removing the objectionable smell of the drug. We have had no post-anæsthetic vomiting in our series of cases.

Method of Administration.—The introduction of the catheter into the trachea requires some practice no matter what instrument is used. The majority of anæs-

thetists prefer to use Chevalier Jackson's direct laryngoscope, in order to pass the tube into the larynx under guidance of the eye; others, however, employ some kind of introducer. Cotton's introducer is a metal tube shaped somewhat like a prostatic catheter but more sharply curved; the lumen of the tube is sufficient to admit a catheter No. 24, French gauge.

The catheter itself ought to be about No. 22 gauge for adults, and should be marked at a point 26 cms. from its tip, so that when this point is at the incisor teeth the anæsthetist knows that the end is well within the trachea just above its bifurcation.

The patient is anæsthetised in the ordinary way with ether. It is of great importance that he should be deeply under the anæsthetic, otherwise the attempt to introduce the tube into the larynx will produce spasm and occlusion of the glottis.

If the direct laryngoscope is to be used, the patient's head is allowed to fall backwards over the end of the table. When the introducer is preferred the head is slightly raised, the mouth opened with a gag, and the tongue drawn forwards with tongue forceps. The forefinger of the left hand is passed into the pharynx until the tip of

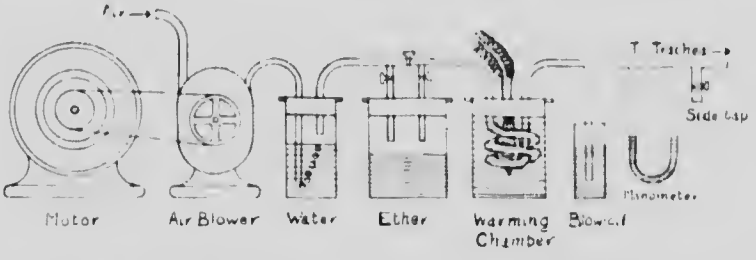

FIG. 2. Diagram illustrating plan of apparatus for the intratracheal insufflation of ether. The air is washed by passing through water, it then passes over the surface of ether, warmed in the copper coil which is immersed in water kept hot by an electric bulb. If the pressure in the trachea becomes too high the mercury in the blow-off tube is spilled. The manometer registers the pressure and indicates the respirations. By opening the side-tap the pressure in the trachea is reduced to that of the atmosphere.

the epiglottis is felt. With this as a guide the introducer loaded with the catheter is passed until its tip is behind the epiglottis, and then the catheter is fed through the tube until it is well within the trachea. As the catheter reaches the glottis there is usually a short cough, and immediately one feels the air coming through the catheter during expiration.

The catheter is fixed by means of a towel clip to the upper lip, and connection is made with the apparatus. The patient now obtains a steady stream of etherised air through the tube, whilst round it there is a steady expiratory current.

When the operation is finished, the ether is turned off and air alone admitted to the lungs. This tends to remove excess of ether and to promote rapid recovery from the anæsthetic.

OMNOPON AND ETHER. When ether is dreaded by patients, and when it is especially desirable to diminish their anxiety before operation and to prolong sleep after it, omnopon will prove a useful adjuvant. Women and adolescents respond admirably, but men are often refractory to its influence. We have employed it chiefly for women patients.

Omnopon is a mixture of some twenty alkaloids of opium, and is most rapidly effec-

tive when given hypodermically. The dose is gr. $\frac{1}{2}$—$\frac{2}{3}$. Deeper narcosis can with perfect security be obtained by combining omnopon with scopolamine (gr. $\frac{1}{100}$), and in many of our cases the two were used. The drug is injected an hour before operation, and the patient usually comes to the theatre in a stuporose state. If she is roused from this, she may show a restless and hysterical anxiety. This is easily produced; it prolongs induction, but it may, except with alcoholics, be easily avoided. Omnopon may be regarded as unsuitable for alcoholics. Symptoms of renal disease are an absolute contraindication to its employment.

It is said to be safely borne by children, but we prefer to use plain ether.

Salivation is suspended by the drug, and mucus is not secreted, but the post-operative sleep secured by omnopon makes thirst unfelt.

Respiration may become shallow or appear normal, and the absence of mucus and saliva makes it quiet.

The conjunctival reflex and the light reflex are not abolished, but the pupil is somewhat contracted and reacts so sluggishly as to require close scrutiny. The pulse and respiration are real guides to the depth of anæsthesia. The chief advantages of this method are—less ether is needed with omnopon; post-operative vomiting is more often absent than with ether alone; morphia is very seldom needed, and the patient usually sleeps several hours afterwards, often for twelve. On the other hand several deaths attributable to omnopon have been recorded. The symptoms were those of opium poisoning.

In an abdominal operation with omnopon if the anæsthesia is relaxed, and the surgeon who has been handling insensitive gut suddenly shocks the patient by pulling upon parietal peritoneum, it will be even more difficult than usual for the anæsthetist to regain anæsthetic control. Co-operation between surgeon and anæsthetist is absolutely essential here and always, the absence of it wastes ether and sometimes life.

HEDONAL.—In 1910 Federoff, of St. Petersburg, introduced hedonal as an intravenous anæsthetic. It was successfully employed on the Continent, and was first used in England about the beginning of 1912. In the *Lancet* of May, 1912, Mr. C. M. Page published an account of two hundred cases, and since then numerous reports have been submitted to the profession. In our experience hedonal anæsthesia is specially indicated (1) in elderly cachectic patients, (2) in cerebral and spinal cases, (3) in severe abdominal cases, (4) in cases in which nephritis is present, and (5) in cases in which hæmorrhage will be severe. In short, this form of anæsthesia is the best we have at present for patients who are in such a critical condition that an anæsthetist would hesitate to administer ether or chloroform. There are, however, definite contraindications to its use. It is absolutely contraindicated in operations on the air passages unless a preliminary tracheotomy or laryngotomy be performed and the laryngeal plug left *in situ* until the patient has perfectly recovered consciousness. The majority of deaths reported have been due to neglect of this precaution. With hedonal the laryngeal reflex is abolished early and remains absent for a lengthy period, consequently there is danger of blood entering the air passages. Hedonal should never be administered to a healthy, robust adult for an operation unaccompanied by shock or hæmorrhage. In these cases the amount of fluid required for anæsthesia may produce œdema of the lungs.

For further discussion of this subject the reader is referred to the *Lancet*, November, 1912, and to a paper by Dr. Crawford, in the *Medical Press and Circular*, October, 1912.

Technique.– Fifteen grammes of hedonal are dissolved in two litres of normal saline solution at a temperature of 140 F. This gives a percentage solution of 0·75. It is filtered and boiled.

The solution is administered exactly like an intravenous saline, into any convenient vein. The apparatus recommended by Sir Berkely Moynihan, and made by Thackray, of Leeds, is very convenient. During induction the fluid is run in at a rate of from 50 to 150 c.c. per minute. In feeble patients it is sometimes advisable to reduce the rate to 40 or even 20 cc.c. per minute (Crawford). In two or three minutes the patient becomes drowsy and yawns, and soon deep anæsthesia supervenes. The slightest cyanosis indicates a slower stream. The air passages must be kept absolutely clear during the whole period of anæsthesia. The corneal reflex should be allowed to return immediately after the skin incision has been made, and the light reflex should be present.

CHLOROFORM.—In Dublin general anæsthesia by ether has always been preferred to that by chloroform. In this respect the Dublin custom coincides with that prevalent in the United States. The special indications for chloroform have all disappeared with the more general use of ether administered by the intratracheal or open method and hedonal. Nevertheless emergencies occur in which chloroform is the only anæsthetic at hand, and in such cases the simplest method of administration is the best. Such is the individual idiosyncrasy to this that the patient is as safely anæsthetised by the drop method as by the most elaborate apparatus.

The difference between ether and chloroform administration may be expressed by saying that we give ether with a little air, but we administer air with a little chloroform. Any exclusion of air during chloroform anæsthesia is dangerous, and it is always wise to keep two fingers between the patient's chin and the edge of the Skinner's mask. Chloroform is then dropped very slowly at first, then more rapidly till the patient is under the anæsthetic. A steady dropping, not an intermittent pouring on, of the drug is essential. Close attention should be given to the patient's colour, respiration, and pulse. The corneal reflex and the light reflex should be present throughout.

Deaths under chloroform occur usually during the period of induction of anæsthesia, and are probably due to a sudden increase of the amount administered. Pallor with the light reflex present is often premonitory of vomiting, but when the light reflex is absent pallor is of ominous import and calls for immediate attention.

In chloroform anæsthesia, as in that due to all drugs, one of the most essential points is the maintenance of an absolutely free airway. The jaw is pushed forward, and if any respiratory embarrassment should occur, a gag is introduced and the tongue drawn out ; if all else fails, tracheotomy may be employed as a last resource.

The Administration of Chloroform by Junker's Inhaler. In operations in the region of the mouth or nose it is impossible to administer the anæsthetic by means of any apparatus possessing a face piece. In such cases Junker's inhaler proves extremely useful. This inhaler consists essentially of a narrow bottle graduated to hold from 1 to 8 drachms of chloroform. The stopper is pierced by two tubes, one of which passes nearly to the bottom of the bottle so that its extremity is under the surface of the chloroform, the other simply passes into the bottle and is not immersed in the fluid. To the longer tube is attached an ordinary air bellows, while the shorter leads by a long rubber tube to a bent mouth-tube of hard metal. By pressing the air bellows air is pumped through the chloroform and is conveyed by the shorter tube to the patient.

Our usual method of procedure, for instance in the radical operation for empyema of the maxillary sinus, is as follows :—

The patient is anæsthetised in the ordinary way by the gas-ether sequence. When a sufficient depth of anæsthesia has been obtained, the ether inhaler is removed and chloroform is administered on a Skinner's mask till true chloroform anæsthesia is produced. A gag is now inserted and the metal tube passed to the back of the buccal cavity. By squeezing the air bellows during each inspiration, chloroform vapour is transmitted into the pharynx and maintains a sufficient depth of anæsthesia.

Steady, rhythmical pumping is essential, rapid, jerky compression of the bellows renders it impossible to preserve regular anæsthesia.

It is of vital importance for the anæsthetist to satisfy himself before inducing anæsthesia that the air bellows is attached to the *long* tube, otherwise liquid chloroform may be forced into the patient's throat. The same accident may occur if the bottle be filled too full of chloroform, or if it become tilted during anæsthesia.

We endeavour to maintain anæsthesia of such a depth that the coughing reflex is never completely abolished ; although this may sometimes be inconvenient for the surgeon it is infinitely safer for the patient, for it prevents blood or foreign matter entering the air passages.

With the advent of the intratracheal method of etherisation it is possible now to dispense entirely with chloroform in operations in the region of the naso-pharynx and mouth, but in places in which the former method is not in vogue, familiarity with the use of Junker's inhaler is to be recommended.

ANÆSTHETIC SEQUENCES.—We have already described the gas-ether sequence in the section on ether.

The Ether-Chloroform Sequence.—It is frequently found convenient, though not often safe, to employ the ether-chloroform sequence. The patient is anæsthetised in the ordinary way by means of ether and then chloroform is substituted. It is of extreme importance that the change should be made with care. If it be made too early when the patient is struggling [illegible] anything deeply a dangerous amount of chloroform may be inhaled suddenly, [illegible] disastrous results. Again, it is not wise to change to chloroform when the patient [illegible] deeply anæsthetised by ether for it is safer to produce deep anæsthetisation by ether than by chloroform. The most favourable moment to change is when the conjunctival reflex is abolished and the cough reflex is present, or *vice versâ*, for the presence of either of these reflexes by itself shows that the patient is not too deeply under the effects of the anæsthetic.

The Chloroform-Ether Sequence.—This sequence in our opinion should never be employed. The great majority of the deaths under chloroform occur during the period of induction, and to deliberately choose the more dangerous drug when the safer is at hand is irrational and unscientific. It is beyond all comparison, better to injure the patient's æsthetic sensibilities than to endanger his life.

ANOCI-ASSOCIATION.—Anoci-association is a term introduced by Crile of Cleveland to indicate a procedure by means of which no harmful impulses may reach the central nervous system during anæsthesia. Crile holds that a general anæsthetic inhibits all motor expression, but does not prevent afferent impulses reaching the brain and producing definite organic changes therein of the nature of chromatolysis. He attributes shock to the injurious associations—"noci-association." He has

attempted to prove in addition that fear may produce a similar condition of the nervous centres. Acting on this reasoning Crile has elaborated his theory of non-injurious association during anæsthesia, "Anoci-association." His procedure is as follows. Morphia is administered to abolish fear in the patient's mind. Nitrous oxide and oxygen is given as the general anæsthetic, as he considers it less liable to produce toxic effects than ether or chloroform. In addition to the general anæsthetic, complete anæsthesia is established by the injection of novocain and adrenalin. The local anæsthetic blocks the nerves and so prevents any hurtful impulses reaching the brain from the field of operation. At the conclusion of the operation quinine urea hydrochloride is injected in order to continue the anæsthetic effect. Crile advocates this method very strongly in every operation, but with special emphasis in cases of exophthalmic goitre.

The combination of local with general anæsthesia had been popular with some surgeons before Crile elaborated his theory, and it certainly would appear to be useful. We cannot, however, join whole-heartedly with him in putting into practice the conclusions of reasoning which is largely speculative. For furth information on this subject, the reader is recommended to consult "Surgery, Gynæcology and Obstetrics," August, 1911; "Journal of the American Medical Association," December, 1911; "Proceedings of the American Philosophical Society," Vol. LI., No. 204, 1912; *Lancet*, July 5th, 1913.

DIFFICULTIES DURING THE ADMINISTRATION OF ANÆSTHETICS.—Speaking generally, the difficulties met with during anæsthetisation are more often due to faulty administration than to any individual peculiarity in the patient. There is no fixed line of procedure to be followed in every case; the rate of induction, the amount of air admitted and the quantity of anæsthetic given must all be adapted to the requirements of the individual and to his physical and mental condition. When induction is undertaken with ether alone a free intermixture with air must be allowed otherwise the concentrated ether vapour promotes forcible coughing. In this regard the anæsthetist must be familiar with the construction of the apparatus which he is using, for it has happened that the indicator in Hewlitt's inhaler has been placed carelessly after cleaning the inhaler in such a way that it points to zero when it ought to point to full. If this occur the patient is blamed for undue excitement when the inhaler is put in position.

Coughing only occurs during light anæsthesia and proves extremely troublesome to the surgeon in operations on the abdomen, head or neck. During the period of induction coughing is due to a sudden increase in the concentration of the anæsthetic vapour and can be avoided by steady administration and gradual increase. If coughing occur during induction it is wise to go more slowly. If, however, the operation is well advanced, a greater depth of anæsthesia is indicated.

More troublesome than coughing and brought about by the same conditions is spasm of the muscles at the back of the tongue or of the larynx. The air-way becomes obstructed and the patient rapidly becomes cyanosed. Immediate treatment is called for. The lower jaw should be drawn forwards forcibly in order to bring the base of the tongue away from the posterior wall of the pharynx. Both hands are used, one behind each ascending ramus, and at the same time the head is extended slightly. If the teeth interlock the mouth is opened, a closed gag inserted, and the jaw drawn forwards. If the cyanosis is not relieved by this procedure, tongue forceps are applied and the tongue pulled forwards. This usually suffices to re-establish an effective air-way and easy respiration. When, however, well marked stridor

accompanied by cyanosis indicates laryngeal spasm and occlusion, more vigorous measures must be adopted. The lips are briskly rubbed, and preparations made for laryngotomy. In some instances the respiratory spasm is so general that even the establishment of a free air-way is of no avail to restore respiratory movements, artificial respiration must be resorted to, and inflation of the lungs attempted through the laryngotomy opening.

So great is the congestion of the air passages brought about by the respiratory embarrassment that it is sometimes useful in thick necked, plethoric individuals, to perform venesection as a secondary procedure to the laryngotomy.

These extreme measures are very seldom indicated but a free air-way must be maintained all through anæsthetisation at any cost, and the anæsthetist must be prepared for all emergencies.

The anæsthetist should always remember not to waste time by administering stimulants, others must attend to that as he will require to devote himself to maintaining respiration artificially or otherwise. Such respiratory embarrassments as above occur as a rule during light or moderate anæsthesia, and are due essentially to obstruction in the air passages. More dangerous than these is the respiratory failure which occurs during deep anæsthesia and indicates paralysis of the respiratory centre itself. When this occurs the breathing becomes shallower and shallower, pallor rather than cyanosis appears and the pulse becomes very feeble. The anæsthetic must be withdrawn immediately and artificial respiration performed steadily till the patient's colour returns and the breathing becomes easy again. This paralysis of respiration is much more apt to take place under chloroform than under ether. There is no necessity to perform laryngotomy in this condition, for the air-way is probably quite free or can be rendered so by pulling forward the jaw. Artificial respiration is the proper treatment.

Vomiting sometimes occurs during induction and depends both on the preparation of the patient and on the amount of mucus and saliva secreted. If the anæsthetist notices swallowing movements towards the end of induction he should prepare to let the patient vomit, the head should be turned to the side and the jaw kept well forward. In the majority of cases it is better to allow the patient to empty his stomach at this stage for otherwise the anæsthetic will not proceed smoothly. Difficulty in induction is very frequently due to this cause.

Muscular rigidity is one of the most common complaints of the surgeon who is operating on the abdomen. In many instances he has only himself to blame. Under ether it requires from ten to fifteen minutes to produce muscular relaxation, and if the surgeon insist on making his incision too soon he prolongs this necessary period and is apt to blame the anæsthetist. Again, the depth of anæsthesia which is sufficient to complete for instance an appendicectomy after the abdomen has been opened, is not sufficient for a general exploration of the upper abdomen, and certainly not enough for any pulling on the parietal peritoneum. The surgeon must give the anæsthetist notice of his intentions if he is to have proper co-operation. Often, however, the blame lies on the anæsthetist. It is common to find that relaxation is retarded although the patient seems to be deeply anæsthetised. In such cases air is indicated, and it must be given without impediment. When Clover's or Hewitt's inhaler is being used, the removal of the rebreathing bag with the indicator at full is usually sufficient to bring about relaxation in the course of a few minutes. It is a mistake to change to chloroform when the patient is deeply anæsthetic and rigid. In practically every case the rigidity is due to some degree of asphyxiation. In the distinct case in which nothing seems to produce relaxation, chloroform may be

administered for a few minutes and then ether given again ; but even then it is wise to allow the patient to recover a little before giving chloroform. When an operation is accompanied by profuse hæmorrhage the amount of anæsthetic required is materially diminished, and the anæsthetist ought to keep the patient more lightly under than usual.

The essential point in dealing with anæsthetic difficulties is to give the patient a free air way and induce him to breathe through it, all other procedures are secondary, such as the administration of saline solution, of strychnine and pituitary extract ; these latter, however, must not be neglected.

SECTION II

THE HEAD AND NECK

THE CRANIUM AND ITS CONTENTS.

CRANIO-CEREBRAL TOPOGRAPHY.—In considering the chief procedures in connection with the operative surgery of the cranium and its contents it will be necessary, by way of introduction, to define the relationships of certain cortical areas of

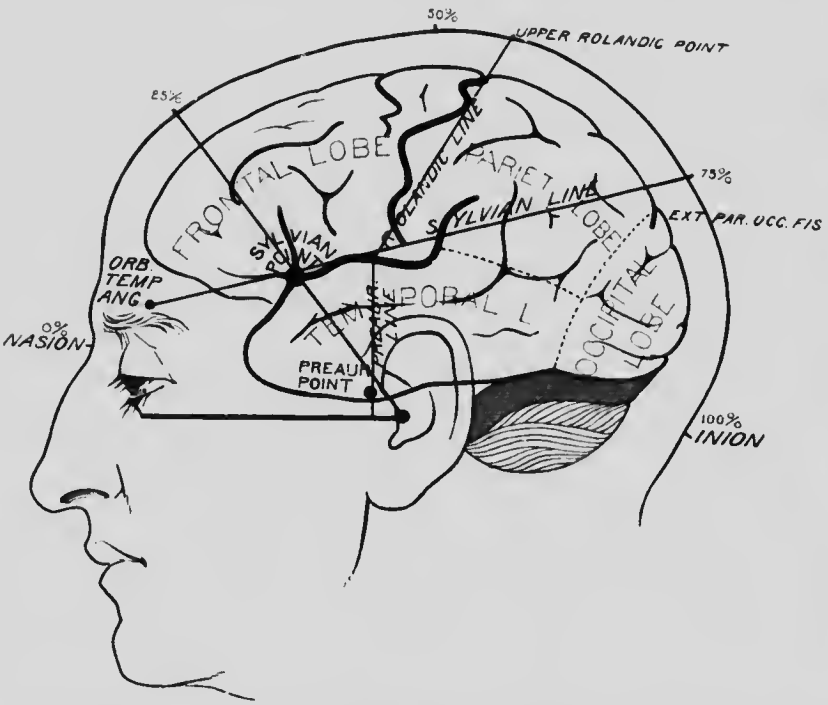

FIG. 1.—Cerebro-Cranial Topography. The diagram represents the author's method of determining the topography of the principal fissures and convolutions on the outer surface of the cerebral hemisphere. (For fuller details, see Trans. Roy. Acad. Med. Ireland, Vol. XVIII.)

the brain as well as those of certain meningeal vessels and venous sinuses to the surface of the head in the living individual.

There are three fundamental fissures, the position and direction of which it is absolutely essential to determine, as they separate the four main lobes of the brain

from each other; they are the fissure of Sylvius, the fissure of Rolando, and the external parieto-occipital fissure. If lines can be drawn upon the surface of the head corresponding to these, it becomes a comparatively simple matter to locate the various convolutions.

The Fissure of Sylvius. The distance between the root of the nose (*nasion*) and the external occipital protuberance (*inion*) is carefully measured and divided into four equal parts, the points of junction of which are indicated on the surface of the scalp by means of an aniline pencil. From the orbito-temporal angle a line is drawn across the side and over the vertex of the head to meet the junction of the third and fourth segments of the naso-iniac line (Fig. 3); it will usually be found to correspond to the posterior limb of the fissure of Sylvius in the greater part of its extent, and is consequently termed the "Sylvian line." Its posterior extremity, as a rule, will overlie or closely approximate the external parieto-occipital fissure. If another line be now drawn from the junction of the first and second segments of the naso-iniac line to the centre of the external auditory meatus, it will be found that its point of intersection with the Sylvian line will overlie the "Sylvian point"—that is, the point where the main stem of the fissure reaches the outer aspect of the hemisphere. From this the posterior limb follows the Sylvian line backwards but finally leaves it by curving upwards beneath the lower and posterior part of the parietal eminence. The ascending and horizontal limbs of the fissure will be indicated by two lines, each ¾ inch long and starting from the Sylvian point, one directed upwards at right angles to the Sylvian line, the other horizontally forwards.

The Fissure of Rolando is found as follows: An upper or superior Rolandic point is indicated ¾ inch behind the centre of the naso-iniac line; this will represent from 53 to 55 per cent. of the naso-iniac distance, measuring from before backwards. A second or lower Rolandic point is obtained by erecting a perpendicular to the upper margin of the zygoma through the preauricular point to meet the Sylvian line. Should the upper margin of the zygoma be difficult to determine, the perpendicular may be erected on a line which connects the centre of the infraorbital margin with the auricular point. The "Rolandic line" is now obtained by connecting the upper and lower Rolandic points. It will, of course, be understood that, as the fissure pursues a markedly sinuous outline, the line so drawn will merely indicate its main direction. Furthermore, the fissure does not reach quite up to the middle of the line of the head above, and it terminates below, a short distance above the Sylvian line.

The Cortical Areas of the Brain.—According to the observations of Sherrington and Grunbaum, the so-called motor area of the cerebral cortex occupies unbrokenly the whole length of the pre-central convolution, and in places the greater part or the whole of its width. It extends into the depth of the Rolandic fissure, occupying the anterior wall and in some places the floor, and sometimes extending even into the deeper part of the posterior wall of the fissure (Fig. 4). Out of nineteen hemispheres examined they never found the motor area extend to the outer free surface of the post-central convolution, and in this observation a very marked discrepancy is to be noted between their results and those of preceding observers. In their paper they also state that although "small lesions in the pre-central convolution cause marked paralysis and descending spinal degeneration, similar and larger lesions in the post-central produce not even temporary paralysis and no unequivocal degeneration."

CRANIECTOMY AND CRANIOTOMY.

CRANIECTOMY.—In this procedure the skull is first exposed by turning aside a suitably arranged flap of the tissues of the scalp. The bone is then penetrated either by a trephine, burr, or drill, and the aperture is subsequently enlarged in the required direction by means of bone-cutting forceps.

Very large apertures may be made in this way, but such an operation results in a

FIG. 4.—The left hemisphere of the brain exposed *in situ* after previous hardening with intravascular injection of formalin. The motor cortical areas for the face, arm and leg are indicated in the precentral convolution. A tracing from this figure is represented in Fig. 5 with fuller detail.

permanent cranial defect, as the bone removed is not replaced, but the scalp when turned back and sutured in position directly overlies the dura mater and the brain.

Craniectomy carried out in the method just described may be employed in the treatment of hæmorrhage from the middle meningeal artery, excision of the Gasserian ganglion, the evacuation of cerebral or cerebellar abscesses, certain cases of depressed fracture, etc.

CRANIOTOMY.—This is an osteoplastic operation in which a flap consisting of tissues of the scalp and the subjacent bone is raised from the underlying dura and

temporarily turned aside pending the intracranial part of the operation. When this has been accomplished the flap is replaced, and the margins of the scalp wound are adjusted by sutures.

As many of the steps in these operations are similar, the following description will apply to both, the essential differences being noted under the various stages:—

Preliminary Measures in Cranial Operations. The cleansing and disinfection of the scalp must be carefully attended to. The entire scalp may be shaved, but for many operations involving the cranium and its contents the hair need only be re-

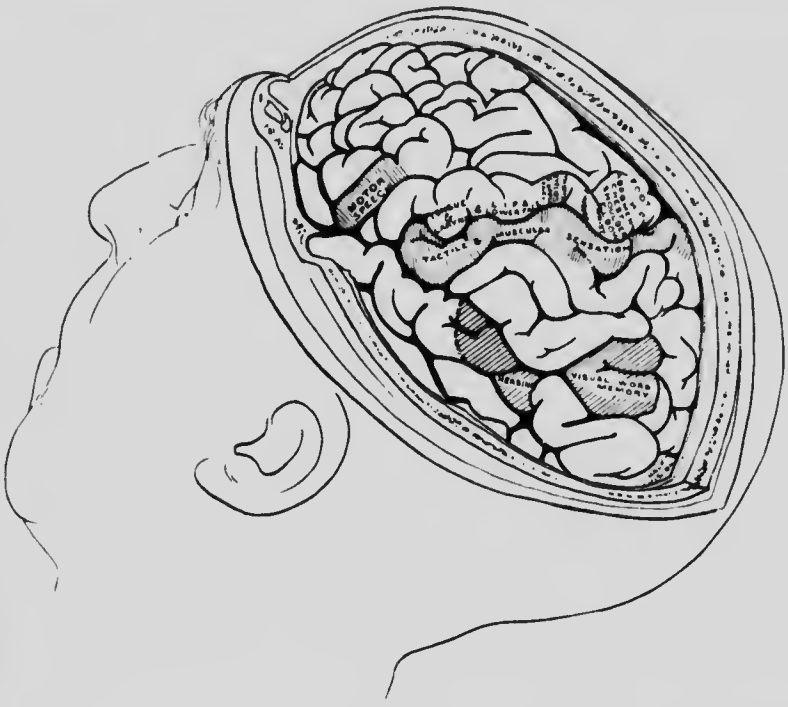

FIG. 5.

moved over an area somewhat more extensive than that concerned in the operative procedure.

The shaving is usually postponed until the morning of the operation. It is followed by an antiseptic dressing which is not removed until the patient has been anæsthetised; tincture of iodine is then applied to the entire scalp area.

Should it be necessary to outline the direction of the principal fissures, this had better be done before the administration of the anæsthetic. The markings may be made with an aniline pencil before the antiseptic dressing is applied, after the scalp has been shaved. In addition to the surface marking of the fissures, it is sometimes useful to mark the subjacent bone before the scalp is incised and turned aside. This is readily accomplished by perforating the scalp, already marked, with a sharp

instrument and scratching or perforating the outer layer of the skull in two or more places.

The administration of urotropin for some days before operations on the cranial contents is recommended by Cushing, as this drug is excreted in the cerebro-spinal fluid, and consequently may exert a beneficial action through its antiseptic qualities. From 20 to 30 grains may be administered daily.

With a view of facilitating the anæsthesia, a hypodermic injection of ¼ grain of morphin is useful about half an hour before the operation is commenced. Omnopon

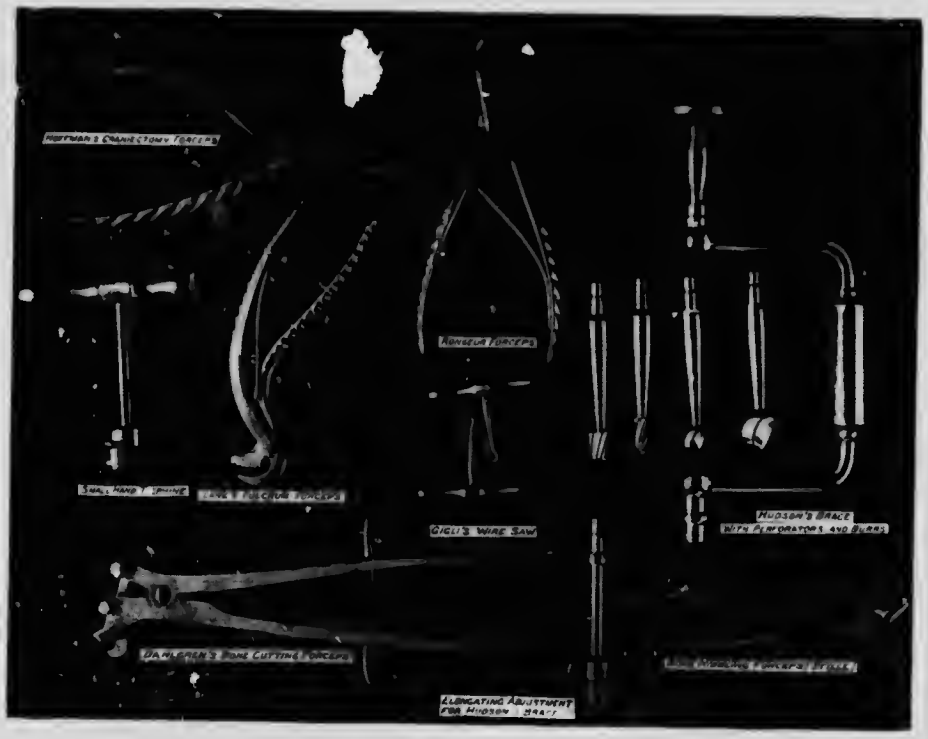

FIG. 6.—Some Instruments employed in Cranial Surgery

has also been recommended, and its use does not appear to have been attended by any unpleasant consequences.

Instruments.—In addition to the usual instruments required in the majority of operative procedures, the following should be available: assorted bone drills and braces; those of Hudson and Doyen are very useful; trephines (½ inch, ¾ inch, and 1 inch); dural separator; Gigli's wire saws with handles and dural protector; bone-cutting forceps, of which the best are those of Dahlgren, Montenovesi, and De Vilbis; rongeur forceps; Horsley's brain knife; Horsley's wax for arresting bleeding from vessels in the bone; a special tourniquet of rubber tubing to encircle the head. A plethysmomanometer to enable a record of the blood pressure to be taken during the operation is usually advisable (Fig. 6).

CRANIECTOMY.

The patient lies upon the back, the head supported by a firm pillow or sand-bag, and the chin turned away from the surgeon.

Good illumination is necessary. Some surgeons employ a head lamp, and work entirely by artificial light. This is useful for deep illumination when dealing with tumours in the cerebellar fossa.

The scalp will have been shaved and disinfected and the main fissures, if necessary, outlined with an aniline pencil, etc. The subjacent bone may also be marked by means of a sharp awl or a bone drill before making the scalp incision. The tourniquet is applied over a sheet of muslin protecting the head.

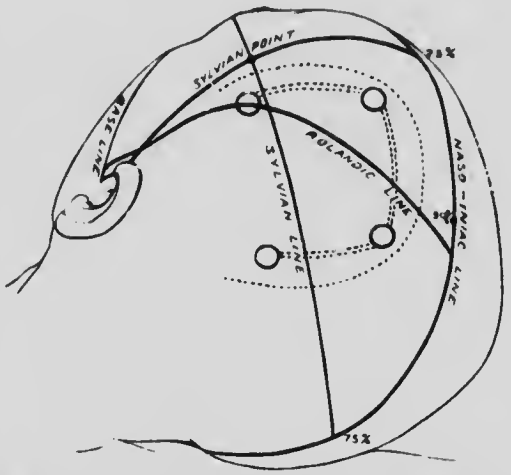

FIG. 7.—The heavy black lines correspond with those represented in Fig. 3, to illustrate cranio-cerebral topography. The single dotted line represents the large T-shaped incision of the scalp employed in craniotomy. The circles and the double dotted lines indicate apertures made in the skull, and subsequently connected by dividing the intervening bridges of bone in the formation of an osteoplastic flap.

The Anæsthetic. Chloroform has been extensively employed in cranial surgery, owing to the fact that it produces less congestion of the head than ether. The objections to the latter, however, are largely dependent upon its faulty administration. The congestion is due to suffocation, but this can be largely obviated with skilful administration. We believe that the best method of administering ether for cranial operations is by intratracheal insufflation. As the aeration is good, there is no respiratory embarrassment and no congestion. Of course in certain cases of well-marked intracranial pressure the veins of the diploë and of the membranes are greatly engorged, but such engorgement is beyond the control of any anæsthetic. By employing intratracheal insufflation not only is there an absence of congestion, but the anæsthetist is out of the way of the operator, and the administration of the anæsthetic is uniform in spite of any alterations in position or posture.

Ether given with skill by the open method produces the minimum of congestion, but the difficulties of uniform administration when the patient is in the prone position for cerebellar operations and the proximity of the anæsthetist to the surgeon when other parts of the skull are being interfered with render this method difficult, and difficulty in cranial surgery means danger.

We have employed hedonal as an anæsthetic in a few cases with most satisfactory results. It is administered intravenously, and promotes even anæsthesia without any congestion and without any post-operative vomiting. This absence of vomiting which we have noted in our own cases is of the greatest importance in brain surgery. We usually introduce the hedonal solution into the internal saphenous vein at the

ankle, and in this way the anæsthetist and his apparatus are well removed from the field of operation

The Scalp Incision and Exposure of the Bone.—A large U-shaped flap is outlined, and when the incision has been made it is turned down, exposing a large area of the bone. The flap is arranged in all cases so that it receives an adequate blood supply.

The Cranial Aperture.—A trephine or brace preferably that of the Hudson pattern, is applied over the central part of the exposed area, and the bone is perforated; the dura is exposed and separated for some distance all round, and the aperture is progressively enlarged with cutting forceps, the bone being detached in small pieces. This can be readily accomplished with rongeur forceps if the bone is thin. Lane's forceps may be employed with advantage if the bone is thick.

The Intracranial Procedures.—These constitute the second stage of the operation

FIG. 8.—Craniotomy.—This figure represents the method of dividing the bridge of bone which intervenes between the upper apertures made in the skull. A flexible strip of metal has been passed from one aperture to the other, the dura having been previously detached from the deep aspect of the bone. The bone section can thus be made with a Gigli saw without risk of wounding the dura or the brain.

and will depend upon the condition for which the operation has been undertaken. At the present day craniectomy finds its chief indication in the procedures employed in effecting decompression of the brain, in the treatment of meningeal hæmorrhage and certain cases of depressed fracture of the cranium, etc.

CRANIOTOMY, OR OSTEOPLASTIC RESECTION OF THE CRANIUM.

Like the preceding, this operation consists of two stages, the first of which is terminated when the osteoplastic flap has been turned aside

The preliminaries are similar to those indicated in the last section.

The scalp incision is made as before, but the flap, instead of being reflected as in

craniectomy, is merely detached to a sufficient extent to permit of the manipulations attending the perforation of the skull and the bone sections (Fig. 8).

If the symptoms point to a tumour involving the motor area of the cortex, the level of the fissure of Rolando (*Sulcus centralis*) must first be determined.

The Bone Sections.—Four apertures are made with a burr or brace. They are approximately at equal distances from each other, and are situated one beneath the base of each vertical limb of the large scalp incision and one at each extremity of its convex segment. The four apertures are next connected above and at the sides by three bone sections. These may be carried out with Gigli's wire saws, which as a rule are very suitable for the purpose. The dura between the apertures is first detached from the bone by means of a narrow, flexible strip of copper or similar appliance. A grooved guide is then passed from one aperture beneath the bone and out through the other. It serves to protect the dura from the saw while the bone section is being made. Cushing's flat combined dural separator and Gigli saw protector is a useful instrument for this purpose. The saw is made to cut obliquely, with the result that the bone section is oblique or bevelled, the object of this being to prevent the possibility of the bone flap when replaced pressing against the dura and the brain (Fig. 9). The three bone sections may be made in this way, or if preferred the two vertical sections may be effected with Dahlgren's cutting forceps or with a gouge and hammer. The bone flap having been divided on three sides, is carefully undermined by means of a blunt separator and forcibly raised, the dura is inspected, and any meningeal vessels requiring ligature are secured. This completes the first step of the operation, *i.e.*, the craniotomy. The second, or intracranial, step may now be undertaken or postponed for a period varying from five to ten days if considered advisable. It will be fully considered in connection with the operative surgery of brain tumours.

COMMENTS.

1. Shock is frequently observed as a result of extensive operations on the cranium and its contents. It is most effectively prevented by operating quickly, preventing excessive loss of blood, having the operating theatre heated to a suitable temperature —75° F.—and carrying out the procedure in two stages.

If the symptoms of shock appear, they must be counteracted by the administration of warm saline solution per rectum or subcutaneously. Pituitary extract seems to be useful in such conditions.

2. Hæmorrhage may be considerable in cranial operations, and consequently careful measures should be adopted to prevent its taking place in excess. The encircling tourniquet when properly applied, as represented in Fig. 9, is very efficacious. Should extensive scalp incisions be made without any controlling tourniquet, the divided scalp vessels should be quickly seized with hæmostatic forceps. A useful method of controlling bleeding from scalp wounds is to pass a series of temporary interlocking sutures in such a way as to control the vessels at the base of the flap.

Emissary veins are sometimes troublesome if inadvertently wounded. The chief of these is the mastoid vein, which may be met with in operations in the occipital region. It is most readily secured by raising the scalp carefully, exposing it at the mastoid foramen, and surrounding it with a ligature which at the same time includes the pericranium at this level.

Hæmorrhage from the emissary veins may be exceedingly severe where there is marked increase of intracranial pressure. It occurs when the flap of skin and periosteum is being reflected, and is most readily checked by inserting a wooden or ivory

plug into the opening in the skull. It is futile to attempt to mop up the blood to see the bleeding point. However, by remembering the situation of the emissary veins it is easy to slip a conical plug into the opening. Plugs of various sizes should always be at hand.

Diploic veins may bleed freely. Hæmorrhage from this source may be arrested by crushing the surrounding bone so as to occlude the venous channel, or Horsley's antiseptic wax may be squeezed into the open spaces of the bone. The middle meningeal artery sometimes runs in a complete bony canal in the temporal region

Fig. 9. Craniotomy. An osteoplastic flap has been raised and turned aside leaving the dura mater exposed. Cushing's elastic tourniquet encircles the head which is covered by a sterile sheet of muslin.

of the skull, and may cause trouble when wounded. Probably the best method of arresting the bleeding here is to plug the bony canal with a sterile plug of soft wood. Vessels in the dura are sometimes wounded and require to be ligatured. The ligature is passed with a fine curved intestinal needle and includes the dura. In passing it care is taken not to injure the underlying pia and arachnoid. Both the distal and the proximal ends of divided meningeal arteries should be secured.

3. The Bone Sections.—The method of using Gigli's wire saws has already been described. The chief risk attending them consists in wounding the dura and possibly the brain unless suitable measures be employed to protect these parts by a grooved protector or flexible strip of metal such as is represented in Fig. 9. With a little

practice the bone sections may be quickly and effectively carried out by means of cutting forceps such as those devised by De Vilbis and Dahlgren. The use of hammer and chisel, unless with careful manipulation, is objectionable on account of the concussion which it entails.

4. Craniotomy and Craniectomy contrasted.—Craniectomy is favoured by many. Amongst British surgeons it has been extensively practised by Sir Victor Horsley. One of its advantages is th. t it can be accomplished quickly and more easily than the

FIG. 10.—Craniotomy. The dura mater has been divided by a U-shaped incision and turned down in the form of a flap leaving the brain exposed with its pial and arachnoid investment.

osteoplastic method. The latter is suitable in cases requiring a large exposure of the brain or where the operation is performed as an exploratory measure in the absence of definite localising symptoms. The bone segment of the flap will need to measure at least 3 to 4 inches in each diameter so as to permit of a good exposure of the dura and the brain.

MIDDLE MENINGEAL HÆMORRHAGE.

ANATOMY.—The Middle Meningeal Artery enters the middle cranial fossa through the foramen spinosum. It extends outwards and slightly forwards upon the great wing of the sphenoid bone, and, as a rule, while still in contact with the base, divides into two main branches (Fig. 11). The anterior branch ascends in a groove on the deep

aspect of the parietal bone near its antero-inferior angle, and from this point it is directed upwards and backwards giving off several collateral branches and rapidly diminishing in size. Occasionally that part of the meningeal groove which is situated beneath the antero-inferior angle of the parietal bone is very deep, and may be completely bridged over and converted into a canal. The posterior branch pursues a backward course beneath the squamous portion of the temporal bone; it too gives off numerous collateral branches and may be traced as far as the middle line.

In some cases the anterior branch divides into tw almost immediately after its origin; the main vessel might then be said to have an anterior, middle, and posterior division.

In addition to one or two small companion veins, the middle meningeal artery, or at least its anterior division, is accompanied by a thin-walled venous channel, which at the vertex communicates with the superior longitudinal sinus, and is continuous below with the spheno-parietal sinus which opens into the cavernous sinus.

Sites for Trephining.—The anterior division of the middle meningeal artery will be exposed with almost absolute certainty by applying the pin of a ¾-inch trephine at a point on the bone 2 inches vertically above the centre of the zygomatic arch.

The posterior division will be exposed by trephining at a point below and behind the parietal eminence. The exact level at which to apply the pin of the trephine, as recommended by Kronlein, is at the intersection of two lines, one passing backwards from the supraorbital margin and the other upwards, just behind the mastoid process.

The Sites and Sources of Extradural Meningeal Hæmorrhage.—The area in which extradural hæmorrhage occurs has a fairly wide extent, and over it the dura mater is less firmly connected with the bone than elsewhere. It extends at the side of the cranium from the level of the lesser wing of the sphenoid bone back to the vicinity of the external occipital protuberance, and from the level of attachment of the falx cerebri above to the horizontal level of the lateral sinus below. All this area, of course, is not usually involved.

Kronlein classifies hæmatomata within this area into three groups, which he terms respectively (1) fronto-parietal, (2) parieto-temporal, and (3) temporo-occipital, according to the levels which they occupy.

The usual source of the bleeding is the anterior division of the middle meningeal artery and the veins by which it is accompanied. The walls of the artery are thin, and it adheres closely to the dura. The vessel also lies in a deep, bony groove, and may run for part of its course in a complete bony tunnel. The anatomical conditions of the artery therefore are unfavourable for the spontaneous arrest of bleeding.

Sometimes in meningeal hæmorrhage the blood may find its way beneath the dura and extend diffusely between it and the arachnoid in the subdural space, or it may collect beneath the arachnoid in the meshes and expansions of the subarachnoid space.

Following extradural hæmorrhage, a hæmatoma usually forms, and the extravasated blood tends to coagulate, forming a black, solid mass interposed between the bone and the dura and presenting in outline the appearance of a biconvex disc. The hæmorrhage from the wounded vessel may continue until death supervenes, but it may become arrested by the formation of a thrombus or by the gradual increase of the intracranial pressure.

The usual indication for operative intervention is a train of symptoms suggestive of intracranial pressure succeeding an injury to the head. The classical and typical "conscious interval" between concussion and the onset of symptoms of compression may or may not be present, and its absence should not afford a reason for delaying operation. The symptoms of concussion and compression may merge into each other. Localising symptoms are by no means frequently present as the part of the cortex cerebri usually compressed is outside the zone of the motor area. In some cases the

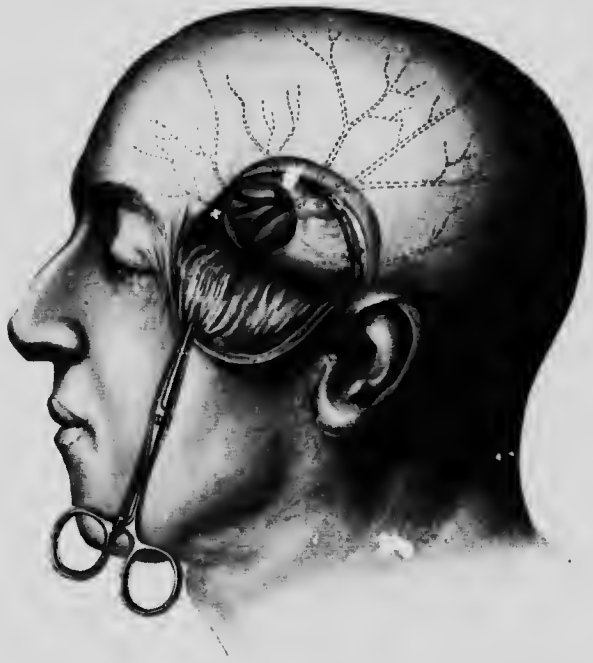

FIG. 11.—Craniectomy for middle meningeal (extra-dural) hæmorrhage. A large U-shaped flap has been reflected in the temporal region and the anterior division of the middle meningeal artery has been exposed by removing a disc of bone at the level of the anterior inferior angle of the parietal bone. The ramifications of the middle meningeal artery are represented by coloured dotted lines.

existence of limited paralyses—monoplegia, aphasia—may afford useful localising indications.

Cases of extradural hæmorrhage, unless relieved by operation, are frequently fatal from paralysis of the cardiac and respiratory centres, loss of blood, sepsis, or aspiration pneumonia.

The Operation.—This has for its object the arrest of the bleeding and the relief of the cerebral compression.

The area concerned in the operation as well as the surrounding scalp for some distance is shaved and cleansed as thoroughly as possible.

As the patient will probably be in an unconscious state, the administration of an

anæsthetic may not be necessary. Should an anæsthetic be required, however, chloroform is to be preferred to ether.

In the absence of definite localising symptoms, the site selected for exposing the middle meningeal artery will be that already described in the topography i.e. the anterior division of the vessel. The overlying tissues may show signs of injury at this level, an open wound may be present, or there may be a doughy swelling in the temporal fossa, the result of extravasated blood.

The Cutaneous Incision has a curved or U-shaped outline with the convexity of the curve directed upwards (Fig. 11). It circumscribes a flap in the temporal region, and is carried through all the tissues quite down to the bone. The tissues are detached from the latter by means of a rugine, and when the flap has been fully turned aside the condition of the subjacent bone is carefully examined for evidences of fracture or depression. Some blood may be observed issuing from a fissure, or there may be some hæmorrhagic infiltration of the temporal muscle.

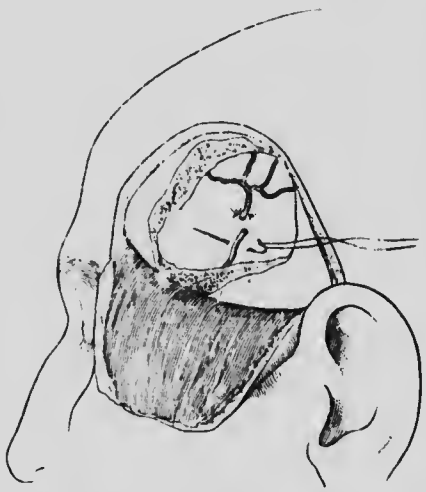

FIG. 12.—Method of securing a wounded meningeal vessel. A fully curved intestinal needle has been passed through the dura mater beneath the wounded artery and tied with a fine ligature of silk. The aperture in the cranium has been enlarged with bone cutting forceps.

The Craniectomy.—If the bone is fractured and comminuted, the fragments will require to be elevated and removed, and trephining may not be necessary. More frequently, however, trephining must be performed. A circular disc of bone is first removed by means of a trephine, or the bone is drilled with a Hudson brace or burr (Fig. 11). The aperture is then enlarged with bone-cutting forceps of the rongeur pattern to the required extent to permit of the evacuation of the clot and the occlusion of the bleeding vessel.

The Removal of the Clot and the Arrest of Hæmorrhage. — The dark mass of coagulum is removed piecemeal with a blunt scoop or spoon; a stream of warm saline solution will be found useful in clearing it away. If the brain expands and pulsates, and no further bleeding occurs, the wound may be closed. If, however, the middle meningeal artery is torn, or if there is a persistent oozing from beneath the edges of the bone, the vessels must be secured.

The securing of the wounded meningeal vessel may be attended by difficulty. If the artery has been wounded as it lies on the dura, it will require to be doubly ligatured. Each ligature is passed with a fine curved intestinal needle, which is made to traverse the dura beneath the vessel as the latter is bound down to the membrane and cannot be readily raised to an extent sufficient to permit of its independent ligature. In passing the needle care is taken not to wound the subjacent pia and arachnoid. The ligatures must be tightened very gently and carefully for they readily cut through the thin-walled vessel and the dura (Fig. 12).

If the meningeal artery has been wounded as it traverses a canal in the bone, the bleeding will be most satisfactorily controlled by means of a plug. For this purpose

a small piece of Horsley's antiseptic wax may be firmly pressed in, or the canal may be occluded with a fine wooden peg. Crushing the bone with force sufficient to approximate the walls of the bony canal may suffice.

If the oozing persist from between the dura and the bone at the lower part of the aperture, it is due very probably to a wound of the main stem of the artery. Should the bleeding come from a deep point at or near the foramen spinosum where the artery enters the cranium, it may be necessary to introduce a gauze plug between the dura and the bone, having first rongeured away the latter in a downward direction. In cases of middle meningeal hæmorrhage difficult of arrest it has been suggested to ligature the external carotid artery, but this procedure is not to be recommended as it would be unlikely to succeed in view of the very free collateral circulation.

Hæmorrhage beneath the dura may be recognised by bulging of the membrane and absence of pulsation. If present, the dura must be incised or an existing aperture enlarged and the blood allowed to escape so far as is possible. Blood beneath the dura may travel widely as there is no obstacle to its progress. The dura is then sutured with fine thread or catgut passed with a curved intestinal needle.

If no blood be discovered when the dura is incised and if the brain be tense, prominent and without pulsation, hæmorrhage may have taken place within the subcortical area. In such a contingency the brain must be incised and the clot evacuated If after the evacuation no further evidences of bleeding can be detected, the wound may be closed; but if some oozing persists, the cavity in the brain must be lightly plugged with gauze.

Closure of the Wound. Drainage.—Assuming that all bleeding has been arrested and that the wound is dry, it may be closed without drainage. The flap is replaced and sutured with silkworm gut. If there is oozing or if any doubt exists as to the asepticity of the tissues, drainage had better be employed. A rubber tube is passed through a stab wound at the centre of the flap and retained for twenty-four or forty-eight hours.

COMMENTS.

Alternative Procedures for exposing the Wounded Vessel.—(*a*) Cushing exposed the middle meningeal artery by the procedure employed in effecting temporal decompression of the brain. This is fully described below (see p. 47).

(*b*) Krause's osteoplastic method consists in raising a flap of bone with its overlying tissues and turning them aside. It does not appear to have any advantage over the craniectomy, but, on the contrary, is more difficult and more tedious.

Difficulty in localising the Site of Meningeal Hæmorrhage.—Hæmorrhage from the middle meningeal artery may be found on the opposite side of the skull from that struck; the brain at this level may also have been damaged by *contre-coup*. If, therefore, the skull is opened on one side, and there is no sign of hæmorrhage, it is the duty of the surgeon to repeat the procedure on the other side.

THE OPERATIVE TREATMENT OF FRACTURES OF THE CRANIUM.

Operative measures undertaken in cases of fracture involving the vault of the cranium are directed towards removing foreign matter introduced at the time of the injury, arresting meningeal hæmorrhage, and relieving the brain from the compressing effects of extravasated blood or depressed bone.

The varieties of fracture for which operation may be undertaken vary; the following are the more usual :—

1. A simple fissure of the vault. In this case the trouble is mainly in connection with a co-existing wound of the middle meningeal artery.

2. A compound depressed fracture in which one or more detached fragments have been driven in and wedged beneath the peripheral margin of the depressed area, and in which foreign matter may have been introduced.

3. A simple depressed fracture in which the depressed bone may cause trouble, *e.g.*, epilepsy.

4. A punctured fracture. In such an injury splinters of bone may have been driven, in and the extent of the intracranial injury may be greater than the superficial appearance of the wound would lead one to suspect.

The Operation.—The scalp is cleansed, shaved, and disinfected over a sufficiently wide area. As it is not unusual to find individuals after these injuries in a state of insensibility, the administration of an anæsthetic may not be necessary, but if it should be required, chloroform is best suited for the purpose.

Compound Fissured Fractures.—In every case of compound fracture the existing wound must be enlarged so as to enable the underlying bone to be examined.

Assuming that a fissure is found, that bleeding from the bone has ceased, and that there are no cerebral symptoms, the wound is carefully cleansed, a small strip of gauze is introduced for drainage and the wound is closed for the greater part of its extent by suture. If on examining the fracture, however, the broken edges are not quite accurately in contact, if blood continues to flow, and if some hairs or foreign matter are observed between the margins, further operative measures must be undertaken. The wound in the scalp is enlarged, if necessary, and perhaps the best way for dealing with the fracture is to remove a small disc of bone or drill an opening close behind the fissure. Through the resulting aperture cutting forceps of the rongeur type may be introduced and some bone on each side of the fissure removed (Fig. 13). Before nibbling away the bone the membrane beneath is gently separated with a flexible copper spatula. This is a better way to deal with the bone than the method with chisel and mallet, the employment of which necessitates more or less concussion.

The intracranial aperture having been sufficiently enlarged, extravasated blood and any foreign matter present are removed. The dura is cleansed with a swab rinsed out of sterile salt solution; and if its condition is satisfactory, the wound in the scalp is closed, drainage having been provided for by a strip of gauze.

In some cases the dura is torn and the brain also may be lacerated. Cleansing is carried out as before, and drainage is provided for by a piece of gauze or rubber tubing. Prompt attention to these details immediately after the injury may prevent the subsequent development of meningo-encephalitis or the Jacksonian type of epilepsy, which has been observed not infrequently as a sequela of injury to the brain in the motor cortical area.

Compound Comminuted Fractures with or without Depression.—Symptoms pointing to injury of the brain may or may not be present. If the injury to the brain involves its cortical motor area, localising symptoms will probably be present in the form of paralysis or loss of power in the face, arm, or leg of the opposite side. If the patient is unconscious, it may not be possible to ascertain these facts.

The procedure indicated in this form of cranial injury is the removal of the depressed bone and the careful cleansing of the wound.

The nature and extent of the fractures vary. There may be a depression which presents several fissures in the form of starlike radiations, the fragments, however, remaining connected. In more severe injuries the latter may not only be depressed, but driven in beneath the adjoining margin of the skull. The procedure for the removal of such depressed fragments must needs vary in different cases. It may be possible if some are small to detach and elevate them. The removal of one piece renders the removal of the remainder much easier. In the process of extraction great care must be taken of the dura. Fragments must not be forcibly elevated and extracted, but traction should be exerted upon them in a plane parallel to the cranial surface. Rotation of fragments in the course of their extraction would result in one margin being elevated and the other depressed and driven in against the dura and the brain. The use of a lever in elevating a large fragment may be dangerous for the same reason. The removal of interlocking fragments is facilitated by trephining or drilling the skull at the margin of the depression. Rongeur forceps can then be employed and enough bone removed from the periphery to enable the underlying fragments to be extracted.

When all the fragments have been removed the dura is examined, and if there are no signs of subjacent extravasation of blood, the wound is cleansed and the scalp incision sutured, drainage being provided for.

During the extraction of the depressed fragments free bleeding may take place, the source of which may vary, viz., a meningeal artery, a venous sinus, or a pial vessel

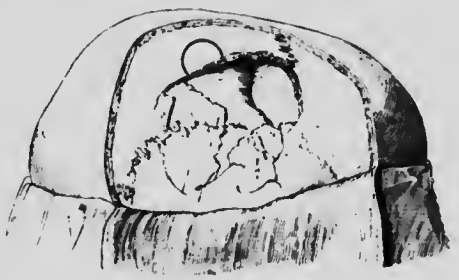

Fig. 13. Comminuted and Depressed Fracture of the Skull. This figure represents the usual method of elevating the depressed bone, viz. by first removing a small disc of bone from the overhanging rim beneath which the broken fragment has been displaced.

As a rule the site of the fracture will serve to indicate the source of the bleeding. A diploic vessel may be arrested by crushing the bone at the bleeding point or by rubbing in a small piece of Horsley's hæmostatic wax. Bleeding from a venous sinus is most effectively controlled by plugging, and a favourite method consists in introducing several yards of stout, absorbable catgut, which is allowed to remain *in situ* as it gradually becomes absorbed. A small aperture in a large sinus, such as the longitudinal or lateral, may possibly be closed with a fine suture, a method which has the advantage of not obliterating the sinus. Bleeding from wounded pial vessels is best controlled by gauze packing. Meningeal hæmorrhage will be dealt with later.

The rule of treatment in cases of simple depressed and comminuted fractures has been not to intervene in the absence of symptoms. It is probable, however, that a safer course would be to expose the seat of fracture and elevate the depressed fragments. Such timely intervention may prevent later complications and obviate the necessity for operative intervention at a subsequent period.

Punctured fractures of the skull are particularly in need of operative treatment as they often present extensive splintering from the inner table and laceration of the dura and brain. As before, the readiest way to treat these fractures is to perforate the skull at one side and then enlarge the aperture with cutting forceps, all loose splinters being removed. The dura is carefully examined and the condition of the brain noted.

Basal Fractures of the Skull.—*Treatment.*—The chief point to be borne in mind in these cases is the necessity for careful disinfection immediately after the injury, so as to prevent the risk of meningo-encephalitis, seeing that the majority of basal fractures are of the compound variety.

Later on symptoms indicative of increased intracranial tension may require relief by lumbar puncture or a decompression operation.

THE OPERATIVE SURGERY OF INTRACRANIAL TUMOURS.

General Considerations.—A tumour developing within the cranium may have its origin in the bone, in the meninges, in the substance of the cerebrum or cerebellum, or in one of the cranial nerves. Again, tumours originating in the brain substance may be classified according to their relative positions with regard to the surface as (*a*) cortical, (*b*) subcortical, and (*c*) central.

An important pathological classification of brain tumours is that which arranges them in two groups, viz., circumscribed and diffuse, as those of the former type are well suited for the radical operation of enucleation, whereas the latter are only amenable, as a rule, to palliative measures. Of the cases of brain tumour which come under the notice of the surgeon but a small proportion is suited for radical extirpation, probably under 20 per cent.

Difficulties attending Diagnosis.—The part of the brain affected may be situated in a district to which the term "silent area" has been applied, or it may correspond to one of the cortical motor areas, *e.g.*, the pre-central convolution, interference with the function of which may be clearly recognised and is of great diagnostic value.

Another consideration to be noted in the case of brain tumours is that the surgeon cannot tell for certain if, after having made the diagnosis of the situation of the brain tumour, it can be dealt with by radical measures. The operative procedure undertaken, therefore, in the majority of cases of this kind is, in the first place, exploratory. With the tumour exposed the operator will have to decide between its removal and purely palliative treatment.

In considering the operative measures applicable in cases of brain tumour it will be more convenient to deal, in the first place, with those of a palliative character. These have for their object the relief of intracranial tension (decompression).

DECOMPRESSION PROCEDURES.—A decompression operation is one in which a large aperture is made in the cranium, usually in the temporal or suboccipital region, the dura freely divided, and the brain substance allowed to bulge outwards. The relief of intracranial tension by one of the procedures about to be described is indicated in the following conditions: (1) intracranial tumours the seat of which is not accessible; (2) cases in which the seat of the tumour cannot be localised; (3) cases in which the tumours, although accurately localised, are found too extensive for radical operation; (4) apart from cases of intracranial tumour, decompression may be indicated for pressure disturbances resulting from cerebral œdema in cases of fracture of the skull, Bright's disease, etc.

The Sites selected for Decompression.—These should correspond to those parts of the cerebral cortex known as the "silent" areas. The part of the cerebral hemisphere best suited for this procedure is the temporal lobe on the right side. The site of the craniectomy is the temporal fossa, beneath the temporal muscle, and the procedure is known as subtemporal decompression.

Another site for effecting decompression is the cerebellar fossa. The procedure here is known as subtentorial decompression. It is not wise to aim at effecting decompression over the area involved by the tumour.

SUBTEMPORAL DECOMPRESSION.

Preliminary Measures.—The same precautions are taken as before in cleansing the skin of the scalp, but shaving of the entire head is not necessary.

The control of hæmorrhage by the ring rubber tourniquet is not suitable in this

FIG. 64.—Cushing's procedure for effecting Subtemporal Decompression of the Brain. A large flap consisting of the tissues of the scalp has been reflected exposing the dense temporal fascia. This latter has been incised and the temporal muscle split in the direction of its fibres. The subjacent bone has been perforated by Hudson's drill and rongeured away so as to provide a good exposure of the dura mater.

procedure, but the temporal vessels may be compressed where they cross the zygoma while the scalp incision is being made.

Steps of the Operation.—The *Scalp Incision* is curved, and extends over or a short distance within the arc formed by the temporal ridge, lying thus entirely within the hair line. It should not descend too low in front for fear of wounding the orbicularis palpebrarum muscle or its temporal nerve of supply.

The scalp flap thus outlined is turned down, and then the lateral extension of the

occipito-frontalis aponeurosis is reflected downwards, exposing the glistening and tense temporal fascia (Fig. 14).

Division of the Temporal Fascia and Splitting of the Temporal Muscle.—The incision in the fascia is oblique, parallel to the direction of the subjacent muscular fibres, and extends from near the middle of the temporal ridge towards the centre of the zygoma. The muscle is split in this line, and together with the periosteum is reflected from the subjacent bone, exposing as large an area as possible.

The Craniectomy.—A large burr or a Hudson drill is applied over the centre of the exposed area and the bone perforated. The latter instrument is safer for the purpose than a trephine as it does not cause damage to the dura and the subjacent pia-arachnoid, an accident which should on no account be allowed to happen.

The exposed dura is loosened from the bone by a blunt instrument, and the margins of the cranial aperture are progressively enlarged by snipping away pieces with rongeur forceps. The instrument represented in Fig. 6 is very well adapted for this purpose, as one of its blades is thin and flat and can be readily insinuated between the bone and the dura.

Caution is necessary in enlarging the aperture in front so as to avoid injury to the middle meningeal artery which grooves the deep aspect of the bone at this level.

Division of the Dura.—The membrane is most readily divided by raising a small fold of it with a sharp hook and cutting this with a scalpel held with the blade horizontal. A blunt and grooved director introduced through the aperture enables the remainder of the section to be completed without injury to the tense brain and its pial investment. The entire area of dura exposed had better be removed.

Should the brain appear unduly tense when the dura is opened, it will be advisable to perform a lumbar puncture. The relief of tension which follows this simple procedure is often remarkable and is not attended by any risk. There is danger, however, if the puncture is made before the opening of the skull, owing to the possibility of pressure being brought to bear upon the medulla through crowding down of the cerebellum into the foramen magnum as the cerebro-spinal fluid escapes.

Closure of the Wound.—The wound is closed in strata. The temporal muscle is first sutured by fine silk thread. The next row of sutures adjusts the margins of the temporal fascia. The epicranial aponeurosis is restored and retained by a few additional sutures, and finally the scalp wound is closed.

The subsequent protrusion of the brain will depend upon the degree of tension obtaining within the skull. It may be very marked; but, owing to the way in which the scalp incision is planned, there is little risk of the wound margins coming apart and permitting of a hernia cerebri. This would be very likely to happen were the scalp incision linear and situated directly over the gap in the temporal muscle.

SUBTENTORIAL DECOMPRESSION.

Preliminary Measures.—These are similar to those which have been already described. The patient is placed in the face-down position, which greatly facilitates the steps of the operation by affording good access to both sides of the cerebellar fossa. As an alternative the patient may be placed on his side with the head slightly raised by a suitable support. The arm which is uppermost must be well drawn down.

With the former position the anæsthetic is sprayed on to the gauze covering the face piece of the apparatus.

Easy respiration is permitted by means of crutches against which the shoulders rest and keep the patient's chest off the table. The head rests upon a special curved support standing out from the table which can be raised or lowered at will (Cushing).

Stages of the Operation. *The Skin Incision and Exposure of the Bone.*—The skin incision consists of an upper curved part, overlying the superior curved lines of the occipital bone, and a median part, extending downwards to the crest of the occipital bone and the spinous processes of the upper cervical vertebræ (Fig. 15). The entire incision has been likened to a cross-bow (Cushing).

Two flaps are turned aside, and the occipital muscles are reflected from the bone outwards to the posterior border of the mastoid process on each side and downwards to the foramen magnum. Sufficient muscle tissue should be left along the superior curved lines to permit of the subsequent retention of sutures when the reflected muscles are being restored back into position (Fig. 16).

The Craniectomy.—The bone is perforated with a Hudson burr or small trephine on each side of the middle line, and the dura is separated gently all round each aperture. Rongeur forceps are employed for enlarging the apertures, and the bone is progressively removed over a large area extending upwards to the lateral sinuses, but not exposing the torcular, outwards to the posterior part of each mastoid process, the mastoid emissary vein being avoided if possible, and downwards to the foramen magnum, the margin of which is removed in its posterior half. The bone in the middle line should be left to the last and then removed rapidly in order to control the bleeding from the emissary veins which are sometimes present in this region. Great care must be exercised in removing the margin of the foramen magnum so as not to exert pressure on the medulla oblongata.

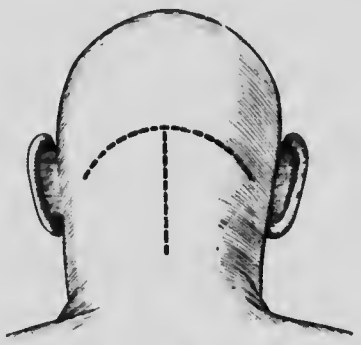

Fig. 15.—Cushing's Method for effecting Subtentorial Decompression of the Brain. The cross-bow incision.

The Dural Incision and Division of the Falx Cerebelli.—The dura is opened with the same precautions as before. A grooved director is then passed if possible in front of the falx cerebelli from one aperture to the other and the occipital sinus doubly ligatured. If there be any difficulty in passing a director in front of the falx, the ligatures may be passed by means of a curved intestinal needle.

Such a large exposure of the cerebellum greatly facilitates the subsequent manipulations, assuming that the case is one in which there is a tumour capable of being removed. The cerebellum may be dislocated without serious risk so as to expose the fourth ventricle or the recess on each side between the cerebellum and the pons, *i.e.*, the cerebello-pontine angle.

Should the dura when exposed appear very tense as the result of high intracranial tension, it is a wise precaution to open it first near the foramen magnum so as to get below the wedged part of the cerebellum and facilitate the early escape of the cerebro-spinal fluid.

COMMENTS.

Danger of a Hernia Cerebri.—This can usually be avoided. Owing to the unsightly character of the protrusion and the desirability of a more secure protection,

the subtentorial region has been regarded as the more favourable site for the decompression operation.

Selection of Site for Decompression. Subtemporal decompression is not suited for subtentorial lesions nor for cases complicated by an internal hydrocephalus.

It may be performed with advantage in certain cases where the intracranial tension, though high, will probably, as the result of the operation, quickly return to its normal

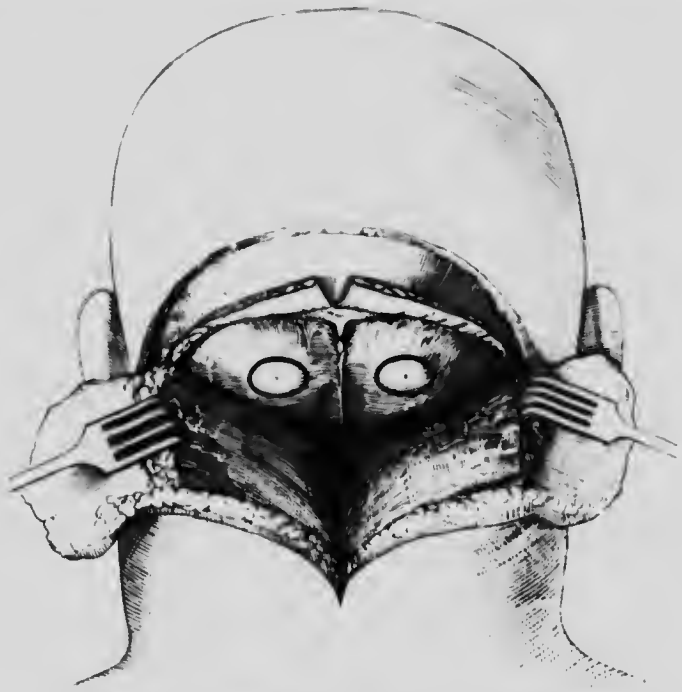

FIG. 16.—Cushing's Subtentorial Decompression. The tissues covering the bone in the suboccipital region have been reflected from the level of the superior curved lines down to the posterior rim of the foramen magnum. The circles marked on the bone represent the sites selected for the removal of two discs of bone.

level, viz. severe head injuries associated with meningeal haemorrhage and swelling of the brain from œdema, also the œdema which occurs in Bright's disease.

When there are definite signs of a cerebellar tumour the subtentorial operation should be performed, not so much to effect decompression, but in order to give the surgeon the opportunity of removing an operable growth.

Exploration followed by Decompression. An exploratory craniectomy may have to be terminated as a decompressive procedure. Assuming that an osteoplastic operation has been performed so as to expose a tumour in the parietal region, with the osteoplastic flap reflected the bone in the temporal region may be rongeured away, and when a sufficiently large aperture has been made the flap is replaced

Some years ago we had occasion to carry out this procedure in a case of tumour of the brain incapable of being removed. A marked protrusion took place subsequently in the temporal region and the osteoplastic flap was raised to a slight extent (Fig. 18). This patient survived the operation three years; during this period he had complete relief from the headache and vomiting which had been severe before the decompression was effected.

Some Points in Operative Technique. We find of the middle meningeal artery is

FIG. 17.—Cushing's Subtentorial Decompression. The bone in the occipital region of the skull has been extensively removed with cutting forceps. The dura has been divided on each side of the middle line by a curved incision below and parallel to the lateral sinus. The falx cerebelli has been doubly ligatured and divided so as to occlude the occipital sinus. The dural flap has been displaced downwards and the lateral lobes of the cerebellum exposed.

to be avoided. The vessel is endangered if the bony aperture is extended too far forwards. If it should be injured, its occlusion might be attended by considerable difficulty, as it would probably be necessary to rongeur away a considerable amount of the surrounding bone in order to expose the artery sufficiently to allow of a ligature being applied. Careful separation of the dura, however, reduces this danger to a minimum unless the vessel is contained within a definite canal in the bone.

Care in dividing the dura is necessary so as to [illegible] to the subjacent pia and arachnoid. In view of the bulging of the [illegible] these membranes should be preserved intact.

The risk attending lumbar puncture has been noted. It should not be attempted before the dura has been divided for fear of pressure being exerted upon the medulla through crowding down of the cerebellum in consequence of the high intracranial tension and the sudden withdrawal of the cerebro-spinal fluid.

Subtentorial Decompression.—The advantage of a large cerebellar exposure is considerable as it enables the lateral lobe to be dislodged from its recess much more easily and with greater safety than when the craniectomy is confined to one side.

FIG. 18.—This figure has been drawn from a photograph taken nearly three years after an osteoplastic operation on a tumour situated in the right hemisphere of the brain. The growth was deeply situated and had given rise to an enormous distension of the lateral ventricle. Owing to difficulty in controlling a branch of the middle meningeal artery some bone had to be rongeured away at the base of the osteoplastic flap. In the figure this area is represented by a fulness, and the entire flap appears somewhat raised in consequence of the high intra-cranial pressure. Although it was impossible to remove the tumour in this case yet the patient lived for more than three years after the operation, and during this period he was free from headache and vomiting. The beneficial effects of the procedure were due to decompression.

RADICAL PROCEDURES FOR CEREBRAL AND CEREBELLAR TUMOURS.

CEREBRAL TUMOURS.—The first stage of the operation has already been described under "Craniotomy" and "Craniectomy." The osteoplastic method is preferable as a rule to craniectomy. The second stage of the operation may be undertaken immediately after the craniotomy, but as a rule an interval of a few days is advisable.

The Second Stage of the Operation.

Examination and Division of the Dura Mater.—The operator should observe if the membrane pulsates, if it bulges unduly, or if instead of its normal bluish white colour it presents an abnormal red or yellow tint.

The membrane is next palpated for evidence of fluctuation or solidity. The incision in the dura may be made with a U-shaped outline parallel all round to the margin of the bony aperture about and ¼ inch away from it, or it may be of the crucial form. The arachnoid is carefully avoided when the dura is being divided. Kocher makes the U-shaped dural incision with its convexity downwards. This is a wise precaution near the vertex as there is less risk of wounding the large cerebral veins which empty into the superior longitudinal sinus.

Investigation of the Brain.—Should the tumour be exposed, the first question to decide is whether it is cystic or solid. If visual evidence of a tumour is not distinct it may be possible to determine if there is one in the subcortical region. The finger is a useful guide. Electrical stimulation of the exposed cortex may sometimes be employed.

Removal of the Tumour. There may be some difficulty in deciding whether this stage of the operation is feasible or not. The main point to be noted is whether the

tumour possesses a well-defined outline or if it passes into the surrounding brain substance without any sharp line of demarcation. Circumscribed tumours originating in the meninges or in the cortical or subcortical regions of the brain can usually be shelled out or enucleated. In doing so large dilated vessels around the tumour are underrun and ligatured on either side of the line of section, and the removal of the mass is carried out with a blunt rather than with a sharp-cutting instrument. A special form of brain knife devised by Sir Victor Horsley is well adapted for this purpose. Incisions made into the brain substance should be made at right angles to the surface and large vessels avoided. The enucleation is most readily carried out with the help of a flexible spatula. A cyst of small size may be shelled out entire, but when large it will probably be safer to open it and dissect away its outer wall.

Subcortical growths may escape recognition during operation owing to their consistency differing little from that of the brain substance. Careful puncture may be necessary, or even microscopical examination of the tissue removed in a hollow needle.

In all intracranial procedures of this kind the use of irritating chemical solutions should be carefully avoided. Hæmorrhage, if merely in the form of a general oozing, can usually be arrested by gentle pressure with folded pieces of gauze rinsed out of hot saline solution. Hæmostatic forceps are not satisfactory as their employment is calculated to aggravate bleeding owing to the tendency on the part of the vessels to tear.

In the case of deep-seated definite vessels, silver clips, such as those devised by Cushing, may be applied with success.

Irrigation of the wound with a stream of hot saline solution at a temperature of 115° F. is useful. Following the removal of an encapsuled tumour, the cavity which it occupied quickly disappears with the resulting expansion of the brain.

Suture of the Dura is carried out with fine silk passed with a fully curved intestinal needle. The sutures are interrupted, and care should be taken to ensure as accurate a degree of approximation of the edges of the membrane as possible.

Drainage will be indicated if signs of oozing persist. A piece of rubber tubing is led away from the depth of the wound through one of the apertures in the bone, and reaches the surface either through a puncture in the flap or between the margins of the incision in the scalp. It need not be retained as a rule for more than twenty-four hours.

Suture of the Scalp wound completes the operation. Silkworm gut is employed, and perhaps a few sutures of horsehair in addition may be useful to ensure greater accuracy in coaptation of the wound margins. A large absorbent dressing is applied.

CEREBELLAR TUMOURS.—The first stage in the operation for the removal of a cerebellar tumour is accomplished most satisfactorily by the method of Cushing, viz., by a large craniectomy involving both cerebellar fossæ. This procedure has already been described in connection with subtentorial decompression. The dura is not opened, and silk sutures are inserted to mark the position of the sinuses.

The second stage will probably require to be postponed in most cases for a few days unless immediate relief is demanded and the condition of the patient is otherwise satisfactory.

The Incision of the Dura and Examination of the Cerebellum.—The incision in the dura is convex upwards with due regard to the position of the lateral sinus. The divided membrane in the form of a flap is turned downwards. The cerebellum is displaced, and in gaining access to the cerebello-pontine angle a broad, flexible metal

spatula affords much assistance. Great gentleness is necessary so as to safeguard the cardiac and respiratory centres in the medulla (Fig. 19).

The Removal of the Tumour.—The technique will depend on the site and the nature of the tumour, viz., intra- or extracerebellar, cystic or solid. Extracerebellar tumours occupying the cerebello-pontine angle are difficult to approach unless a free craniectomy has been performed so as to enable the cerebellum to be partially dislocated without a dangerous degree of compression. Artificial light is very useful in exposing

FIG. 19.—Method of gaining access to a Tumour situated in the Cerebello-pontine Angle. The lateral lobe of the cerebellum has been gently drawn aside by means of a flat retractor made of flexible metal, which enables it to to be suitably bent. The tumour occupying the cerebello-pontine angle is represented in its deep recess.

and removing tumours from this part of the cerebellar fossa. These usually have a pedicle, a circumstance which tends materially to facilitate their dislodgment and subsequent removal (Fig. 19).

Exposure of both lateral lobes of the cerebellum may be attended by a considerable degree of shock, the procedure is difficult, and there may be a large amount of hæmorrhage.

Suture of the Dura is performed as described in the preceding section, and drainage is established if considered necessary.

COMMENTS.

Hæmorrhage is one of the dangers to be anticipated in operations for the removal of intracranial tumours, but more especially when these have to be approached through the cerebellar fossa. The best methods of dealing with hæmorrhage during the various stages of the procedures have been already noted.

Ligature of one of the larger cerebral veins related to the outer surface of the cerebral hemisphere may be dangerous, as it may result in paralysis from cerebral œdema and softening (Cushing).

A plethysmomanometer applied to the patient's arm before commencing the operation will afford evidence of dangerous lowering of the blood pressure, if such should happen, from loss of blood and shock. As a preliminary measure it has been

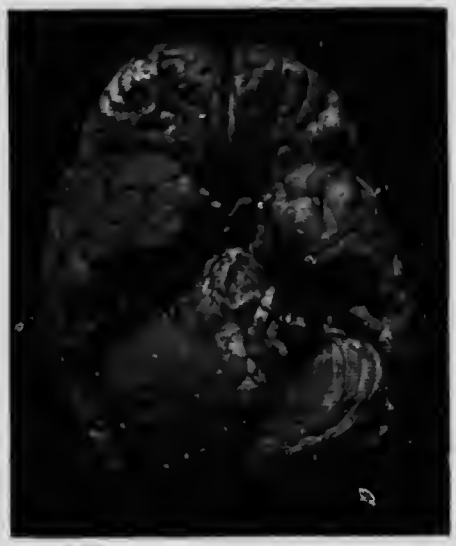

FIG. 20.—Tumour in the Left Cerebello-pontine Angle.

suggested to administer calcium chloride or horse serum preliminary to brain operations with a view to hastening the coagulation of the blood.

An ingenious method to diminish the risk of loss of blood has been recommended by Dawbarn, who applies an elastic tourniquet with a moderate degree of constriction to each lower limb, with the result that the veins become engorged, and a large volume of blood is retained here—sequestration anæmia. At the end of the operation the elastic bands are slowly removed so that the circulation may readjust itself gradually.

The amount of bleeding is greatly increased by any tendency to congestion of the vessels of the head during the administration of the anæsthetic. This tendency is one of the chief objections to ether, but if given skilfully and by the open method, the degree of congestion may be very slight. Chloroform is favoured by many, as it ensures more quiet respiration and less superficial congestion. Oxygen given at the same time appears to act very favourably.

Hernia Cerebri is an occasional sequel of operations on the brain. Protrusions of the brain through apertures in the cranium may be *primary* or *secondary*. The former tend to develop in cases of high intracranial tension resulting from intracranial tumours; the latter are determined by infection of the brain wound of a septic nature.

Shock is a frequent occurrence in these operations. Its chief determining causes may be regarded as (*a*) the sudden fall of the systemic blood pressure which takes place on relieving the intracranial tension; (*b*) loss of blood; (*c*) the anæsthetic.

MASTOID OPERATIONS.

The operative procedures which may be required in the mastoid region are—(1) an incision confined to the tissues overlying the mastoid process; (2) mastoid antrotomy; (3) the radical mastoid operation.

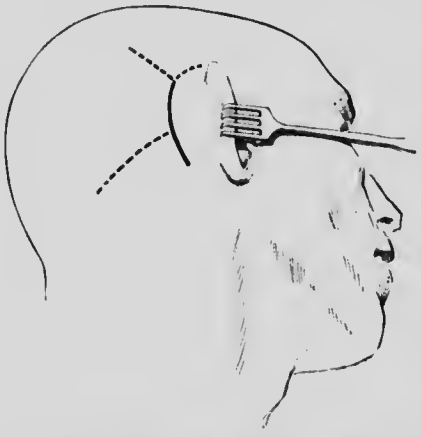

FIG. 21. Cutaneous Incisions in Mastoid Operations. The continuous black line represents the usual incision employed in mastoid antrotomy. The interrupted lines indicate the directions in which additional incisions may be made if it is considered necessary to expose the temporal lobe of the brain or explore the cerebellar fossa.

SUPERFICIAL MASTOID INCISION.

This will usually be required for circumscribed collections of pus resulting from suppurative periostitis. In such cases the pinna is red and thickened; it is pushed forward by the mastoid swelling, which is usually pronounced, and is accompanied by redness and œdema of the skin and subcutaneous tissues as well as obliteration of the retroauricular groove. Fluctuation can frequently be detected.

These abscesses usually result from acute inflammation within the tympanic cavity, the infection having made its way to the surface by way of the mastoid cells or through a membranous interval between the segments of the bone, which in the child or young subject have not yet fused.

Less frequently a superficial mastoid abscess may have had its origin in a furuncle of the external auditory meatus. In either case the incision will be made over the most prominent part of the swelling through all the tissues down to the bone. Hæmorrhage may be free at first, but it is seldom necessary to apply a ligature; a pledget of gauze usually suffices to arrest oozing. If a branch of the posterior auricular artery spouts, it should be secured by hæmostatic forceps, the crushing force of which is all that is necessary to occlude the vessel.

MASTOID ANTROTOMY.—In this operation the mastoid process is exposed, and a passage is tunnelled through it leading to the antrum. It may be required in certain acute cases when, owing to pain and fever, there is reason to believe that drainage by way of the tympanum is not sufficiently free.

The skin over the mastoid may be red and somewhat puffy, and usually there is marked superficial tenderness over its anterior portion.

Instruments.—Scalpel; hæmostatic and dissecting forceps; periosteal elevator; retractors; a mallet and gouges of various sizes; sharp spoons or curettes; a probe; sinus forceps.

THE OPERATION.—The area of the scalp in the vicinity of the mastoid is shaved

FIG. 22.—Mastoid Antrotomy. The tissues covering the outer aspect of the mastoid bone have been reflected and drawn forwards. The area circumscribed by the circle represents the site at which the bone is perforated. The interrupted lines serve to indicate the directions in which additional incisions may be made if it is found necessary to explore the temporal lobe of the brain or the cerebellum.

and disinfected beforehand. Just before the operation the tympanum and the external auditory meatus are irrigated with a weak antiseptic solution, and excess of moisture is subsequently removed with small pledgets of cotton wool held in forceps.

The operation needs a good light, and the procedure is best carried out with the aid of artificial light, the operator having an electric lamp and reflecting mirror adjusted to his forehead and the operating room or theatre somewhat darkened.

The Superficial Incision and Exposure of the Bone.—The pinna is held flat against

the head by the fingers of the left hand, while with the right the operator, following its upper and posterior borders, incises the tissues of the scalp and mastoid region, the scalpel being carried quite down to the bone.

The tissues investing the mastoid are reflected forwards and the operative area of the bone exposed, viz., the smooth part below the infratemporal crest and behind the upper and posterior part of the external auditory aperture, which can generally be recognised by the small projection known as the suprameatal spine (Fig. 22).

The Mastoid Resection.—With the aid of a gouge and mallet, the cortical layer of bone over the suprameatal area is scaled away, and the subjacent mastoid cells are exposed. In the same way the bone is penetrated more and more deeply in a direction forwards, inwards, and slightly upwards, parallel to the external auditory meatus until the antrum is reached.

The adjacent mastoid cells are now more fully opened in a downward and backward direction, care being taken not to wound the lateral sinus.

The aditus, or connecting passage leading forwards into the tympanum, is examined and its patency tested. The exposed area is flushed with warm saline solution and subsequently swabbed with a solution of carbolic acid in alcohol.

The mastoid wound will present a conical appearance, being much wider externally than internally and directed forwards, inwards, and slightly upwards. It is lightly plugged with a strip of iodoform gauze, after which the reflected tissues are replaced and retained by a few interrupted sutures.

The gauze plug is removed after twenty-four hours, the cavity irrigated, and the drainage tube inserted.

COMMENTS.

Risks attending the Operation.—1. Wound of the facial nerve would be likely to occur if the bony aperture were deepened too far in an inward and downward direction. Just behind the level of attachment of the membrana tympani is a mass of dense bone in which lies the Fallopian aqueduct with its contained nerve; consequently great care is necessary when using chisels or gouges close to this region.

2. Wound of the external semicircular canal could hardly occur if reasonable care is taken. The bony wall of the canal is exposed to injury at the inner side of the aditus, the position of which should be carefully investigated when the antrum is opened. Wound of the canal would open up a path for septic infection to the internal ear and to the posterior cranial fossa.

3. Wound of the lateral sinus might readily be occasioned by deepening the bony aperture too far backwards. The seriousness of this accident depends rather upon the possibility of infection reaching the sinus than upon the danger of hæmorrhage. The pressure within the sinus is low, and the arrest of bleeding from it consequently is not difficult. The best methods for effecting it are either to introduce a small strip of sterile gauze or else, having exposed part of the outer wall of the sinus, to detach it for a little distance all round from its bony groove and then press its outer wall inwards so as to obliterate the lumen of the channel.

Results of Antrotomy.—If antrotomy is reserved for acute cases, recovery usually follows the procedure just described.

Failure to progress to a satisfactory issue may be due to a multiple infection. It

is of importance that the same precautions in operative technique should be observed as if the operation were an aseptic one, lest micro-organisms other than those originally present should be introduced (Woods).

THE RADICAL MASTOID OPERATION.—In a certain percentage of cases purulent otitis media is followed by extension of the infective process to the mastoid antrum and cells, with resulting osteomyelitis and suppuration. There is persistent otorrhœa; discharges do not escape with facility, and masses of granulation tissue form within the tympanum, filling its cavity and surrounding the ossicles. The latter may become necrotic, loosen, and act as foreign bodies. Furthermore, after some time the mastoid antrum and cells may be found to have coalesced, following absorption of their thin, bony partitions, so as to form a large cavity with smooth walls and containing in its interior a pultaceous, cholesteatomatous mass. Under such conditions the mere opening up of the mastoid region is inadequate, and the radical operation about to be described is clearly indicated

FIG. 23.—This illustration represents the Completed Mastoid Dissection in the Radical Operation. The mastoid antrum and cells, the tympanic cavity, and the bony external auditory meatus have been converted in one large cavity. The dense mass of bone containing the facial nerve is seen in the depth of the wound. The dark area immediately in front of this is the fenestra ovalis which lodges the stapes. The walls of the cavity have been rendered as smooth as possible. I am indebted to Sir Robert Woods for valuable help in the preparation of this figure.

Preliminary Details.—The scalp is thoroughly disinfected and shaved for some distance above and behind the pinna on the affected side. The external auditory meatus is irrigated and mopped dry. The area of the operation is carefully surrounded by sterilised towels, and there is some advantage in having these of a dark material, for glaring white surroundings do not help the surgeon to see into the mastoid cavity (Fig. 23).

What has been already stated about good illumination under the heading of "Antrotomy" is also applicable here. A good electric head lamp and reflector may be regarded as essential to enable the operator to see clearly the parts which are progressively revealed as the mastoid wound is extended, and to follow out those paths along which pathological changes have advanced beyond the confines of the tympanic cavity.

The Operation.—*Instruments.*—These have been enumerated in the operation of antrotomy, and do not need to be recapitulated.

The Superficial Incision and Exposure of the Bone.—The same incision is made behind the pinna as for antrotomy, and the outer surface of the mastoid is exposed.

Bleeding vessels, chiefly branches of the posterior auricular artery, are secured by clip forceps.

In addition to drawing the pinna forwards and clearing the bone, the cartilage of the external meatus is detached above and behind and retracted forwards. This

FIG. 24.—The Operative Surgery of the Mastoid Region. Commencing at the usual mastoid incision behind the pinna two additional sections have been made upwards and backwards respectively. The trephine circles indicate the site of approach to the temporal lobe of the brain and the cerebellum. The mastoid cells have been opened and the antrum exposed.

renders inspection of the membrana tympani easy; it is invariably perforated and altered in character.

The Mastoid Resection; clearing the Tympanum, etc.—A fistulous opening is sometimes noted, especially in young subjects, in the exposed bone, and when present it forms a useful guide to the antrum. This latter and the cells surrounding it are

opened up as already described, and in addition the posterior bony wall of the external meatus is removed, but not completely. Near the level of the membrana tympani the lower part of this bony wall must be preserved, as it contains the facial nerve bending down within the terminal or vertical stage of the Fallopian aqueduct.

FIG. 25.—Dissection to demonstrate the Principal Intracranial Relationships of the Tympanic Cavity and the Mastoid Cells. The temporal lobe of the brain has been exposed above. The cerebellum will be recognised below and between both the lateral sinus forms a conspicuous object. A piece of flexible wire has been passed from the mastoid antrum forwards into the tympanic cavity.

By means of suitable forceps or by careful use of the gouge, chisel, and mallet, the outer wall of the aditus is removed, a bent probe or director in the passages serving as a guide meanwhile. This is perhaps the most critical stage of the operation, as it is now that the risk is greatest of wounding the facial nerve and the external semi-circular canal. Both the nerve and the canal are related to the inner wall of the aditus, and the nerve is also related to the floor of this passage.

The tympanic cavity is fully illuminated and cleared of all granulation tissue and debris. The ossicles, malleus and incus, too, are removed, but the stapes is left behind. Special attention is bestowed upon the attic or epitympanic recess, and the descending ridge of bone between it and the external meatus is cut away.

The resulting, bony cavity, which is made up of the external osseus meatus, the tympanum, aditus, antrum and mastoid cells, is rendered as smooth as possible, disinfected, and wiped dry.

Adjustment of the Cartilaginous Meatus and Closing of the Wound.—The posterior part of the cartilaginous meatus is now dealt with. Its contained cartilaginous tissue is excised as far as possible and its raw surface brought into contact with the posterior wall of the large bony cavity. To permit of this being done it is necessary to split the cartilaginous meatus, otherwise it could not be made to lie in accurate contact with the bony wall of the excavated mastoid cavity.

Those parts of the cavity which remain uncovered may subsequently be provided with Thiersch grafts or allowed to granulate and become covered with epidermis from the surrounding cutaneous surfaces.

COMMENTS.

1. Risks attending the Operation.—These have been dealt with in the preceding section, but in addition, wound of the dura mater in the floor of the middle cranial fossa may be mentioned. It is not of serious import unless overlooked and the membrane exposed subsequently to septic influences.

2. The Operation may be incomplete.—This may happen in consequence of some diseased tissue being left behind. It will account for persistence of the otorrhœa instead of complete cicatrisation and drying up of the cavity.

3. Varying Conditions of the Temporal Bone may be observed.—In children and young adults the antrum is more readily exposed than in those more advanced in years. In adults the mastoid varies in structure between a light cancellous texture and dense bone. In cases of the latter a pathological guide in the form of spaces filled by granulation tissue may be wanting, and the operator must rely on accurate anatomical knowledge and careful working to direct his progress.

In some cases of intracranial infection when the evidences are not at all clear as to the exact seat of the trouble (temporal lobe ; cerebellum ; lateral sinus), an accurate guide may be furnished by following up recesses filled by granulation tissue which communicate with the antrum. These may lead upwards to the middle cranial fossa or backwards to the cerebellar fossa.

Sometimes the entire mastoid is hollowed out into a cavity containing cholesteatomatous matter, the bony tissue having disappeared owing to a gradual process of rarefaction.

OTITIC ABSCESSES.

Intracranial suppuration following middle ear and mastoid disease may be found between the dura and the bone (extradural) between the membranes (intrameningeal) or within the substance of the brain (intracerebral). Collections within the brain substance are usually found either in the temporo-sphenoidal lobe or in the cerebellum, the former being involved much more frequently than the latter.

Considerable difficulty may attend the accurate localisation of the intracranial suppuration in these cases, and the operator may feel much in doubt whether to direct his efforts to the temporal lobe or the cerebellum. The safest course to adopt under such circumstances would be to open up the primary foci of the disease in the tympanum and mastoid antrum and then endeavour to ascertain by which path the infection had travelled intracranially, the fact that it travels upwards in the direction of the tegmen tympani and the temporal lobe more frequently than in a backward direction towards the cerebellar fossa being borne in mind.

Good illumination of the mastoid and tympanic cavities in the course of the operation may reveal a sinus discharging pus and lined with granulation tissue, which may give a direct lead to the site of the intracranial infection.

The method by which the mastoid wound may be extended is represented in Fig. 24.

TEMPORAL ABSCESS. If an abscess is suspected in the temporal lobe, a vertical incision is carried upwards through the scalp tissues, facilitating the exposure of the squamous segment of the temporal bone. The latter is perforated with a trephine or large burr and the aperture extended to the desired extent with cutting forceps. The best site for perforation is above and slightly behind the external auditory meatus (Fig. 24). The dura is raised slightly from the floor of the middle cranial fossa, and search made for extradural suppuration immediately above the tegmen tympani. Should it prove negative, the exposed dura is divided, the condition of the brain noted, and an exploring needle of adequate size introduced in a direction inwards, forwards, and slightly downwards. If an abscess is not tapped by one puncture, the needle should be withdrawn and again inserted, but in a slightly different direction.

If pus is revealed, a sinus forceps is introduced and its blades separated sufficiently to permit the abscess contents to escape. The opening must be free, as sloughs are often present in addition to thick, creamy, purulent fluid.

A rubber drainage tube is inserted and fixed in position, or the aperture leading into the abscess cavity may be loosely packed with gauze.

If a suspected abscess in the temporal lobe is approached without a preliminary mastoid investigation, the same area of the temporal bone is exposed as above. A suitable form of scalp incision is that recommended by Cushing in his operation of temporal decompression (see p. 47). The remaining steps of the procedure are similar to those just described.

CEREBELLAR ABSCESS. The occipital bone in the cerebellar fossa may be exposed by carrying an incision from the original mastoid wound backwards beneath the superior curved line and reflecting the occipital muscles downwards by means of a rugine.

The bone, which is usually very thin in the cerebellar fossa is perforated, care being taken to place the trephine or burr below the level of the horizontal and behind that of the descending limb of the lateral sinus. More frequently the procedure in opening up the cerebellar fossa will consist in removing the bone piecemeal in the mastoid region, extending the aperture already made with the gouge in a backward direction, so as to expose the lateral sinus and further back the lateral aspect of the cerebellum. This exploration will enable one to ascertain if the lateral sinus is thrombosed. The condition of the mastoid emissary vein may afford an accurate criterion of the condition of the sinus as this vessel will come into view at its point of emergence from the cranium in the course of the operation. The operator will note if it bleeds freely or if it is thrombosed.

The dura is incised and an exploring needle inserted in a direction forwards and inwards into the substance of the lateral lobe of the cerebellum.

The method of dealing with the abscess is similar to that just described for abscess in the temporal lobe.

LATERAL SINUS THROMBOSIS. It is well to remember that when thrombosis of an infective nature involves the lateral sinus there are other channels which communicate with the latter and may be implicated by an extension of the process. These are the internal jugular vein with which the sinus is continuous, the petrosal sinuses, the mastoid emissary vein, and the posterior condylar vein.

The extent of the sinus which may be involved in the process is variable. The

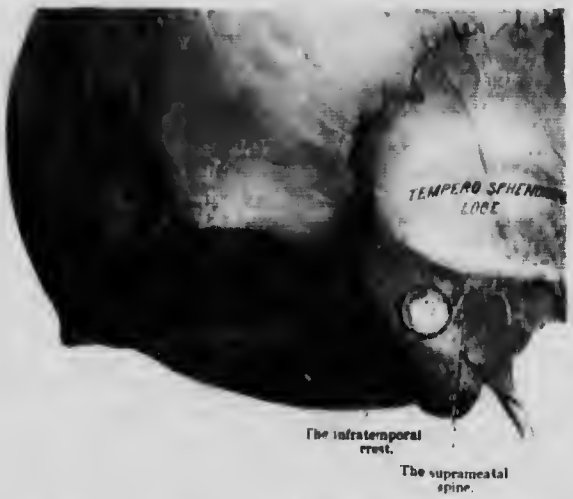

FIG. 29.—Side view of the posterior part of the Skull, showing the topographical Relationships of the Lateral Sinus to the operative Area of the Mastoid Bone. The area immediately behind the retro-meatal spine indicated by the circle, represents the site at which the bone is penetrated for the purpose of reaching the mastoid antrum and opening up the surrounding mastoid cells.

thrombus is situated most frequently in the forward bend which the sinus takes after entering upon its descending stage.

It may happen that the sinus, on being exposed in a case where the clinical symptoms point strongly to sinus infection, is found to contain liquid blood. A thrombus, too, within the sinus may present quite different appearances, depending essentially upon its duration. If recent, it may be dark and firm, but at a later period it will be found diffluent and puriform owing to disintegration having taken place.

The Operation.—Assuming that the mastoid region has been fully opened up as in the radical operation, the bone over the sigmoid groove is progressively scaled away until the wall of the sinus is exposed. Pus may be found between the groove and the outer aspect of the sinus.

Assuming that a healthy part of the sinus is exposed on the distal side of the

thrombus, a small pledget of gauze is inserted between it and the bone so as to obliterate its lumen.

The thrombus containing segment of the sinus is slit up, and the clot is removed either completely or only to a partial extent. The cavity is subsequently plugged with iodoform or xeroform gauze. Hæmorrhage may not occasion trouble, but if it should supervene, it can be easily controlled by plugging.

If the thrombus is extensive and undergoing disintegration, it will be advisable to expose the internal jugular vein in the neck at the level of the cricoid cartilage, ligature it in two places, and divide it between the ligatures. The proximal end is dissected up towards the base of the skull, its tributaries being ligatured at the same time. When this has been done the isolated segment can be drawn out of the wound and incised vertically above the site of the ligature. This enables the sinus to be thoroughly cleansed and flushed out from above without risk of infective emboli being carried into the circulation.

The posterior condylar vein, however, remains as a likely channel for the extension of septic infection downwards to the heart and lungs.

A drainage tube is placed in the distal segment of the vein in the neck, and another tube is employed to drain the sinus higher up. The cavity occupied by the decomposing clot is packed with gauze.

THE REGION OF THE UPPER JAW, AND THE MAXILLARY SINUS

EXCISIONS.—The operation of excision as performed in the upper jaw may involve but a small part of this bone or entail its almost complete removal with portions of certain other bones with which it is closely related.

In the ordinary excision of the upper jaw the degree of mutilation is very great, and serious functional disturbance may result from loss of support to the eyeball, in consequence of which it drops somewhat, and the patient suffers from the distress of double vision. Removal of the palatal segment of the maxilla with its mucoperiosteal covering brings the buccal and nasal cavities into open communication, so that great inconvenience occurs in speaking and in taking food. For these reasons partial or [illegible] as of the maxilla are to be preferred whenever they can be performed with safety and efficiency.

The Investigation of Growths involving the Maxilla. A careful examination is necessary [illegible]. Should the growth have originated in the maxillary sinus, it may by the time the patient comes under observation have extended upwards so as to involve the floor of the orbit, downwards into the palate, or inwards and project into the nose as a fungating mass. In an upward and inward direction the ethmoidal cells may be encroached upon, and even the base of the skull. Extension backwards may be followed by infiltration in the spheno-maxillary and temporal fossæ behind the jaw.

The following conditions would point to wide extension of the disease: the presence of an ulcerating and fungating mass in the roof of the mouth; displacement or limitation of the movements of the eyeball; a decided fulness at the inner canthus; a mass of growth occupying the posterior aperture of the nasal fossa on the same side as the maxillary disease; a fulness in the temporal or zygomatic fossa; marked prominence of the cheek.

Enlargement of the maxilla resulting from inflammatory conditions within the

antrum should be carefully differentiated from that due to neoplasms. In cases of malignant maxillary growths the condition of the cervical glands beneath the lower jaw and along the internal jugular vein should be ascertained.

PARTIAL EXCISIONS OF THE MAXILLA.—Indications.—Portions of the maxilla may be removed for disease of limited extent, situated, for example, in the palatal region, the alveolar border or beneath the floor of the orbit.

THE OPERATION.—In the case of an alveolar growth or epulis the procedure is simple. The section of the jaw is made wide of the disease. Vertical cuts are made into the alveolus in front of and behind the part to be removed, the teeth at the corresponding levels having first been removed. The piece thus delimited is detached from the main mass of the bone with chisel and mallet. Bleeding, which may be free, is most readily arrested by gauze pressure. The cut bony surface soon granulates and becomes epithelialised from the healthy gum at its periphery. After an interval of some months a suitable plate carrying teeth may be provided.

If the disease is situated in the vicinity of the orbital plate and the nasal process of the maxilla, it may be removed without interfering with the palatal segment of the bone as follows: An incision is carried from the inner canthus of the eye downwards between the side of the nose and the cheek, round the ala into the nostril, and vertically down through the paramedian line of the lip. The cheek is rapidly detached from the bone, and the mucous membrane divided close to its maxillary attachment in an outward direction. Bleeding vessels are secured. Three bone sections are now made. The first extends through the nasal process of the maxilla, the second through the malar process or through the malar bone itself (Fig. 28); the final section is directed horizontally outwards from the nasal aperture above and parallel to the plane of the hard palate, and is connected at its outer extremity with the malar section. The segment included between these sections is first loosened with a bone chisel and gently levered out. Forcible efforts to dislodge it might result in smashing it up and necessitate its removal piecemeal. If such should happen, there would be considerable risk of leaving some portions of the growth behind.

COMPLETE EXCISION OF THE MAXILLA.—Indications.—This operation is usually undertaken for the removal of growths which extensively involve the jaw, such as sarcomata, epitheliomata originating primarily in the antrum or involving the bone secondarily from the mouth, osteomata, odontomata, fibromata, likewise certain growths in the naso-pharynx. It may be carried out also when the bone is completely necrosed, but without the elaborate details described below.

Contraindications.—The operation is contraindicated for malignant growths which have invaded the surrounding parts, viz., the ethmoidal cells and the basis cranii, the zygomatic and pterygo-maxillary fossæ, the roof of the mouth on both sides of the middle line, and the orbit and the interior of the nasal cavity. Enlarged cervical glands are a contraindication also. Vascular growths of soft consistency, and which tend quickly to involve the tissues of the cheek, are to be regarded as very unfavourable for the radical operation. Too frequently it happens that maxillary growths which appeared suitable for removal are found during the course of the operation to be much more extensive than had been suspected.

Instruments.—Scalpels; hæmostatic, artery, and dissecting forceps; metacarpal saw; Horsley's jaw saw; Gigli's wire saw; aneurysm needle; lion forceps; bone

chisel; hammer; Paquelin's cautery; straight and curved scissors; retractors; flexible copper spatula; rugine; gag; laryngotomy tube; plug for the pharynx; needles, ligatures, and sutures.

Preliminary Measures.—Some days beforehand the condition of the teeth is investigated; those which are carious are removed, and deposits of tartar are scaled away. The mouth is rinsed several times daily with a solution of sanitas. The face is shaved. The patient receives a hypodermic injection of ¼ gr. morphin half an hour before the operation, and just before the anæsthetic is administered a solution of novocain and adrenalin may be injected into the tissues of the cheek and upper lip in the line of the cutaneous incision.

Preliminary Laryngotomy.—The patient is first anæsthetised in the usual way with gas and ether. Laryngotomy is then performed as described in another section, and a tube is introduced into the larynx through which the remainder of the anæsthesia may be maintained by means of chloroform. The operating table is arranged so that the patient's shoulders are raised and the head slightly thrown back. The jaws are separated by a gag, the tongue drawn forwards, and a gauze plug, with a piece of stout silk attached, is passed into the pharynx so as to occlude the inlet of the larynx. The end of the silk ligature is brought out at the angle of the mouth and allowed to hang down over the cheek.

Fig. 27.—The Lines of Cutaneous Incision in Resection of the Upper Jaw. This figure has been drawn from a photograph of a young woman aged twenty-one, in whom the operation was performed for a malignant growth involving the maxillary sinus.

The Steps of the Operation.—*The Cutaneous Incisions and Exposure of the Maxilla.*—A paramedian incision is made through the entire thickness of the upper lip from the aperture of the nostril downwards and through its red border. It is then carried round the ala of the nostril and upwards at the side of the nose to just below the inner canthus of the eye. A second incision commences at the upper extremity of the first or vertical incision about ¼ inch below the inner canthus, and passes outwards and slightly downwards to terminate beneath the malar prominence.

These incisions are accompanied by rather free bleeding, especially from the angular vessels at the inner canthus.

The flap included between these two incisions and comprising the tissues of the cheek is quickly raised, care being taken not to encroach too closely upon the growth if it is advancing in a forward direction. Bleeding vessels are controlled by hæmostatic forceps and sterilised swabs.

If the pharynx has not already been plugged, this is a suitable opportunity for doing so.

The Bone Sections.—These are three in number. The first extends through the malar bone near its junction with the maxilla, and is most conveniently made with Gigli's wire saw. Before this section is made the periosteum of the orbital floor is

raised, and the orbital tissues are retracted upwards. The Gigli saw is drawn into and through the outer extremity of the spheno-maxillary fissure with the aid of a curved aneurysm needle carrying a long loop of silk ligature. While this section is being made the eyeball and the tissues of the orbit are gently held back with a flat retractor (Fig. 28).

The second bone section is made with a fine saw or forceps, and extends through the nasal process of the superior maxilla. Before making it the lateral nasal cartilage is separated from its bony attachment, and the periosteum at the orbital rim is raised

FIG. 28.—Excision of the Maxilla. The large flap consisting of the tissues of the cheek has been raised and drawn aside. The lines of bone section are represented by interrupted black lines.

and the inner part of the orbital floor exposed, the inferior oblique muscle being at the same time detached from its site of origin. This incision, if prolonged backwards along the floor of the orbit, should meet the inner extremity of the spheno-maxillary fissure.

The third bone section traverses the palate. Before making it the central incisor tooth, if present on that side, is extracted, and the soft palate is detached from the hard palate posteriorly by a transverse incision. If the palatal tissues are healthy, the soft covering of the hard palate may be spared and detached from the bone in a manner similar to that performed in cleft palate operations. This bone section is most easily made with a narrow-bladed saw introduced into the inferior meatus of

the nose and made to cut through into the mouth, or, if preferred, Gigli's saw may be employed. This latter may be passed from the nose into the mouth through an aperture made in the hard palate near its posterior part by means of a curved trocar.

Extraction of the Maxilla.—A chisel is passed successively into each saw-cut, and by gentle to-and-fro movements the jaw is mobilised. The extraction is best effected, as a rule, by first passing a blunt elevator inwards at the back of the maxilla, between it and the pterygoid processes (pterygo-maxillary fissure), and loosening it here and dividing the attachments of the buccinator and pterygoid muscles with curved scissors. The entire mass is next depressed by the operator's two thumbs placed against the infraorbital rim and dislocated forwards. In doing so the infraorbital nerve and artery are exposed and divided far back, and the remaining attachments of the bone are severed with scissors or scalpel.

Arrest of Hæmorrhage and Inspection of the Wound. Bleeding vessels are controlled by rapidly filling the large chasm with muslin compresses. These are made to press firmly for a few seconds, and on being removed any spouting vessels are seized with hæmostatic forceps and ligatured; some may require the actual cautery. Search is carefully made for any outlying masses of the growth, and if found, they are removed.

Suspicious portions of tissue are swabbed with a strong solution of zinc chloride (grs. 40 to 1 ounce).

Sometimes the maxilla, instead of coming away *en masse*, may break at its posterior part, and unless care is taken, some of the disease may be left behind. To prevent this occurrence all rough and projecting pieces of bone at the back of the cavity should be detached with cutting forceps and removed. It may happen, too, that subsequent to the extraction of the maxilla the operator realises the fact that the orbital cavity has already been invaded, although previous to the operation no evidence of this fact could be ascertained. In view of such a contingency, it is desirable that the consent of the patient to removal of the eyeball should be obtained before the operation is undertaken in case such a step should appear necessary at this stage.

Removal of the Pharyngeal Plug and Suture of the Facial Wound. The plug is removed from the pharynx, and the large wound cavity is packed with a long strip of iodoform gauze, the end of which is brought out through the aperture of the nostril. If the coverings of the hard palate have been spared, they are sutured to the divided edge of the mucous membrane of the cheek, and in this way one may succeed in cutting off the buccal cavity from the nasal fossa on that side. The cheek flap is replaced and sutured, accurate adjustment being of great importance, more particularly at the red labial margin and where the incisions meet near the inner canthus. The sutures are passed in interrupted fashion, and the materials employed are silkworm gut and horsehair. A few additional sutures of fine catgut serve to adjust the mucous membrane of the lip on its deep aspect.

The Dressing.—Two or three muslin swabs rinsed out of warm boracic solution are applied to the wound, the eye being covered at the same time. Over these is placed a piece of sterile gamgee tissue, and all made secure by a muslin bandage.

COMMENTS.

Hæmorrhage.—Free bleeding sometimes attends the removal of maxillary tumours; and, as the patients affected may be already anæmic and in a cachectic state, an attempt may be made to diminish the loss of blood by the application of a temporary or permanent ligature to the external carotid artery

Owing to the risk of interference with the cerebral circulation, ligature of the common carotid artery is not to be recommended.

Preliminary Laryngotomy.—We unhesitatingly recommend this procedure in all cases of excision of the maxilla. It possesses the following advantages: (1) the risk attending the excision is diminished; (2) the operation is greatly facilitated by abolishing oral respiration and by obviating the necessity for perpetual sponging; (3) the anæsthetist can proceed without interruption instead of taking turns with the operator; (4) the time required for the operation is lessened; (5) there is very slight involvement of the neck tissues. With tracheotomy, on the other hand, the deeper tissues are opened up more extensively, and consequently it is a more serious operation.

Aspiration Pneumonia.—More than one-half of all deaths after this operation are referable to pulmonary complications. Kronlein considers most of these latter to be the results of aspiration during anæsthesia, and supports his opinion with the surprisingly good results in his own cases, which were operated upon under more or less suggestive anæsthesia, and show a mortality of 2·8 per cent. (Von Bergmann).

The Extraction of the Jaw.—The technique usually recommended whereby the maxilla is seized with lion forceps and wrenched away from its surroundings is attended by the risk of crushing the infiltrated and softened bone. A safer method is for the operator to stand behind the patient's head, and with both thumbs applied against the infraorbital rim to depress the maxilla and gradually detach it from its surroundings. An elevator passed in behind the jaw in the direction of the pterygo-maxillary fissure is of material assistance in effecting its detachment in this direction.

The Floor of the Orbit.—The importance of preserving this has already been alluded to in connection with partial excision of the maxilla (p. 66).

Preservation of the Palate.—The soft coverings of the hard palate may be preserved and subsequently connected by suture with the tissues of the cheek. If this cannot be done, the palate defect may be rectified by means of an obturator fitted by a dentist when the wound in the mouth has fully healed.

The Question of Recurrence.—The results of this operation are by no means satisfactory.

At the Zurich surgical clinic recurrences were observed after an average of 3·9 months in all cases of malignant tumour involving the entire jaw. In the Erlangen statistics one permanent cure was recorded in 17 cases. In the Greifswald statistics of 17 cases there was not one permanent cure; Estlander found 10 recurrences in 12 operations. In the Goettingen clinic of 74 total resections, with 23 deaths, Martens found 16 permanent cures. Stein has recently reported from Von Bergmann's clinic that of 13 resections for carcinoma of the upper jaw between 1890 and 1900 not one of those whose record was obtainable was living at that time. After total resection of the upper jaw on account of carcinoma recurrence took place on an average about 3·6 months after the operation, while death usually took place after 13 months. The prognosis is more favourable in cases of sarcoma. The permanent cures in 47 cases of total resection at the Berlin surgical clinic Stein estimates at 12·6 per cent. Cases of partial resection have shown permanent cure for at least three years in 50 per cent. of the cases (Von Bergmann).

Post-operative Treatment.—After twenty-four hours the plugging is removed, and

the large chasm is syringed daily with some mild antiseptic solution, which is introduced through the nostril and allowed to escape by the mouth as the patient sits up with the head leaning forward. The mouth is rinsed occasionally with a weak solution of sanitas.

It is advisable to let the patient sit up as soon as possible, *i.e.*, within the first five or six days.

Shock may be avoided by preventing excessive loss of blood and by operating expeditiously. Should the patient's condition appear low after being brought back to bed, a pint of warm saline solution may be administered per rectum and repeated, if necessary, in four or five hours.

The administration of liquid nourishment should be attended to; the patient generally takes it well.

The sutures in the face wound may be all removed on the fifth day, by which time it will be found securely healed.

When healing within the mouth is complete the services of the dentist may be requisitioned.

GROWTHS WITHIN THE NASAL FOSSÆ AND THE NASO-PHARYNX.

General Considerations.—Naso-pharyngeal tumours vary in their structural characters and in their mode of connection with the surrounding parts. The most common form of malignant growth in this region is endothelioma; sarcoma is sometimes observed here, but epithelioma is excessively rare.

Naso-pharyngeal endotheliomata are noted most frequently in young adult males, and are most unsatisfactory for treatment except in their early stages. These growths have a tendency to develop insidiously, and glandular metastases, which may supervene early, often present inflammatory characteristics, with the result that their real nature is liable to be overlooked and the primary growth unsuspected until its increasing proportions render its recognition quite obvious.

Naso-pharyngeal growths may be attached to the basis cranii by a comparatively narrow stalk or pedicle, but more frequently they have a broad area of attachment to the roof of the naso-pharynx, from which they extend forwards to the roof of the nose. One of their most striking features is their marked vascularity. They contain large vessels, and the veins may assume a cavernous arrangement and occasion great difficulty and danger in the course of the operative procedures which are described below.

Sometimes naso-pharyngeal tumours attain an enormous size, gradually encroaching upon the surrounding parts, pushing down the soft palate, filling the upper part of the pharynx and extending perhaps forwards into the nose. Those of a rapidly growing tendency may ulcerate and bleed.

Naso-pharyngeal tumours which are of limited dimensions and pedunculated may be removed without great difficulty by means of a galvanic wire loop passed through the nose. Where the tumours are large, however, broadly attached, and possessing a sarcomatous structure, this method is not satisfactory, as it does not remove the entire mass, and, notwithstanding the cauterising effect of the wire, copious bleeding may occur. The procedures about to be described have for their object the adequate exposure of the tumour and its area of attachment so that it may be possible to remove it as well as the tissue from which it springs.

Routes of Approach. 1. Through the Mouth. The procedure of Gussenbauer, a modification of that introduced by Nelaton, is perhaps the best by this route.

The patient lies on the back, the head hanging over the end of the table, as in the operation for cleft palate. A median incision is carried through the soft palate and the uvula and extended forwards through the soft coverings of the hard palate for about an inch where two additional incisions are made, each running outwards and slightly backwards across the corresponding segment of the palate. By raising the two muco-periosteal flaps and dividing the attachment of the soft palate to the hard palate on its nasal aspect the posterior part of the hard palate will be exposed, and may be removed by a process of morcellation. The mucous membrane of the floor of the nose is divided close to the septum, and portion of the latter is removed. The growth can now be more closely defined, but for the purpose of extirpation the access afforded by this palatal route is not quite sufficient except for growths of limited dimensions.

2. Through the Nose. This method of approach has been recommended by Rouge. By dividing the mucous membrane at its reflection from the upper lip to the maxilla and detaching the tissues from the bone in an upward direction the pyriform aperture of the nares can be exposed. There is still a considerable distance intervening between the nasal aperture and the seat of the disease, and for this reason the access afforded is totally inadequate for the object in view.

Another procedure, devised by Ollier, aims at exposing the nasal cavities from the front by turning the nose down, but it too may be rejected for similar reasons.

3. The Naso-maxillary Route. In this procedure the anterior surface of the maxilla is exposed; its nasal process, the anterior and inner walls of the maxillary sinus, and also some of the bony framework of the nose are removed. Through the large opening thus established the naso-pharynx is well exposed. The following are the steps of the operation:

Exposure of the Maxilla.—The cutaneous incision extends downwards from the inner extremity of the eyebrow, beside the root of the nose and the cheek, and, around the ala into the nostril. For greater facility in removing the bone, another incision about an inch in length may be made below the infraorbital rim, commencing in the first a little below the inner canthus of the eyelids. With a periosteal elevator the tissues covering the nasal and maxillary bones are carefully raised and held aside.

The Bone Resection.—The soft tissues all around the exposed area are well retracted, and then, commencing at the bony aperture of the nose and by means of a cutting forceps, the nasal bone and the nasal process of the maxilla are progressively resected. This is followed by resection in whole or in part of the anterior wall of the maxillary sinus, and subsequently the inferior turbinal and even the posterior part of the septum may be resected if more room is necessary. The posterior wall of the antrum is readily chipped away, and the pterygoid processes of the sphenoid bone may be removed if additional room is required.

The Removal of the Tumour.—Owing to the free bleeding which is certain to occur, it will be advisable to perform laryngotomy, introduce a tube, and pack the lower part of the pharynx so as to prevent blood from entering the larynx. This may be done as a preliminary measure before resecting the maxilla, etc.

The injection of a 5 per cent. solution of adrenalin into the tissue at the base of the tumour may have an excellent effect in diminishing the amount of blood lost. The detachment of the growth will be effected with a blunt knife or raspatory, and care will be taken not to allow the instrument to penetrate deeply into the bony tissue at the basis cranii.

Suture of the Facial Tissues. Oozing of blood from the roof of the naso-pharynx will have been arrested as far as possible by gauze pressure, and, if thought desirable, a gauze plug may be introduced and pressed firmly against the bleeding surfaces. The face wound is adjusted by means of sutures of silkworm gut and horsehair, and the end of the gauze plug is brought out through the nostril. The resulting deformity is very slight, as the orbital rim is not interfered with, and the sinking in of the cheek is slight.

COMMENTS.

Other methods have been employed for the removal of growths from the naso-pharynx, notably that in which access is afforded by a temporary or osteoplastic resection of the upper jaw. In this form of procedure the maxilla is mobilised and turned aside pending the removal of the naso-pharyngeal growth. Our experience of these osteoplastic resections has not been satisfactory, and we prefer to adopt one of the procedures described above.

THE MAXILLARY SINUS.

EMPYEMA OF THE MAXILLARY SINUS. Pus in the maxillary sinus may occur as the result of infection from a carious bicuspid or molar tooth of the upper jaw or from extension of suppuration from the nasal cavity.

There are many methods of treating suppurative conditions in the antrum. For diagnostic purposes the antrum may be punctured through the naso-antral wall of the inferior meatus of the nose by means of a trocar cannula and the cavity syringed out.

In cases of empyema consequent upon infection from a carious tooth it is essential to extract this and provide drainage by puncturing the antrum through the tooth socket by means of an antrum trocar. This opening, which may be enlarged by means of burrs, is kept patent by inserting a suitable rubber antral plug which is removed daily for the purpose of irrigating the cavity with an antiseptic lotion.

In recent cases such treatment may be efficient in bringing about a cure, but in the more chronic cases radical methods are usually necessitated by the persistence of suppuration.

THE CALDWELL-LUC OPERATION. Instruments. Retractor, scalpel, scissors, pressure forceps, periosteal elevator, gouge, Hajek's bone punch, Wood's curved mucous membrane separator, malleable curettes, needle-holder, fully curved needle, and catgut. Good illumination is provided by a Clar's head lamp.

The Operation.—When the patient has been anæsthetised a naso-pharyngeal plug of gauze is introduced to prevent the passage of blood from the nasal cavity into the pharynx and trachea. A sponge is also inserted between the cheek and gums.

With the upper lip retracted upwards and outwards by an assistant who stands above the head of the patient, an incision is made through the mucous membrane over the canine fossa down to the bone. The incision should be about 1½ inches in length, and should be about ½ inch above and parallel to the alveolar margin. The muco-periosteum is dissected upwards and the canine fossa exposed.

By means of a gouge an opening is made into the antrum and enlarged to the necessary extent with Hajek's bone punch or rongeur forceps.

The diseased and polypoid mucous membrane is dissected carefully off the interior of the cavity and removed.

Particular attention must be paid to small recesses in which fragments of diseased mucous membrane may lurk, and which, if left behind, may vitiate the results of the operation. These may be removed by the use of the curette, their position being indicated by a small post-rhinal mirror introduced into the cavity.

The next step consists in gouging a large opening through the naso-antral wall into the inferior meatus.

It is very seldom necessary to remove any part of the inferior turbinated body. To avoid injury to the nasal duct this opening should not be made too far forward.

The antrum is packed with ribbon gauze, one end of which is brought out through the opening in the inferior meatus. The original incision in the mucous membrane should be closed with a few catgut sutures. The wound usually heals by first intention.

After-treatment.—The plugging is removed through the nose on the following day. If any purulent discharge is observed, the cavity may be syringed with boric lotion or peroxide of hydrogen through the naso-antral opening. This treatment should be continued until all discharge has ceased.

THE FRONTAL SINUS.

EMPYEMA OF THE FRONTAL SINUS.—This condition may be treated either by the intranasal route as practised by Halle, or by the external method as recommended by Killian.

Owing to the impossibility of reaching all the recesses of the sinus through the nose, most surgeons nowadays resort to the external method in spite of the fact that some degree of deformity usually results.

KILLIAN'S OPERATION.—This procedure is suited to all cases, since it affords access to the ethmoid cells, a point of some importance in view of the fact that these cells are frequently infected simultaneously with the frontal sinus.

Instruments.—Scalpel, scissors, dissecting forceps, pressure forceps, retractors, small trephine, rongeur forceps, malleable curettes, and gouge.

Steps of the Operation.—General anæsthesia by nitrous oxide gas and ether is employed as a rule.

The eyebrows having been previously shaved or thoroughly sterilised, an incision carried right down to the bone is made along the length of the eyebrow towards the middle line, and then curved downwards and outwards for ½ inch over the nasal process of the superior maxilla.

The skin and periosteum are next dissected upwards, and the anterior wall of the frontal sinus is trephined, the opening being subsequently extended by rongeur forceps so as to obtain free access to the cavity. The supraorbital ridge should be preserved intact to obviate deformity.

All degenerated mucous membrane is carefully separated from the sinus and removed. The mucous membrane generally peels off readily, the use of the curette being seldom required. In fact, this dangerous instrument can be entirely dispensed with for this purpose, a piece of muslin swab being substituted with greater safety

for separating the mucous membrane, particularly when working in the region of the posterior wall of the sinus, against which the frontal lobe of the brain abuts, since injury to this bone is liable to lead to suppurative meningitis or brain abscess.

Having cleared the sinus, the next step consists in providing for free drainage into the nose by enlarging the fronto-nasal opening into the middle meatus. In doing this every precaution should be taken to preserve the pulley of the superior oblique muscle.

If the ethmoidal cells are involved, they can be curetted through an opening made into the nasal process of the superior maxilla, due precautions being taken to avoid perforation of the cribriform plate and the os planum of the ethmoid in the curetting process.

If sufficient drainage into the nose has been provided, it will be possible to suture completely the original skin wound, gauze plugging being inserted into the cavity, and one end brought out through the nose to facilitate its removal after twenty-four hours.

In many cases it will be found a safer policy to close the incision partially and insert a rubber drainage tube through the wound. This can be gradually shortened until finally dispensed with as the cavity becomes filled up with granulation tissue

The deformity following this operation is occasionally somewhat disfiguring. It is especially marked in those cases in which the frontal sinus is of large dimensions and where the wound is not completely sutured at the time of the operation. The depression can, however, if desired, be partially obliterated by subsequent subcutaneous injections of paraffin.

THE LOWER JAW.

EXCISION OF THE LOWER JAW.—The resection operations which are performed for disease affecting the lower jaw vary in extent from the removal of a limited area of the alveolar margin to that of a large segment of the bone. Apart from the removal of portions of the jaw, a temporary resection is sometimes performed, *i.e.*, the bone is divided, usually in its horizontal segment, and by drawing the parts widely asunder access is provided to the posterior part of the buccal cavity and the upper region of the pharynx.

Indications.—The following are the principal conditions for which a limited or extensive resection of the lower jaw may be required: (1) the various forms of epulis; (2) epitheliomatous growths arising in the floor of the mouth or in the lip and subsequently extending to the gum; (3) sarcomata, peripheral or central; (4) extensive necrosis of the jaw, resulting from acute periostitis due to dental caries, phosphorus poisoning, etc.

RESECTION OF A PART OF THE ALVEOLAR MARGIN.—The area of the disease may be so limited that it is possible to remove the affected part without destroying the continuity of the jaw. This is a material advantage, as it obviates the difficulties in mastication which are likely to ensue after resection of a portion of the whole thickness of the bone from failure of the teeth to meet.

The technique in these limited resections is simple, and the procedure can usually be carried out efficiently through the widely opened mouth. In a typical case a vertical cut is made through the alveolar margin on each side of the growth, any teeth

requiring removal having first been dealt with. A horizontal section of the bone is then made with a bone chisel at a safe distance beneath the zone of disease. A limited operation of this kind may sometimes be carried out under local anæsthesia with novocain and adrenalin

RESECTION OF THE MEDIAN SEGMENT OF THE LOWER JAW. This is usually required for extension of an epithelioma from the under-surface of the tongue or floor of the mouth to the jaw.

Division of the Lip and Reflection of the Tissues from the Bone. The patient lies on the back; the shoulders are slightly raised, and the head bent forwards.

FIG. 20.—Excision of half of the Lower Jaw. The tissues covering the outer aspect of the bone have been reflected and drawn upwards. The facial vessels have been ligatured opposite the anterior border of the masseter. The mucous membrane has not yet been divided. The line of bone section is represented close beside the symphysis menti.

A vertical incision is carried through the lower lip and the prominence of the chin to the submental region, and from this two additional incisions are prolonged outwards and backwards in the direction of the tip of the mastoid process, each incision describing a slight downward curve. The two flaps thus outlined are quickly dissected from off the bone, and bleeding vessels are secured with hæmostatic forceps.

The Bone Sections. These are made one on each side of the middle line, their exact levels having first been carefully determined. The bone is partially divided with a saw, and then the section is completed with bone-cutting forceps. Before the jaw is divided holes are drilled in its lateral segments for the introduction of wire later on. Drilling is difficult after the bone section has been made.

Removal of the Growth with the Detached Segment of the Jaw.—It is of importance to remove the diseased tissues *en masse*. The submaxillary lymphatic glands and the upper glands of deep cervical chain, together with their surrounding connective tissues, are raised on each side. One or both submaxillary salivary glands may be included in the resection if there is reason to suspect their involvement, or with a view to render the lymphatic dissection more thorough. A stout ligature of silk passed through the tongue near its tip draws it forwards and upwards while the muscles, genio-hyoids and genio-glossi, attached to the back of the symphysis are being divided. Both sublingual salivary glands will necessarily be included in the resected parts.

Introduction of a Prosthetic Apparatus between the remaining Jaw Segments.—The two portions of the jaw which remain have a great tendency to approach each other and narrow the space for the tongue. The latter, too, having been deprived of its anterior attachments, is liable to fall backwards and threaten suffocation by closing

the entrance of the larynx. A suitable wire frame should be inserted between the divided segments of the jaw so as to keep these at their normal level, or a piece of perforated metal capable of being bent into the proper shape may be interposed between the lateral segments of the jaw and fastened to these by wire. Later on when the wound within the mouth has healed, the gap may be filled with a permanent prosthetic apparatus carrying teeth.

FIG. 30.—The jaw has been divided by a Paramedian Incision. The mucous membrane also has been divided both on its outer and its inner aspect. The left segment of the jaw has been seized with powerful forceps and depressed in order to bring the coronoid process into view and facilitate the division of the tendon of the temporal muscle.

EXCISION OF HALF OF THE LOWER JAW. Instruments. Scalpels; hæmostatic, artery, and dissecting forceps; rugines; blunt dissector; aneurysm needle; Horsley's jaw saw or a Gigli wire saw; bone-cutting forceps; lion forceps; stout scissors, straight and curved; retractors; needles; ligatures and sutures; drainage tube.

The Cutaneous Incision and Reflection of the Tissues attached to the Jaw. The head and shoulders of the patient are raised and brought well to the side of the table on which the operator stands. The incision in the lower lip commences about ¼ inch below its red border, and extends across the chin to about ½ inch below the level of the symphysis. A second incision is carried outwards from this at least ½ inch below the horizontal ramus of the jaw. Its posterior extremity curves upwards, and terminates in front of the tragus, or it may be continued backwards between the angle of the jaw and the mastoid process. The horizontal portion of the incision is deepened, and the facial vessels are isolated in front of the masseter muscle, doubly ligatured, and divided. The outer aspect of the jaw is stripped of its coverings, care being taken in the case of a tumour not to encroach upon it too closely. It may be possible in some cases to save only the overlying skin. In this stage of the operation the cavity of the mouth is not opened, as the mucous membrane passing from the cheek to the bone has not yet been divided (Fig. 29).

The inner aspect of the jaw is dealt with in a similar manner, *i.e.*, the mylo-hyoid and the internal pterygoid muscles are detached, but the mucous membrane passing from the jaw to the tongue should still remain intact in order that blood may be prevented from getting into the mouth.

Division of the Jaw and Disarticulation.—The jaw is divided near the symphysis. To do this it is necessary to divide the mucous membrane for a limited distance on both aspects of the bone, and to extract one of the teeth, usually the lateral incisor, unless this is wanting. The section of the bone may be carried out very satisfactorily with a Gigli saw.

The mucous membrane on the outer aspect of the jaw and the buccinator muscle are now divided and the cheek flap raised. The cut extremity of the horizontal ramus is seized with lion forceps, and as it is drawn outwards the mucous membrane on its inner aspect is divided from before backwards at a safe distance from the disease.

The isolated segment of the jaw is now depressed so as to bring down the coronoid process from beneath the zygomatic arch and facilitate the division of the tendon of the temporal muscle. This is usually accomplished with strong scissors, the surrounding tissues being at the same time fully retracted (Fig. 30).

By depressing the jaw still further it may be possible to divide the external pterygoid muscle close to its insertion just below the condyle and the external lateral ligament. The bone, now firmly held by forceps, is forcibly twisted outwards by a rotatory movement; its remaining attachments give way, and it usually comes away without further cutting. The inferior dental artery which has been torn will require a ligature.

Closure of the Wound: Drainage.—The wound is closed with interrupted sutures of silkworm gut and horsehair. A drainage tube is inserted at its posterior angle, and extends upwards towards the glenoid fossa. In some cases the mucous membrane of the tongue can be subsequently united to the skin of the cheek and lip by sutures of catgut, and this is a material advantage in promoting the primary closure of the wound.

COMMENTS.

The External Incision.—It is not necessary as a rule to divide the red border of the lip; it may facilitate matters, nevertheless, to do so if the growth is large (Fig. 31).

The horizontal limb of the incision is placed in the submaxillary region, as the resulting scar will be less obvious, and it may be possible through its posterior part to ligature the external carotid artery, if such a course should appear advisable to the operator. Kocher carries this part of the incision from the hyoid bone along the submaxillo-cervical crease to a point a finger's breadth behind and below the angle of the jaw and from thence up to the apex of the mastoid process. This incision also safeguards the lower branches of the facial nerve which supply the muscles of the lower lip and the angle of the mouth.

Hæmorrhage.—It is usually possible to prevent blood from getting into the mouth during the earlier stages of the operation, as the mucous membrane reflections are preserved intact for the most part until the saw-cut has been made. After this, further bleeding can be supervised and the access of blood to the pharynx prevented by pulling the jaw outwards and placing a swab between it and the tongue. The internal maxillary artery may be wounded in the manipulations attending the dislocation of the jaw. In carrying out this step the diseased segment of the bone, held by forceps, may, as it is twisted forcibly outwards, draw out the vessel at the same time, and if the scissors or scalpel be used too freely in dividing the tissues on the deep aspect of the neck of the jaw, the artery, with its companion vein, will run considerable risk of being wounded.

The inferior dental branch of the internal maxillary artery must be avoided when the operator is engaged in detaching the internal pterygoid muscle from the deep

aspect of the ascending ramus of the jaw. If the clearing of the bone is carried up too far, the artery runs the risk of being wounded as it approaches the inferior dental canal.

Post-operative Treatment.—The chief indications here are the administration of adequate nourishment to the patient and keeping the mouth as clean as possible.

Owing to the difficulty in swallowing, a soft rubber nasal tube will be found

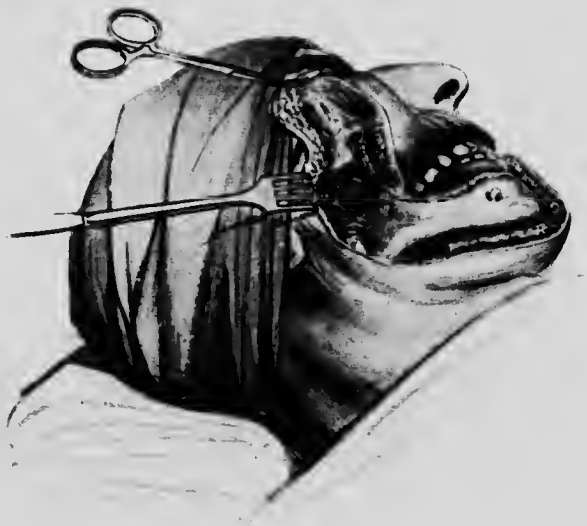

FIG. 31.—Excision of half of the Lower Jaw. In this figure the lower lip has been completely divided, the incision traversing its red border. The tissues covering the bone have been reflected and held aside.

admirably suited for feeding the patient. Salines introduced per rectum are useful in combating shock and improving the quality of the pulse.

The mouth should be washed out at frequent intervals with a weak solution of sanitas or euthymol.

It is advisable to let the patient sit up soon, as it facilitates breathing and the clearing of the mouth; the danger of aspiration pneumonia too is lessened.

Preliminary Laryngotomy.—This may be performed if the tumour in the jaw is large and possibly somewhat adherent to its surroundings. The dissection and disarticulation may be tedious in a case of this kind, and there may be great difficulty in preventing blood from trickling back into the throat. Under such conditions a plug in the pharynx may be indispensable.

OPERATIONS UPON THE LIPS.

Plastic operations performed upon the lips are sometimes required to repair the loss of tissue resulting from trauma, but more frequently they are necessitated for the removal of cancerous growths or for the correction of deformities such as ectropion of the lower lip, atresia of the buccal aperture, etc.

One of the most important points to be attended to in these operations is to arrange that the flaps which are destined to repair the loss of tissue in the lips are provided

FIG. 32.—Excision of an Epithelioma of limited extent involving the Lower Lip.

with mucous membrane on their deep aspect, otherwise the exposed raw tissue will granulate and undergo a marked degree of cicatricial contraction.

When the amount of tissue removed from the lower lip is of limited extent, as occurs with certain epitheliomatous growths, the resulting gap has a V-shaped outline, the margins of which are readily brought together. The laxity and pliability of the tissues greatly facilitate these operations, so much so that direct union of margins of the gap may be accomplished when one-third or even half of the lip been removed.

When more than half of the lip must he removed direct union of the portions which remain, although possible, would have the effect of causing a very unsightly deformity. It will be necessary in such cases to employ some plastic procedure.

THE OPERATIVE TREATMENT OF CANCER OF THE LIPS.—The lower lip is much more frequently affected than the upper; indeed cancer involving the upper

lip is comparatively rare. The site and extent of the disease in the lower lip vary : it may involve a small area of the labial margin and present a well-defined warty character ; occasionally it commences at the commissure of the lips, and in some cases the greater part of the affected lip may be involved by the time the patient applies for treatment. In extensive cases of the latter type examination may reveal fixity of the diseased part to the jaw and possibly a perceptible infiltration of the submaxillary lymphatic glands.

Operative Procedures.—The extent of the procedure to be adopted in a case of lip

FIG. 33.—Method of introducing the sutures to connect the divided margins of the lower lip after the excision of a V-shaped segment. The uppermost suture appears on the cut surface on each side between the coronary vessel and the edge of the mucous membrane.

cancer will necessarily depend upon the site and extent of the disease, and of course in all cases the excision of the labial growth must be supplemented by a clearance of the lymphatic glandular area connected with the affected part.

General Preliminary Details.—The condition of the mouth must be carefully attended to; and if the front teeth are in a highly septic state, they had better be removed some days beforehand. The mouth will be rinsed frequently with some suitable antiseptic solution, such as carbolic acid, 1 in 80, or sanitas, a tablespoonful to a pint of water. The face will be shaved and cleansed in the usual way before the operation.

Operation for a Growth of Limited Extent.—Assuming that the epithelioma is situated between the middle line and the commissure of the lips, it will be excised by

a V-shaped incision, and the submaxillary space will be cleared at the same time. The glandular dissection is first undertaken and followed immediately by the operation upon the lip.

The Submaxillary Dissection.—The glands which are connected most intimately with the lower lip are those situated within the submental and the digastric triangles beneath the jaw. The submental glands are connected with the median or central segment of the lip, those in the digastric triangle with the outer part of the lips, including the angle of the mouth.

When the dissection is performed for a limited growth involving the lip between the middle line and the commissure the submaxillary space is exposed by turning up a flap of the superficial tissues and removing both the submaxillary lymphatic glands, with their surrounding connective tissue, and the submaxillary salivary gland as well.

The cutaneous incision commences just beneath the symphysis menti whence it is carried downwards to the hyoid bone and then outwards in the direction of the tip of the mastoid process. By turning up the superficial tissues the facial vessels are exposed where they cross the lower margin of the jaw in front of the masseter muscle, and are divided between ligatures. The submaxillary salivary gland in the course of dissection is raised and the facial artery again secured just above the posterior belly of the digastric muscle; it is ligatured here and divided. Wharton's duct is exposed as it passes beneath the mylo-hyoid muscle and divided. The further clearing of the space is readily accomplished, and the employment of a dry muslin swab rolled around the index finger will be found very helpful in stripping away the glandular and connective tissues. All bleeding from visible vessels is carefully controlled and the wound closed by a series of interrupted sutures, drainage being provided for at its outer angle by means of a perforated glass tube.

As the lymphatic vessels beneath the lower jaw communicate freely across the middle line, it will be advisable to remove the glands from both sides except perhaps when the labial growth is of quite limited extent.

The Removal of the Growth.—This is accomplished in the manner represented in Fig. 32. The surgeon grasps the lip at the commissure on his side, and his assistant with the left hand grasps it at the opposite commissure. By so doing the lip is steadied and made tense, and the coronary vessels are effectively controlled. The first cut is made by transfixing the lip at a point vertically beneath the centre of the growth and dividing the tissues up to and through the red margin, the knife emerging at a point not less than ½ inch from the visible margin of the growth. The assistant now with his right hand seizes the labial commissure on the side of the section; and the surgeon, having grasped the growth in his left hand, makes the second section through the lip from the free margin fully ½ inch from the zone of infiltration down to the starting point.

The Sutures.—The first suture, which consists of silkworm gut, is passed on each side at the junction of the red border of the lip with its cutaneous surface. It includes all the tissues of the lip with the exception of the mucous membrane. The next suture is introduced through the wound margins at the apex of the V-shaped section and knotted. By drawing these two sutures apart the wound margins are approximated, and the remaining sutures are more readily introduced, the precaution being taken in passing the needle to traverse all the tissues of the lip with the exception of the mucous membrane. The inclusion of the latter would lead to inversion of the opposing margins and delay in the healing process.

The first suture at the junction of the skin with the red labial margin should extend

beneath the divided coronary artery on each side of the wound. By so doing it approximates the tissues and at the same time controls bleeding. If the coronary vessels are not controlled, bleeding may continue and cause trouble by filling the mouth and possibly getting into the air passages.

By everting the sutured lip it will be possible to inspect the mucous edges of the wound; and if these do not come satisfactorily into contact, they may be adjusted by a few additional sutures of fine catgut.

The Dressing.—The wound is wiped dry and painted over with collodion, after which a little antiseptic powder may be dusted on.

OPERATIVE PROCEDURES FOR EXTENSIVE CANCERS INVOLVING THE LOWER LIP. — The autoplastic methods which are employed in these operations consist in raising one or more flaps and transferring them by gliding, displacement, or torsion to the part to be repaired. The flap or flaps may be taken from the cheek, from the chin and neck, or from the upper lip. Flaps taken from the tissues of the chin and neck are not to be recommended, as they are devoid of mucous membrane on their deep aspect; the raw tissues granulate, and the cicatricial contraction which takes place results in marked deformity of the new lip and its firm adhesion to the jaw.

FIG. 34.—The lines of incision in Dieffenbach's operation for the excision of epithelomatous growths which extensively involve the lower lip.

DIEFFENBACH'S PROCEDURE. —The nature and extent of this operation will be rendered clear by a reference to the adjoining Figs. 34 and 35. It is well adapted to cases in which the lower lip must be excised in the whole or the greater part of its extent, as it provides for the lateral displacement of two flaps which can be brought together without tension and are provided with mucous membrane on their deep aspect.

In its complete form Dieffenbach's operation is employed to restore the entire lower lip, and flaps are raised on each side, but when the amount of tissue to be replaced is less it may only be necessary to raise a flap on one side.

Just as in the operation for cancers of limited extent, the surgeon's efforts must be directed to the removal of the growth and the clearance of the lymphatic area beneath the lower jaw on both sides.

The Excision.—The growth which occupies the greater part of the labial margin and infiltrates the tissues beneath this is removed by two incisions which meet below at the chin. Bleeding vessels are secured with forceps, and blood is prevented from flowing back into the mouth. If the growth extends up to the angle of the mouth, a short incision must first be carried outwards into the cheek on each side.

Detachment and Mobilisation of the Flaps.—While the surgeon makes the tissues of the cheek tense by the left index finger passed beneath its mucous surface, an incision is directed outwards from the former angle of the mouth in the direction of the external auditory meatus, but it stops short about an inch in front of the tragus. The tissues of the cheek are progressively divided up to the level of the anterior border of the masseter muscle, but behind this level the superficial tissues only are divided, so as to safeguard the lobules of the parotid gland and the filaments of the facial nerve. Before dividing the mucous membrane in the anterior part of the wound the facial vessels are secured and divided between ligatures. The mucous membrane is next divided in the floor of the gaping wound as high up as possible, so as to provide an adequate amount for the inner surface of the new-formed lip. The section of the membrane is made with scissors outwards as far as the masseteric border and thence downwards to where the membrane is reflected on to the jaw. The next incision starts at the outer angle of the cheek wound in front of the ear, and is directed downwards into the submaxillary region parallel to the margin of the defect in front, but it only involves the superficial tissues over the masseter muscle (Fig. 35).

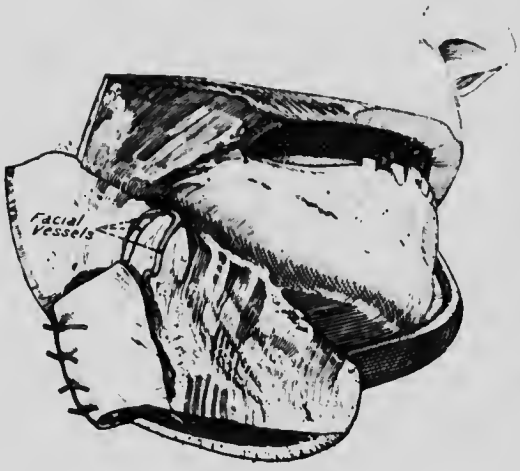

FIG. 35.—Dieffenbach's procedure for the plastic restoration of the lower lip. The lip has been removed by a wide V-shaped incision and the right lateral flap outlined in Fig. 34, has been reflected. Note the quadrilateral area of mucous membrane destined to invest the corresponding half of the new lip. The facial vessels which are the main supply of the flap have been preserved.

The flap thus outlined is detached from the jaw, and in doing so the mucous membrane is divided along its line of reflection from the cheek to the bone. The further separation is facilitated by dry muslin swab, with w tissues may be wiped aw from the jaw without ris facial vessels. The mob of the flap is carried down to a point ab it two fingers' breadths beneath the jaw, and, with the submaxillary space thus freely opened up, the clearance of its contained lymphatic glands, together with the submaxillary salivary gland, can be carried out in the manner already described, care being taken to preserve the facial artery.

A similar procedure is undertaken on the opposite side, and subsequently the submental region is exposed and cleared of its contained glands.

Adjustment of the Flaps.—If the mobilisation of the flaps has been satisfactorily performed, they can now be drawn together so as to cover the large labial gap and meet by their anterior margins without tension. These margins are connected by some interrupted sutures, and then the free border of the new lip is adjusted by introducing some additional sutures which connect the cut mucous and cutaneous margins. The mucous membrane of the flap is carefully adjusted at the angle of the mouth, and outside this the tissues of the flap are sutured to the margin of the wound in the

cheek. A triangular defect is left on each side, but it may be obliterated for the most part by drawing its margins together by suture. Its lowest part is left open so as to prevent the retention of discharges.

Union of the flaps is usually satisfactory as they are provided with a good blood supply, but they should not be compressed by tight bandages for fear of gangrene taking place.

SYME'S OPERATION.—This procedure is sometimes employed for epithelioma which extensively involve the lower lip. If the growth has reached the angles of the mouth, an incision is carried outwards on each side into the cheek, and from the outer extremities of the horizontal cuts two more incisions are directed downwards, circumscribing a V-shaped mass of tissue and meeting at or beneath the chin. The lip is rapidly dissected from the bone, and bleeding vessels are seized with forceps.

The Mobilisation and the Adjustment of the Flaps.—Each lateral flap is outlined by an incision which, commencing at the angle of the V-shaped defect, extends downwards from the prominence of the chin to the hyoid bone and thence outwards and upwards to a point in the vicinity of the angle of the jaw. The flaps are raised, and when sufficiently mobilised are brought together in the middle line and adjusted by sutures of silkworm gut and horsehair. The mobility of the superficial tissues in the neck usually permits of the closure of the wound here.

A drainage tube is introduced in the submaxillary region.

This operation of Syme is apt to be followed by contraction of the new-formed lip, and for this reason we consider it inferior to that of Dieffenbach.

FIG. 36.—Lines of incision in Cheatle's procedure for the excision of an epithelioma involving a limited area of the free border of the lower lip.

CHEATLE'S PROCEDURE. — This operation aims at getting outside the zone of infiltration of the growth by cutting wide of it on all sides and at the same time removing the lymphatic glands beneath the jaw, together with the vessels which drain into these from the area of disease in the lip, the parts removed being taken away *en masse*.

In a case of cancer of limited extent midway between the angle of the mouth and the centre of the lip, two incisions are made, as represented in Fig. 36. These commence on the free margin of the lip fully $\frac{3}{4}$ inch from the growth, and as they traverse the lip from above downwards they diverge slightly as far as the lower border of the jaw. From this they are made to converge in the form of a V and meet at a point midway between the jaw and the hyoid bone. In their upper portions the tissues of the lip are completely divided, but lower down the incisions do not extend deeper than the subcutaneous tissue and the platysma. The affected area of the lip and its muscles are detached from the bone, but the cutaneous area lower down is taken away in continuity with the lymphatic glands and the connective tissue in the submaxillary region.

The inner margin of the wound is reflected to a sufficient extent to enable the submental triangle to be cleared.

From the apex of the V-shaped gap a curved incision is carried downwards and

outwards as far as the anterior border of the sterno-mastoid muscle. The flap so outlined is raised and held aside so as to facilitate the removal of the submaxillary lymphatic glands and the salivary gland as well.

Before connecting the flaps by suture they must be freely undercut so as to diminish tension as far as possible. Drainage will be provided for by means of one or two tubes in the submaxillary region.

When a limited growth involves the central segment of the lip the procedure employed will closely resemble that just described, and the lymphatic dissection will be carried out on both sides.

HARE-LIP.

In a case of simple hare-lip, where the defect is limited to the soft tissues, operation ought to be performed at an early period, but not before the end of the second month after birth. The operator will, of course, be influenced by the general state of health of the child and the way in which nourishment is capable of being taken.

Operation for Simple, Unilateral Hare-lip.—When the lip is affected in association with the palate it is advisable to rectify it first, because an attempt to deal with the palate during infancy is attended by considerable risk, and for the additional reason that the union of the two segments of the lip helps in course of time to diminish the degree of separation of the palatal segments.

In addition to the mere paring and junction of the two sides of the gap in the lip, there are two special objects to be aimed at, viz., to prevent a depression or notch at the free margin of the lip and to diminish the degree of flattening of the nostril on the side of the defect.

Instruments.—A fine, narrow, sharp-pointed tenotome; a small scalpel; some fine pointed clip forceps; dissecting forceps with serrated points; straight, blunt-pointed scissors of the Mayo pattern; sharp-pointed scissors. For double hare-lip there will be required in addition a periosteal elevator; stout cutting scissors; a gouge.

Mobilisation of the Lip.—The child having been anæsthetised with chloroform, the operator proceeds to mobilise each segment of the lip by dividing the mucous membrane which binds it down to the alveolar arch. On the inner side the process of undermining is carried up to the nostril, all the available tissue being detached from the bone (Fig. 37). On the outer side the tissues of the lip and cheek are detached freely from the maxilla, and as a rule it will be necessary to detach the ala of the nostril from its bony attachment. This latter step is particularly indicated when the alveolar border is cleft. It will now be possible to bring the two lip segments together without tension. In order to diminish the bleeding, we find it advantageous to inject a few minims of adrenalin in sterile water into the submucous tissues with a fine hypodermic needle a few minutes before making these incisions.

Paring the Lip Margins and the Introduction of Sutures.—The operation about to be described is that which was first described by Mirault. It consists in fashioning a flap, usually from the inner border of the gap, having its attached part below and its free extremity directed upwards and capable of being applied beneath the opposite border after this has been freely pared. Should the flap be properly made and adjusted by suture, the resulting free margin of the lip should not show any trace of an unsightly notch.

Formation of Flap.—The inner margin of the gap is seized at its lower angle with forceps provided with long blades and mouse-toothed extremities. It is pierced with a sharp and slender knife at a point vertically below the nasal columella and at about ¼ inch from its free border. This provides the flap with a relatively broad base. The

Fig. 37.—Mirault's Operation for Unilateral Hare-lip. The extent of the incision in each margin of the cleft is indicated. The interrupted line at the outer side of the ala of the nostril represents the extent to which the tissues of the cheek and the nostril require to be mobilised before an attempt is made to connect the margins of the gap by sutures.

Fig. 38.—Mirault's Operation. The outer margin of the gap has been pared throughout. On the inner side of the gap the red margin retains its attachment below and is drawn across to form the free border of the lip.

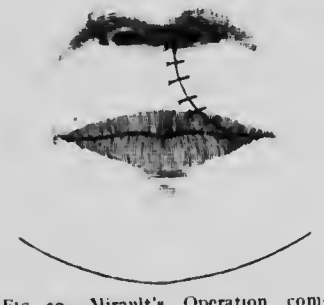

Fig. 39.—Mirault's Operation completed.

Fig. 40.—The Operation of Mirault for Unilateral Hare-lip as modified by Meleux.

cutting edge of the knife is then turned somewhat obliquely upwards and outwards, and emerges in the gap after having traversed a distance of approximately ¼ inch.

Paring the Outer Segment of the Lip.—This margin is freely pared from its upper extremity down to and for a short distance beyond its junction with the lower or horizontal border of the lip, this latter part of the section corresponding in extent with the flap just raised (Fig. 38).

Assuming that the two margins of the gap have been adequately pared throughout, the first suture is introduced in such a way as to approximate the angle on the outer lip segment with that point on the opposite segment corresponding with the

re-entrant angle caused by drawing the flap downwards. This is the predominant suture of the series. If properly applied, the two angles should present an accurate degree of adjustment. The next sutures approximate the margins of the gap above this, and finally the small flap is fixed securely to the raw surface on the lower border of the outer segment of the lip. Very fine needles carrying sutures of horsehair are to be employed here. A few additional sutures should now be introduced between the mucous edges of the lip by turning it up and exposing its deep aspect.

The Operation of Mirault as modified by Meleux.—In Mirault's operation the adjustment of the thin, free extremity of the detached flap is attended with some difficulty. In order to obtain better surfaces for uniting with each other, Meleux divided the lower border of the outer segment of the lip in such a way as to leave a notch to receive the

FIG. 41.—Malgaigne's Operation for Unilateral Hare-lip. Lines of incision.

FIG. 42.—Malgaigne's Operation. The red margins have been detached from the upper extremity of the gap down to the labial margin. They still remain connected here, however, and are drawn down, as represented in the figure, preparatory to removing the excess of tissue on each side.

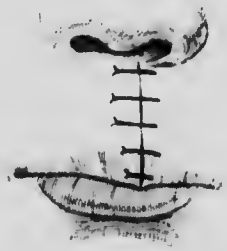

FIG. 43.—Malgaigne's Operation. The margins of the gap connected by sutures.

truncated extremity of the flap raised from the opposite side. We frequently employ this method, and find it very satisfactory.

Malgaigne's Operation.—At one side of the gap a slender, sharp bistoury is pushed through the lip at the junction of its cutaneous and mucous surfaces and made to cut upwards towards the nostril so as to detach a flap with its base below. The same procedure is carried out upon the opposite side. Both flaps are drawn downwards so as to render it possible for their raw surfaces to be brought together and to establish a projection at the free border of the lip instead of a notch. The degree of projection can be easily regulated by cutting away a small portion from each flap. It should be remembered, however, that a degree of projection that might at first sight appear somewhat [illegible]ghtly will tend to diminish with the subsequent cicatricial changes along the line of union. See the adjoining Figs. 41, 42, 43.

Dressing.—Little is required in the way of dressing. It will be sufficient to apply a little boracic or salicylic ointment twice daily for the first few days. Various devices have been employed to prevent any tendency on the part of the lip segments to draw apart, but they are not necessary as a rule, and, besides, they must be irksome and a source of worry to the child.

Removal of the Sutures.—If not all, at least the majority of the sutures will be removed on the fifth day. If there should appear to be any tendency for the wound

margins to part company, one or two of the chief supporting sutures may be left in until the seventh day.

Bilateral Hare-lip. Usually the two gaps in the lip are separated by a central lobule of varying proportions, but too short to extend down to the free border of the lip in the attempt at its repair.

The simplest procedure in these cases is to detach a flap from the outer margin of each gap.

The undermining of each lip and the mobilisation of the nostril are carried out in the same way as has been described in the operation for single hare-lip.

Fig. 14.—Unilateral Hare-lip.

Fig. 15.—The same child as represented in Fig. 14 after operation by Mirault's procedure.

The Central Lobule.—The red border is cleanly cut away along each side and along the lower border of the central lobule.

The Lateral Flaps.—The length and depth of these flaps will depend upon the width and vertical extent of the interval which must be obliterated. Their breadth must be such that when secured beneath the median lobule they will reinforce it sufficiently to reconstitute the normal depth of the lip. Before introducing the sutures the flaps are brought together and examined. If too long, they may be trimmed down to the required extent; if too short, the lateral incisions may be prolonged further into the cheek on each side somewhat obliquely upwards and outwards.

The lines of incision and the manner in which the flaps are manipulated are explained in the adjoining figures.

This operation is applicable to cases in which the defect in the lip is unassociated with any projection of the alveolar portion of the maxilla. Should the maxillary protrusion be sufficient to prevent the approximation of the labial tissues, it must be dealt with in the first instance. The cases in which this may be required are—

(1) unilateral hare-lip, associated with unilateral deficiency of the alveolar margin; (2) bilateral hare-lip, associated with bilateral deficiency of the alveolar margin.

Unilateral Defect in the Alveolar Margin.—There are two ways of dealing with the maxillary projection: it may be removed or bent backwards.

Removal of the Projection.—An incision is made along the lower border of the prominent alveolus, and the overlying soft tissues are raised by means of a periosteal elevator. The denuded bone is then snipped off with a bone-cutting forceps. The result of this removal of the alveolus is to leave an unsightly gap. The lip too has a tendency to recede from want of support behind.

Bending backwards of the projecting alveolus may be accomplished either by osteoclasis or by osteotomy.

Osteoclasis.—This is only applicable in very young subjects in whom the

FIG. 46.—Double Hare-lip. The lines of incision are indicated on each side. The curved interrupted line at the outer side of each ala nasi is meant to represent the extent to which the tissues of the nostril and cheek must be undermined in order to enable the defects to be closed without injurious tension.

FIG. 47.—Double Hare-lip. The margins of the defect connected by sutures.

premaxilla is but slightly prominent, but with considerable mobility and supported merely by a rudimentary septum, and fibrous rather than bony in structure.

The labial tissues are first mobilised, and then by a succession of backward pressure movements the bone is fractured and the projecting part rendered sufficiently flexible to enable it to be moulded in whatever way it is desired.

Osteotomy.—This entails a triangular resection of the vomer, as the result of which it is possible to cause a recession of the premaxillary tubercle. A simple division of the septum may suffice. Following it, pressure from the front causes the two portions of the divided septum to overlap one another and the premaxilla to recede to a corresponding extent.

The Operation.—*Mobilisation of the Premaxillary Tubercle.*—A longitudinal incision about 1 inch in length is made along the free border of the septum behind the tubercle. The mucous membrane and the periosteum are then detached on each side with a periosteal elevator. A cuneiform piece may now be removed or the septum merely divided, whereupon the projecting tubercle can be displaced backwards.

Should the premaxilla be too voluminous to permit of its displacement between the two lateral maxillary segments, it will be necessary to remove a small amount of

tissue from each of its lateral margins, if possible, without interfering at the same time with the dental follicles. Of course the final backward displacement of the premaxilla will be preceded by a paring of the margins of the gap by which it is bounded on each side. If this device fails, the mucous membrane covering the bone may be incised and turned aside to permit of the main part of the bone with the temporary incisions being scooped out with a gouge.

Fixation of the Premaxilla.—Some consider fixation of the premaxilla by sutures unnecessary, and rely entirely upon the back pressure exerted upon it by the upper lip. A few sutures, however, on each side are to be recommended. If the premaxilla is too small for the median gap, it may be retained by suture on one side only. The retaining sutures may include only the muco-periosteal tissues, or may penetrate more deeply into the bone.

The Defect in the Lip.—The bilateral defect is usually treated at the same time and in the manner described above.

COMMENTS.

The Best Time for Operation is after the second or third month. For most cases the third to the sixth month is the best. All should be over by the seventh month, when dentition begins. "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" (Jacobson).

Death from Dyspnœa may follow the closure of large defects, as the upper lip when restored in the manner described is tight, it overhangs the lower, and the nostrils at the same time are flattened and partially closed. The result is that but little breathing space is left, and respiration may be impeded to such a degree as to cause death from suffocation. Difficulty in breathing following the operation is best relieved by depressing the lower lip.

The Premaxillary Bone should be preserved. If not, a permanent gap is left in the hard palate, and the upper lip tends to become flattened and to recede with respiration. The loss of the premaxilla, too, prevents the satisfactory adjustment of false teeth at a subsequent date.

Hæmorrhage during the operation may be diminished or almost entirely prevented by the injection of a weak solution of adrenalin into the tissues of the lips before these are pared.

Rest after Operation is important, and in order to keep the child quiet chloral in small doses may be administered (Treves).

CLEFT PALATE.

Congenital deficiencies of the palate vary in extent. The least degree of defect is that in which the uvula is bifid; the most extensive is that in which the cleft involves both the soft and the hard segments of the palate up to and including the alveolar arch of the maxilla.

Uranoplasty is the term employed to indicate the operative procedure performed for the closure of the gap in the hard palate.

Staphylorrhaphy signifies the procedure which is applied for the rectification of the defect in the soft palate.

Age at which Operation is performed.—Opinions differ as to the most appropriate time for operating in cases of cleft palate. Some are in favour of intervening in early infancy; others would postpone operation until the fifth or sixth year. We prefer to undertake the treatment of these cases at the end of the second year. At this period the tissues of the palate are better developed and are not so delicate as in the infant; the child has not yet learned to speak, and is more easily managed.

The procedure about to be described is that which is applicable to a case in which the defect is complete, extending from the alveolar margin in front to the uvula behind (urano-staphylorrhaphy). It consists in the formation of two flaps derived from the muco-periosteal covering of the hard palate and the tissues of the soft palate. Both flaps are freely mobilised, and while still securely attached by their two extremities are brought together in the middle line and connected by suture, the opposing margins having first been carefully pared and consisting of well-vitalised tissue.

Instruments.—The special instruments and appliances required for this operation are a gag; a straight, sharp-pointed bistoury for paring the margins of the cleft; a stout, short-bladed knife with a long handle for dividing the tissues of the palate preparatory to the detachment of the flaps; one or two pairs of mouse-toothed dissecting forceps with long handles; special cleft palate raspatories; suction apparatus to rid the mouth of blood and saliva; cleft palate needles with handles; tongue forceps; ligature and suture materials.

Preparatory Measures.—The health of the child should be carefully attended to, and such conditions as nasal catarrh or pharyngitis should be treated by appropriate measures. If adenoids and enlarged tonsils are present, they should be removed as a preliminary measure. Teeth with evidences of decay tend to promote post-operative sepsis, and must be treated by appropriate measures.

A well-trained nurse is indispensable in the management of these cases, and some days should be allowed to elapse before operation to permit of her gaining the confidence of the little patient.

URANO-STAPHYLORRHAPHY.—The child is placed upon a rather low and narrow table, and chloroform is administered. As soon as anæsthesia is well marked the shoulders are drawn up to the edge of the table and the head made to hang down with the vertex pointing towards the ground and well supported beneath. The child's clothing should be so arranged that nothing can constrict the neck or chest.

Three or four assistants are necessary as a rule: one to administer chloroform; another to attend to the suction apparatus for removing blood and saliva from the mouth and throat; a third to assist and hand instruments: the fourth assistant holds the tongue forwards and maintains the head steady.

The mouth is opened widely with a suitable gag, and the tongue drawn forwards by forceps and so maintained during the operation.

Paring the Margins of the Palate.—The operator commences with the margin of the cleft on his right by seizing it near its tip, rendering it tense, and transfixing it at its junction with the hard palate. By a series of to-and-fro movements of the knife

the margin is then pared in a backward direction. The knife is again entered at the commencement of the incision and made to cut forwards to the anterior extremity of the gap, and in so doing care is taken to preserve the continuity of the strip of tissue which is being detached. The opposite margin of the cleft is then treated in the same way. These incisions may give rise to fairly free bleeding which fills the mouth and obscures the view of the operator. The blood should be quickly removed at intervals with the aid of the suction apparatus, but if this is not available, a piece of sponge or little muslin bags containing pledgets of wool and held in forceps may be utilised instead.

The Lateral Incisions.—These must be of liberal extent, and are made as far outwards as possible. Each incision commences directly over the tip of the hamular process of the sphenoid bone behind the last molar tooth, and as it is carried forwards

Fig. 48. Complete Unilateral Cleft of the Palate. Drawn from a stereoscopic photograph taken at the time of operation by Mr. C. Arthur Ball, F.R.C.S.I. The child's head is represented hanging over the end of the table in Rose's position, and the lines of incision in the palate are indicated on each side.

it runs close beside the teeth, and terminates at the level of the canine tooth. Where this incision involves the soft palate it does not extend deeper than the submucous layer, but along the hard palate it goes directly to the bone. The free bleeding which attends these lateral incisions may be restrained by digital pressure maintained for a few seconds, and all blood which collects within the mouth is rapidly removed by the suction apparatus.

Mobilisation of the Flaps.—In carrying out this step of the operation care must be taken to damage the tissues of the flaps as little as possible. Each flap is first detached from the bone to a slight extent by working with the raspatory progressively from before backwards to the junction of the soft with the hard palate. By repeating this procedure the portion of the flap which belongs to the hard palate is quickly raised up to the margin of the cleft. The flap is still rigidly held at the junction of the soft with the hard palate where the aponeurosis of the soft palate is attached

This must next be divided, but in doing so the flap must not be injured on its palatal aspect. The detachment can be readily accomplished by introducing a curved, blunt-pointed tenotome from the lateral incision, so that its point emerges in the cleft. Then by a to-and-fro cutting movement the palatal aponeurosis is easily divided by an incision involving the palatal flap on its nasal aspect. When this step has been completed the corresponding flap will be found flaccid and quite free between its attached extremities, and when both sides have been dealt with the two flaps should

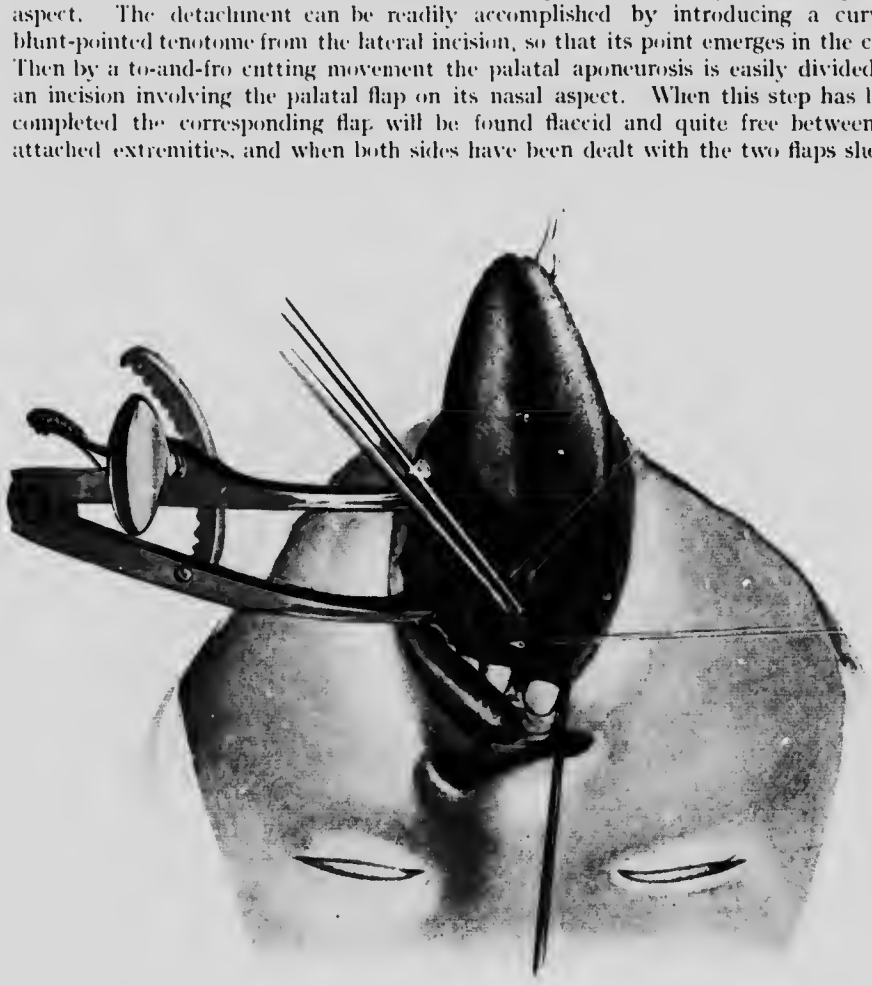

FIG. 49.—Urano-Staphylorrhaphy. The palatal flaps have been mobilised and the first suture introduced at the level of junction of the soft with the hard palate. By drawing upon the two free ends of this suture the inner margins of the flaps are drawn together and the introduction of the remaining sutures thereby facilitated. Drawn from a stereoscopic photograph taken at the time of operation by Mr. C. Arthur Ball, F.R.C.S.I.

be capable of coming together in the middle line without any appearance of tension. The mouth is again cleared of blood so as to facilitate the next step of the operation.

The Sutures.—The best suture materials are silkworm gut and silver wire. We prefer the latter as it is easier to ensure accurate approximation of the margins of the flaps by its use than with fishing gut. However, with proper care this material should be made to serve the purpose well. Fine needles should be employed. Operators have different choices as to the form of needle best suited for passing sutures within the confined space of the mouth. Some employ small curved needles which are passed

with a needle-holder; others prefer needles with handles, and these, provided they are sufficiently fine, are easier to manipulate.

Silver wire, gauge 6, is well suited for cleft palate operations. The individual sutures are separated by intervals of about $\frac{1}{3}$ inch.

We find it convenient to pass the first suture at the level of junction of the hard with the soft palate, as its two free ends when drawn upon bring the inner margins of the freely mobilised flaps into contact and greatly facilitate the introduction of the remainder of the series.

This first suture is passed as follows: A cleft palate needle provided with a handle

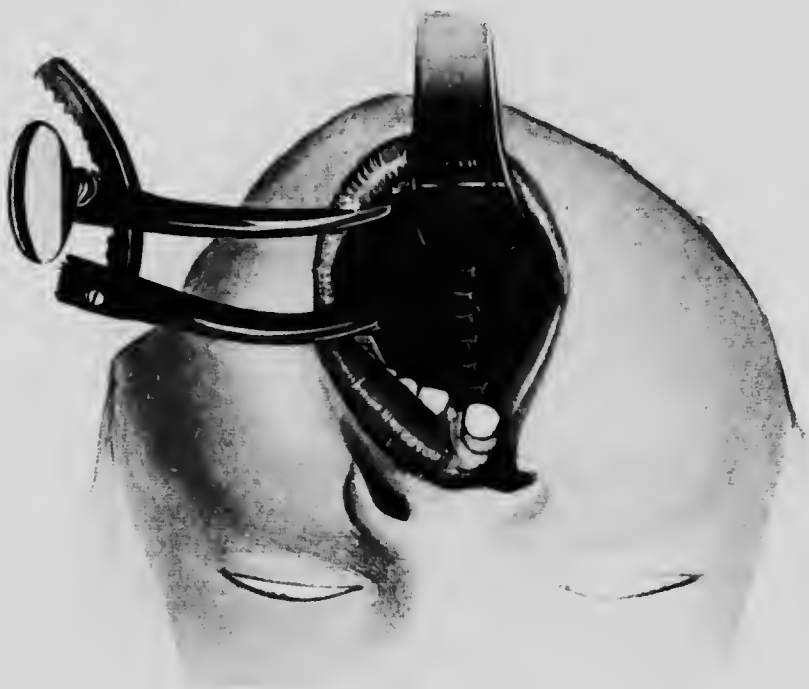

FIG. 50.—Urano-Staphylorrhaphy. The operation completed. Drawn from a stereoscopic photograph at the time of operation

is threaded with a suture of fine silkworm gut, the mid-point of the suture occupying the eye of the needle. The latter being held in the right hand the palatal flap on the operator's right side is caught at its inner free margin with a pair of long, mouse-toothed forceps held in the operator's left hand. The needle is now passed through the flap from its palatal to its nasal aspect at a point about $\frac{1}{16}$ inch from its free border. The margin of the other flap is then seized and drawn inwards, whereupon the needle is passed from its nasal to its palatal aspect, emerging on the latter at the same distance from its free border as on the opposite side. The loop of the suture is seized with forceps or held by a sharp hook close to the eye of the needle and drawn out to a slight extent, and while it is still held the needle is withdrawn. A suitable length

of silver wire suture is now taken and bent at one end in the form of a small hook. This is engaged in the projecting loop of the silkworm gut and made to grip the latter tightly by pressure with the finger and thumb. By drawing on the free ends of the silkworm gut suture the silver wire is drawn through both flaps, liberated from the loop, and its two ends grasped with a pair of hæmostatic forceps.

The remainder of the sutures can now be passed without much difficulty, and, as they are drawn close together, both flaps may be traversed by the one movement of the needle.

The introduction of sutures at the anterior margin of the cleft is sometimes attended with difficulty owing to the narrowness and depth of the space immediately behind the alveolar margin. A U-shaped needle with the eye close to its point is sometimes useful here. The suture of silver wire is engaged in the needle for about ½ inch, and while the flap is held up with forceps the needle is passed beneath it into the cleft, and, a suitable point on the nasal aspect of the flap having been selected, the needle is pushed through. The suture is disengaged from the needle, which is then withdrawn. The procedure is then repeated upon the opposite side.

When all the sutures have been passed—there will usually be from five to seven the mouth is again cleansed and wiped dry. The sutures are now taken in order from before backwards and twisted, but not tightly. Each suture is twisted about five or six times, and the free ends are cut away just where the twisting ends. When all the sutures have been treated in this way, the entire line of union is carefully inspected to ascertain if the apposition of its margins is satisfactory, inversion being carefully avoided. If any of the sutures appears too loose, its twisted part is seized with hæmostatic forceps, and by giving this one or two additional turns a satisfactory degree of tension will be secured. The sharp, projecting, twisted ends of the sutures are caught and bent so that they will be directed upwards towards the palate, and not downwards against the tongue (Fig. 50).

COMMENTS.

Anæsthesia.—During the administration of the anæsthetic there is sometimes difficulty with the child's respiration. This may be due to the tongue projecting back too far, but more frequently it is caused by the strongly arched attitude of the neck in Rose's position. The best means to facilitate the breathing are to draw the tongue well out of the mouth and push forward the angles of the lower jaw.

It is advisable to wait until a stage of deep anæsthesia has been reached before commencing the operation, so that the child may not come to too quickly.

The Gag.—The best form of gag is one which merely separates the jaws. Those designed to press the tongue backwards at the same time that the mouth is widely opened are not satisfactory; they are often very troublesome.

Paring the Margins of the Cleft.—Two considerations should be borne in mind in performing this step of the operation: (1) the paring should be free, so that the margins which are subsequently connected by suture may be as broad and regular as possible; (2) the continuity of each strip that is removed from the cleft margins should be preserved, lest at some point the paring should be omitted or imperfectly performed, as this would tend to prevent satisfactory union.

The Lateral Incisions.—The chief rules regulating these incisions have been dealt with above. Owing to the necessity for free mobilisation of the flaps, especially at

the junction of the soft with the hard segment of the palate, the posterior palatine artery will usually be divided or torn in the course of raising the flap from the bone. One of the chief remaining sources of blood supply reaches the flap in front, viz., the naso-palatine branch of the internal maxillary artery. This vessel must be spared, and, with this end in view, the lateral incision on each side must not advance too far forwards, nor should the undermining of the anterior part of the flap be carried out with undue force or too extensively. In certain cases where the cleft extends forwards into the alveolus it may be necessary to defer the closure of its anterior part for some weeks or months, by which time the collateral blood channels will be well established, and the free detachment of the muco-periosteal coverings of the hard palate in front may be carried out freely without risk.

The Palatal Aponeurosis.—Free mobilisation of the flaps which are to close the palatal cleft is the real key to the success of the operation. The chief difficulty in attaining this object is encountered where the hard and soft portions of the palate join. It is caused by the palatal aponeurosis, but if the method for detaching it described above is properly carried out, the result should be quite satisfactory. The lateral incisions in the soft palate should on no account traverse its entire thickness; they do not require, as a rule, to penetrate more deeply than the submucous stratum.

Failure of Union of the Palatal Flaps.—The chief causes for failure of union are —(1) *Tension.* As stated above, the best means towards ensuring complete and rapid union of the flaps is to mobilise them sufficiently before any attempt is made to introduce the sutures. Even a moderate degree of tension may spell failure. (2) *Inversion of the mucous surfaces.* This may be caused by introducing the sutures incorrectly or by drawing the sutures too tightly. At the conclusion of the operation the margins of the approximated flaps should be carefully inspected, and if any inversion is observed, it should be corrected. A good way to do this is to pass a suitably bent, narrow strip of copper or aluminium through one of the lateral gaps beneath the sutured flaps whereby they can be rendered prominent and any obvious inversion rectified. (3) *Sepsis.* This may be a cause for complete failure of union through the entire line of suture. It is best prevented by careful attention beforehand to the cleansing of the mouth and the general health of the child. The operation, too, should be performed under strict aseptic conditions.

Partial failure of union may occur at the anterior or posterior part of the suture line or at some intermediate point, usually opposite the junction of the soft with the hard palate. Fistulous apertures of medium size frequently close spontaneously, especially if their margins are stimulated by silver nitrate or the cautery. Failure of union at the anterior or posterior part of the cleft will usually require a second operation after some weeks or months. If the failure of union only concerns the uvula, it will not matter.

Post-operative Treatment.—The child should be kept as quiet as possible for some days after the operation and entrusted to the care of a competent nurse. Liquids may be given in small quantities at first by means of a spoon. During this period also the child's surroundings should be maintained at an equable temperature and care taken to avoid a chill, as there is always the risk of pulmonary complications supervening.

With very young children it will be impossible to treat the wounds in the mouth with antiseptic or aseptic fluids, but if the child has reached the age of five or six years

before the operation is undertaken, this method of treatment may be employed. Sterilised water, a weak solution of euthymol, or boracic acid will be found useful.

The sutures may be removed from the eighth to the tenth day.

Complications.—1. *Hæmorrhage.*—When this comes on some hours after the operation it is probably due to the dislodgment of a clot caused by movement of the palatal flaps or to a recurrence of bleeding from the posterior palatine arteries. When it supervenes some days later it is probably explained by the detachment of a piece of tissue which has sloughed. It is seldom serious, and tends to cease spontaneously as a rule.

2. *Pulmonary Complications.*—These occasionally supervene after operations for cleft palate, and vary in severity from a slight bronchitis to a fatal pneumonia. They are best prevented by careful attention to the details already described before, during, and after operation.

Mortality.—These operations are seldom followed by a fatal result. If performed, however, during early infancy, the risk is increased, principally owing to loss of blood.

Functional Results.—The objects to be aimed at in the treatment of a case of cleft palate are—(1) success from the surgical standpoint, viz., perfect closure of the cleft; (2) a good functional result, viz., as perfect a degree of articulation as possible.

In order to obtain this latter result, the period selected for the operation is a matter of importance. It is most essential that it should not be deferred later than the end of the second year, because after the child has learned to speak with a nasal intonation it is very difficult to overcome this tendency. This, no doubt, is often due to a large extent to the anatomical conditions which obtain, viz., the soft palate is shorter than normal and perhaps very rigid: it may not effectually cut off the communication between the buccal cavity and the nasal fossa; in other words, its function as an obturator is imperfect. The naso-pharynx, too, is often larger than normal, and the nasal fossa irregular and unsymmetrical. The defect in the upper jaw may involve its anterior part, as represented by a gap in its alveolar margin. Finally, the muscles of the soft palate are for the most part poorly developed. In order to obtain the best result from the functional standpoint, very great care must be taken in properly educating the child how to speak.

BROPHY'S OPERATION.—This has for its object the forcible approximation of the two superior maxillæ by means of a suture which passes in a horizontal direction and connects these bones and the doing away with the necessity for a plastic operation such as that just described.

The period selected for the operation will be somewhere from the fifth to the twelfth week.

The Operation.—The margins of the cleft are pared throughout their entire extent. By means of a strong needle in a handle a double suture of silk is passed from one side to the other above the level of the floor of the nasal fossæ, the points of entrance and emergence of the suture being behind the level of the malar prominence. A stout piece of silver wire is then caught in the loop of the silk suture and drawn across. Another suture of silver wire is passed in a similar fashion in front of the malar prominence. The extremities of the silver sutures on each side are passed through apertures in a small metallic plate which rests against the gum of the upper jaw. The free ends of the silver wire sutures are twisted on one side.

By means of forcible lateral pressure exerted upon the maxillæ the bones are approximated to an extent sufficient to obliterate the cleft. If pressure fails to produce this effect, the maxilla on one or both sides must be divided horizontally with a sharp knife immediately below the malar prominence. If the lateral pressure is now repeated, the two bones will probably come together.

The margins of the cleft may or may not be connected by sutures.

The silver sutures and the metallic plates are removed after two to four weeks.

URANOPLASTY.—The method of closing deficiencies in the hard palate has been already studied in connection with the operation of urano-staphylorrhaphy.

The margins of the aperture having been pared, two lateral incisions are made close to the alveolar margins, their length depending upon the antero-posterior extent of the aperture.

The two flaps consisting of the muco-periosteal tissues of the hard palate are undermined and mobilised.

The flaps are connected by sutures of silver wire or silkworm gut.

STAPHYLORRHAPHY.—In addition to the paring of the margins of the cleft, it will be necessary to make a lateral incision on each side in order to secure good mobilisation and prevent tension upon the sutures. Each of these lateral incisions will extend forwards to a variable extent into the hard palate.

A temporary loop of suture passed through the soft palate close to the uvula on each side helps to stretch the velum, and thus facilitates the paring of the cleft margins and the introduction of the sutures.

THE OPERATIVE TREATMENT OF CANCER OF THE TONGUE.

The Varying Sites of the Disease.—The extent of the operative procedures which are performed for cancer of the tongue depends mainly upon the part of the organ affected. The situations in which the disease originates most frequently are—(*a*) the anterior part of the tongue, at or close to its lateral free margin, less frequently at its tip; (*b*) beneath the anterior free portion of the tongue in the vicinity of the alveolo-lingual sulcus at the openings of the ducts of the submaxillary and sublingual glands; (*c*) at the side of the tongue where its anterior free portion joins its posterior fixed or pharyngeal segment: cancer originating here tends to travel quickly to the anterior pillar of the fauces, and may extend behind this to the tonsil and pharyngeal wall as well as upwards to the roof of the mouth; (*d*) at the posterior part of the tongue in front of the epiglottis, *i.e.*, in the vallecula. The diagnosis of cancer in this situation is unfortunately seldom made at an early period of its development. By the time it is discovered it will frequently be found to have deeply infiltrated the substance of the tongue.

Cancer of the tongue sometimes assumes the form of an outgrowth or nodular mass, but more frequently its character is that of a deep ulcer which extends into the substance of the organ, rendering it fixed and rigid. The extent of the infiltration beneath the surface of these ulcers may be considerable, and in the operative measures described below cognisance must be taken of this fact, so that the plane of section may be carried deeply beneath the zone of infiltration. Furthermore, it has been pointed out by Cheatle that cancerous infiltration has a tendency to extend along the planes

of the muscle bundles in the tongue, notably along those of the hyo-glossus, stylo-glossus, genio-glossus, and lingualis inferior muscles, a fact which should be borne in mind, for the line of section is determined by the extent of this infiltration and not by the visible and tangible limits of the growth.

Glandular Metastases.—The lymphatic glands which are most directly in communication with areas of the disease in the tongue and in the floor of the mouth are the submental, the submaxillary, and those of the deep cervical chain, which are closely related to the internal jugular vein and the common carotid artery at the level of its bifurcation.

FIG 51.—The more frequent sites for cancer affecting the tongue. The areas indicated in this figure correspond respectively to the anterior part of the tongue at its free margin; the level of attachment of the anterior pillar of the fauces and the vallecula, *i.e.*, the fossa in front of the epiglottis.

As a rule glandular metastases make their appearance early in cases of tongue cancer. The affected glands are often distinctly palpable, but even though no evidence of their enlargement can be detected, it does not follow that they have not already been invaded by the disease.

There is a difference of opinion as to the frequency with which the glands on both sides of the neck may be affected when the lingual growth is unilateral. When the disease approaches the middle line, more especially beneath the tongue in the vicinity of the frænum, the probability of the glands on both sides being involved is considerable. It would appear, too, that a similar tendency exists when the area implicated is at the extreme posterior part of the tongue where there is a free communication between the lymphatics of both sides.

Contraindications to Operation.—The extent of the local disease and the measure of involvement of the lymphatic glands are the chief considerations in deciding for or against operation. As a rule cases are unsuited for radical operative measures in which the growth has spread from the tongue to the floor of the mouth and to the lower jaw, with resulting fixity and induration of the tissues in the submaxillary region. Extension of the disease to the wall of the pharynx, to the tonsil, and to the roof of the mouth, usually contraindicates operative treatment. Large masses of glands in the neck adherent to the sterno-mastoid muscle and the deep vessels place operation out of question.

Apart from the local extent of the disease and glandular metastases, operation is contraindicated in debilitated individuals suffering from such diseases as chronic nephritis, diabetes, heart disease, anæmia, or the effects of alcoholism.

When one considers the great suffering and distress experienced by individuals with tongue cancer, it would seem but reasonable to advocate operative measures for the disease within the mouth if there is a reasonable prospect of being able to prevent recurrence *in situ*. Even should the disease continue in the cervical glands

the condition of the patient will be much better than if the growth in the tongue had been allowed to remain unchecked.

Preliminary Measures : Cleansing and Disinfection of the Mouth. As a rule the mouth is in a highly septic condition, especially in the poorer classes who enter the large hospitals. To remedy this, the services of the dentist are requisitioned. All decayed stumps must be removed, deposits of tartar scaled off the teeth which remain, and the mouth subsequently washed at frequent intervals with a suitable antiseptic fluid, such as glyco-thymoline or euthymol, or a weak solution of sanitas. Sponging the teeth and gums with a solution of peroxide of hydrogen is very beneficial.

Prevent Measures against Post-operative Pneumonia.—Aspiration pneumonia is the greatest danger in operations for excision of the tongue, and every effort must

FIG. 52. Sublingual site for cancer. This figure represents a fairly common starting point of cancer of the tongue.

FIG. 53. One of the more frequent sites of cancer involving the posterior fixed part of the tongue, viz. the level of attachment of the anterior pillar of fauces.

be taken to prevent its occurrence. It is essential to render the mouth as clean as possible both before and after the operation, to reduce hæmorrhage to a minimum, and provide all possible safeguards against blood entering the air passages. Care should also be taken not to damage the muscles which assist in deglutition or the nerves which innervate these muscles. Any impediment to deglutition interferes with the removal of fluids from within the mouth, and must therefore increase the risk of aspiration pneumonia.

Injection of a Polyvalent Serum.—The preliminary injection of a polyvalent serum, *i.e.*, mixed toxins, is probably advisable in cases where there is reason to suspect that the resistance of the patient is low, or when a complete operation is performed at one sitting, and the mouth cavity brought into communication with the recent wound in the neck.

The late Sir Henry Butlin, whose opinions on this subject are deserving of attention, wrote as follows : "I have not used antitoxin injections, although I was at one time

intended to do so. I am, however, again disposed to recommend that they should be used in certain cases, when, for example, the mouth is in an unhealthy condition and the patient is not a good subject for a severe operation, and in those cases in which it is expedient to remove the disease of the tongue and the glands of the neck at a single sitting.

"The injection of a solution of the mixed toxins also holds out a more hopeful

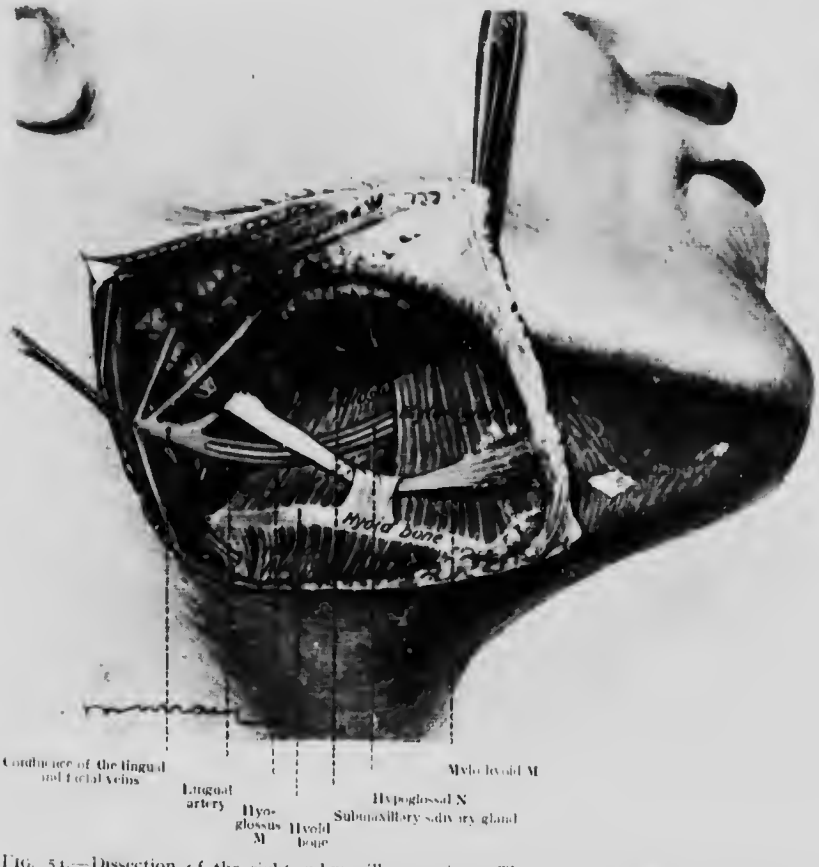

FIG. 54.—Dissection of the right submaxillary region. The superficial tissues including the platysma have been raised and the deeper structures within the space exposed to view. The lingual artery will be observed coming off from the external carotid and disappearing beneath the posterior border of the hyo-glossus muscle. The further course of the artery is represented by a double dotted line. The hypoglossal nerve runs superficial to the hyo-glossus muscle and is accompanied by two veins. The submaxillary salivary gland has been raised with the superficial tissues.

prospect than the injection of a single toxin, which was the only course at our disposal until recently."

OPERATIVE MEASURES.—The ideal mode of treatment for lingual cancer is its excision and at the same time the removal of the glands occupying the anterior triangles on both sides of the neck, the lymphatic vessels directed from the tongue

towards these glands, and the connective tissue in which both the vessels and glands are contained. The objection to such an operation is that it necessarily brings the large area of operation in the neck into communication with the septic cavity in the mouth, thus exposing the patient to very great risk. This risk is all the greater as individuals affected with cancer of the tongue are often advanced in years and debilitated.

As a rule the operative procedure takes place in two stages, viz., the removal of

FIG. 55.—Dissection of the external carotid artery and its branches, which are given off within the carotid triangle of the neck, on the left side. The lingual artery is seen in its first stage, and its further course beneath the hyo-glossus muscle is represented by a double dotted line. The anterior margin of the sterno-mastoid muscle has been drawn aside so as to expose the internal jugular vein, and the spinal accessory nerve. The common facial vein has been divided between ligatures.

the diseased part of the tongue and the clearing away of the infected glands from the neck, but the order in which these are undertaken varies with different surgeons.

From *a priori* reasoning it would appear more correct to deal with the tongue first and after a couple of weeks to proceed with the cervical dissection. A forcible objection to this course lies in the fact that in the interval the cervical glands may be enlarged, softened, and adherent, owing to the absorption of septic products from the mouth. Another circumstance to be considered is that if the tongue operation is

performed first considerable difficulty may be encountered from the hæmorrhage which will inevitably occur. When the glandular operation is performed first the lingual and facial arteries are ligatured on one or both sides, a step which greatly simplifies the second operation by making it relatively bloodless.

The only objection of real weight against the glandular operation being undertaken first is that cancer cells may infect the cervical tissues through the severed lymphatics during the interval, but it is open to question if such risk is at all considerable.

We prefer to undertake the cervical dissection first. Under certain conditions it may be advisable to operate on both sides of the neck. More especially is this so when the disease within the mouth approaches close to or exceeds the middle line, or when palpable glands are present on the side opposite to the disease. When, however, the cancer is situated well to one side of the tongue in its anterior movable part, we consider it sufficient to clear the anterior triangle on that side only.

Under certain conditions the entire operation may be completed at one sitting, when, for instance, the disease is situated beneath the tongue in the floor of the mouth, and the submaxillary salivary and the lymphatic glands are palpably affected.

FIRST STAGE OF THE OPERATION FOR TONGUE CANCER.—This procedure entails the free exposure of the deep connective tissue planes of the anterior triangle and the removal *en bloc* of the deep cervical lymphatic glands as well as those in the submaxillary and submental regions, together with the connective tissue by which they are surrounded; the submaxillary salivary gland is also removed. This lymphatic clearance is followed by ligature of the external carotid artery or those of its branches which are easily accessible in the large open wound.

The Cervical Dissection.—The preparatory details having been carefully attended to, the patient is placed on the table lying on his back, his neck being supported and arched by a stout sand-bag or pneumatic cylindrical pillow; the chin is elevated and turned away from the operator. By a suitably arranged sterilised sheet the patient's face and the anæsthetist are shut off from the field of operation.

An incision is carried from above downwards along the anterior margin of the sterno-mastoid muscle, and from the mid-point of this another incision is directed forwards to the body of the hyoid bone, and, if necessary, upwards to the symphysis menti. The two flaps overlying the anterior triangle are now raised. They consist entirely of the superficial tissues.

The anterior border of the sterno-mastoid muscle is clearly defined along its entire extent and drawn aside with a retractor after the deep cervical fascia has been fully divided. This ensures very free access to the lymphatic area in front and to the outer side of the great vessels.

The pretracheal muscles are either drawn downwards and inwards by a retractor, or, if more room be required, they may be divided close to their laryngeal extremities and turned aside. Commencing low down, the connective and fatty tissues with the contained glands are raised from the vessels by means of a blunt dissector, aided by a process of dry sponging with a muslin swab rolled round the index finger. At the level of the bifurcation of the common carotid artery the glands become more evident, and certain veins proceeding to the internal jugular trunk come into the way and will require division between ligatures; these are the superior thyroid, lingual, and facial veins.

As the lymphatic dissection proceeds from below upwards, care is taken to avoid

injury of the spinal accessory nerve which crosses beneath the upper part of the sterno-mastoid muscle.

The parotid gland is exposed to injury at its lower part, and in this locality, too, the branch of the cervical division of the facial nerve which supplies the muscles at the angle of the mouth is frequently divided, with resulting paralysis of the lower lip on that side.

The dissection is now extended from below and behind forwards into the submaxillary space, and in doing so the submaxillary salivary gland is raised and the facial artery secured on its deep aspect above the digastric tendon. The facial vessels are subsequently exposed and ligatured at the lower margin of the jaw, in front of the masseter muscle. By prolonging the dissection forwards to the submental region all the connective tissue and glands within the space are detached and removed *en masse*.

If not already done, the external carotid artery may now be ligatured between its superior thyroid and lingual branches, or the lingual vessel itself may be exposed and ligatured by drawing up the tip of the greater cornu of the hyoid bone into the wound by means of a hook and dividing the vertically directed fibres of the hyo-glossus muscle immediately above it (Fig. 54).

Hæmostatic forceps are removed, all vessels requiring ligature are dealt with *seriatim*, and the large wound is closed. As a rule some buried sutures are introduced in order to approximate the cut margins of the platysma muscle and the deep cervical fascia and at the same time to draw forwards the sterno-mastoid muscle and take tension from off the skin wound. Silkworm gut, reinforced by Michel's clips, is very suitable for approximating the superficial tissues.

Two drainage tubes are introduced, one at the lower extremity of the wound and another beneath the parotid gland. This precaution is very necessary, as there is usually some post-operative oozing of blood, and not infrequently some secretion from the damaged parotid gland finds its way into the wound. The tubes may be removed after forty-eight hours, but if there is much serous discharge, they may be retained longer.

SECOND STAGE IN THE OPERATIVE TREATMENT OF TONGUE CANCER.—The Lingual Excision.—The operative procedures applicable to the removal of cancer in the anterior free portion of the tongue will first be considered. The operation described by Whitehead is the most suitable for cancer involving the anterior part of the tongue. Excision of one-half of the organ only is required when the disease is situated along its lateral margin.

In dividing the tissues of the tongue an interval varying from $\frac{1}{2}$ to $\frac{3}{4}$ inch should separate the line of section from the margin of the growth. This rule is important also in dividing the deeper tissues beneath the growth. The lingual portion of the operation will have been preceded by a dissection of the lymphatic structures in the anterior triangle on the same side, and, as the lingual and facial arteries will have been ligatured, very little trouble will be experienced from hæmorrhage; indeed, the procedure is singularly bloodless.

WHITEHEAD'S OPERATION FOR REMOVAL OF HALF THE TONGUE.—The attitude best suited for this operation is that in which the table is inclined slightly in the Trendelenburg position, with a stout sand-bag beneath the neck of the patient, arching the neck forwards. This renders the occiput somewhat dependent, and

consequently any hæmorrhage within the mouth will tend to gravitate into the naso-pharynx rather than into the lower air passages.

The jaws are widely held apart by means of a suitable gag, and two loops of silk are passed through the tissues of the tongue, close to its tip, one on each side of the middle line.

The head of the patient being turned towards the operator, the tongue is raised and the mucous membrane divided backwards from the frænum along the floor of the mouth.

Commencing at the tip, an incision is carried from before backwards along the

Fig. 56. Whitehead's Unilateral Excision of the Tongue. The tongue has been split along the raphé and each lateral segment is retained by a loop of silk ligature. The epithelioma for which the operation was undertaken was of limited extent and involved the free margin of the tongue.

line of the median raphé of the tongue to a safe distance behind the level of the disease.

By forcibly raising the affected segment of the tongue its deep attachments are successively divided by snips of scissors. The lingual artery is encountered at this stage, and can be readily seized with forceps before division. The excision is completed by cutting the affected segment of the tongue transversely at least $\frac{3}{4}$ inch behind the growth (Fig. 56).

The remaining portion of the tongue is drawn forwards, and the wound sponged dry. If any vessel of importance is observed to bleed, it is seized and surrounded by a ligature of fine catgut introduced with a curved needle.

The patient should not be removed from the operating table until all bleeding capable of being arrested by surgical measures has been attended to.

Some sutures may be introduced so as to connect the sublingual mucous membrane with that of the dorsum of the tongue and diminish the exposed raw area as much as possible. These sutures are useful also in controlling oozing of blood from the cut surfaces.

WHITEHEAD'S OPERATION FOR THE REMOVAL OF THE ENTIRE TONGUE.—The mouth is widely opened with a gag and freely illuminated. The tongue is drawn forwards by means of two loops of stout silk, one on each side of the median raphé.

Division of the Lateral Attachments of the Tongue.—These attachments are effected on each side by the mucous membrane in the floor of the mouth and the anterior pillar of the fauces. Those on the left side are divided with scissors by raising the tongue and drawing it well over to the right side. The right lateral attachments are similarly divided and the frænum severed close to the bone.

Division of the Lower Attachments of the Tongue.—The genio-glossi muscles are divided and separated from the genio-hyoid muscles, which lie immediately subjacent. As the division of the muscles proceeds the tongue is drawn straight upwards, and the lingual vessels are exposed on each side. By carrying the incision backwards through each hyo-glossus muscle the corresponding lingual artery may be secured by forceps before division, or, if preferred, it may be surrounded by an aneurysm needle and ligatured. The further section of the muscle is then continued from before backwards down to the body of the hyoid bone. It is here that the chief mistake in Whitehead's operation is likely to be made by not carrying the section beneath the tongue to a sufficient depth to get well below the infiltrating zone of the disease.

Transverse Division of the Tongue.—This section is much facilitated by drawing the tongue forwards. It is made with scissors, and extends from one side to the other about ½ inch in front of the hyoid bone. Before the tongue is detached the stump should be grasped with forceps so that it may be drawn forwards, if necessary, to enable any bleeding vessels to be secured.

The Wound in the Mouth.—The large area of raw tissue may be diminished by inserting a few sutures which serve to connect the cut margins of the mucous membrane on the dorsum of the tongue with that in the floor of the mouth. It is a wise precaution to pass a stout ligature through the stump of the tongue and bring its two ends out through the mouth and secure them to the cheek. It helps to prevent the possibility of sudden suffocation from the stump of the tongue falling backwards over the entrance to the larynx.

OPERATION FOR CANCER SITUATED AT OR BEHIND THE LEVEL OF THE PILLARS OF THE FAUCES, OR IN THE SULCUS BENEATH THE TONGUE.—The operation of Whitehead just described is sometimes performed for cancer situated in these localities, but the objection to it is that it does not afford sufficient access.

It is important that the following conditions should be fulfilled by an operation designed for the removal of cancers situated as above: (*a*) it should provide for free inspection of the diseased area, (*b*) it should enable the tissues around the latter to be divided precisely and with clear recognition, (*c*) it should render the control of bleeding easy, and (*d*) it should to the utmost extent provide against the entrance of blood into the air passages.

The operation about to be described fulfils these requirements very fully. Originally it was practised by Sedillot and Syme. More recently, however, it has been slightly modified by Kocher and strongly advocated by him for the cases under consideration.

FIG. 57.—Kocher's Transmaxillary Operation for Cancer situated in the Posterior part of the Tongue. A laryngotomy tube has been introduced and a piece of rubber tubing connected with it for the purpose of administering chloroform. The lower lip has been divided by a median incision and the tissues reflected from the jaw to a slight extent on each side. The line of division of the jaw is indicated a little to the right of the middle line, and the small circles represent the levels at which the bone is drilled.

It provides free access to the diseased region by a paramedian division of the lower jaw and a wide separation of its two segments.

Instruments.—In addition to the ordinary instruments required in the majority of operations, the following should be available: Horsley's jaw saw or Gigli's wire saw, bone drill, annealed silver wire, wire cutter, Lane's tissue forceps, retractors,

Paquelin cautery, scissors with long handles and one at least curved on the flat, and a laryngotomy tube provided with connections for the administration of the anæsthetic.

The Operation.—As a preliminary measure the patient is given a hypodermic

FIG. 58.—Kocher's Transmaxillary Operation for Lingual Cancer. The jaw has been divided and a hole drilled through each segment. By drawing these widely apart the deeper attachments of the tongue and the tissues in the floor of the mouth have been brought into view. If the pharynx has not already been occluded by a plug of gauze, it will be necessary to do so at this stage.

injection of morphin, gr. $\frac{1}{4}$, and atropin, $\frac{1}{100}$ gr., as it facilitates quiet anæsthesia and helps to diminish the mucous secretions within the throat.

The head portion of the table is slightly raised and a sand-bag or air cushion placed behind the neck of the patient.

Good light is a necessity. When the mouth is opened its interior should be well illuminated.

A laryngotomy is now performed, and a suitable tube introduced through the aperture in the crico-thyroid membrane. A piece of rubber tubing is connected with this and the remainder of the anæsthesia conducted under chloroform.

The operation upon the tongue consists of two stages, viz., (1) a paramedian division of the lower jaw and separation of its two segments and (2) a wide excision of the diseased area.

Division of the Jaw.—Commencing at the centre of the red margin of the lower lip, an incision is carried downwards exactly in the middle line over the chin to the level of the hyoid bone. The coronary arteries and other bleeding vessels are seized with clip forceps and the tissues reflected from the bone for a short distance on each side. The periosteum, however, is not detached.

The line of section of the jaw is placed a little to one side of the middle line, corresponding to the alveolus of the lateral incisor tooth. If present, this tooth must be extracted. Two holes, as represented in Fig. 57 are drilled in the jaw before making the section. This may now be readily accomplished by means of a saw of the Horsley pattern or a Gigli wire saw.

The mylo-hyoid muscle having been divided down to the hyoid bone, the two segments of the jaw are easily drawn apart by suitable retractors or loops of stout silk passed through the drilled holes with a curved needle.

Plugging the Pharynx.—The next step of the operation consists in plugging the pharynx with a sponge or roll of gauze held securely by a silk ligature, the free ends of which emerge through the mouth. In introducing the plug the tongue is drawn forwards, the mouth freed of all secretion, and the plug guided far back behind the epiglottis. Care should be taken not to push any septic matter back into the throat when introducing the plug.

Excision of the Cancerous Area.—Two loops of silk are introduced into the tongue, one on each side of the median raphé, about 1 inch behind the tip. The jaw segments are well separated, and the interior of the cavity clearly illuminated.

Commencing in front, the mucous membrane is divided in the floor of the mouth close to its attachment to the inner aspect of the jaw. This is all the more necessary when the growth occupies or encroaches upon the sulcus beneath the tongue.

If the disease is definitely confined to one side, and if it is decided to remove but one-half of the tongue, the genio-glossus muscle of that side is detached from the bone in front (Fig. 58); the median raphé is opened up and an incision carried back along it, if necessary, as far as the epiglottis.

By raising the tip of the diseased segment of the tongue its deep attachments are divided from before backwards, particular care being taken to keep the section at a safe distance beneath the cancer, as it often infiltrates the lingual tissues deeply.

The lingual artery is cut at this stage, and is easily secured. If it should have been previously ligatured in the dissection of the neck, it will bleed but little.

If the disease has invaded the anterior pillar of the fauces and the adjoining area, the line of section is carried in front of it, then above and backwards beyond this to the required extent behind the infiltrated tissues. Finally, the lateral and median incisions are connected, and the growth removed.

Arrest of Hæmorrhage.—Bleeding at this stage may be free. It is mainly venous, from the veins of the pharyngeal plexus and from some vessels in the substance of the tongue itself. Obvious vessels are quickly seized upon the removal of a wisp of gauze temporarily packed against the bleeding surface. One or more deep sutures introduced on curved needles may be required to control these vessels. Any remaining

oozing will quickly cease when the pharyngeal plug is removed, as it tends to interfere with the venous return.

Suture of the Divided Jaw.—The two segments of the jaw are connected by a stout suture of silver wire, and when the ends of this have been twisted and cut short, the projecting sharp points are bent down against the bone and not allowed to injure the overlying tissues. A piece of perforated rubber tubing is placed in contact with the raw area of the wound, its free end being brought out between the margins of the mylo-hyoid muscles beneath the jaw. It serves to carry off the secretions which collect within the mouth. Plugging of the wound within the mouth is not necessary, and there does not appear to be any advantage in applying dusting powders or strong antiseptic solutions to the cut tissues.

Suture of the Lip.—The wound in the lip is closed by sutures of silkworm gut and horsehair, and special attention is directed towards obtaining accurate adjustment of the red labial margin. Part of the wound between the chin and the hyoid bone is left open to afford exit for the drainage tube.

Some xeroform powder is dusted over the lip wound, and an absorbent antiseptic dressing applied beneath the chin.

COMMENTS.

Dangers attending Operations for Tongue Cancer.—These have already been alluded to. Those most deserving of attention, however, are hæmorrhage and broncho-pneumonia.

Hæmorrhage is mainly controlled by preliminary ligature of the external carotid artery, with its lingual and facial branches. The danger from hæmorrhage consists not so much in the amount lost as in the consequences which may result from the entrance of blood into the air passages.

Aspiration pneumonia is guarded against mainly by the careful control of bleeding, by disinfection of the mouth both before and after the operation as far as is possible, and by taking precautions against the entrance of food into the trachea and bronchi.

With a view also to the avoidance of pneumonia, the muscles which assist in deglutition and the nerves which supply these muscles are preserved, so that the power of swallowing may be diminished to the least extent possible.

Post-operative Measures.—Antiseptic mouth washes such as solutions of sanitas, euthymol, cyllin, carbolic acid, etc., are usually employed.

It is advisable to get the patient up as soon as possible. As a rule this may be done with safety on the second or third day.

These operation cases demand the undivided attention of two nurses, one for day and one for night, for upon the careful nursing of the case as much depends as upon the operation itself (Treves).

The administration of nourishment is of importance. For the first twenty-four hours this can be satisfactorily accomplished by means of rectal injections of saline solution and by nutrient enemata. Where difficulty in swallowing is anticipated a good plan is to introduce a large soft rubber tube through the nasal fossa on one side into the stomach. This is done before the patient leaves the operating table. The outer extremity of the tube is secured by some adhesive plaster to the cheek. In the majority of cases, however, liquid nourishment can be taken without difficulty by the mouth. Swallowing is facilitated by introducing fluids into the mouth by

means of a feeding cup, the spout of which is guided towards the back part of the buccal cavity.

Laryngotomy ; Tracheotomy. Laryngotomy is undoubtedly a measure which facilitates enormously the excision of cancers of the tongue which involve its posterior or under aspect, or those in which the entire tongue must be removed. The following points may be mentioned in its favour :—

1. Oral respiration is suspended, and the need for constant sponging of blood from the mouth and back of the throat is abolished. Troublesome coughing, too, is prevented.

2. The anæsthesia proceeds smoothly, and there is no need to discontinue the operation by reason of the patient coming to, as frequently happens when the anæsthetic is given in the ordinary way.

3. The time required for the operation is diminished, as the operator can proceed without interruption. Furthermore, the excision of the diseased area is greatly facilitated, owing to the fact that it can be performed more deliberately and with greater precision in consequence of the air passages being shut off.

4. Laryngotomy has not been attended with any serious consequences in our hands. Owing to the superficial position of the crico-thyroid membrane, the wound is insignificant, and heals rapidly. With high tracheotomy the division of tissues is much greater, and the resulting wound is more extensive. It is, therefore, a more serious operation than laryngotomy. The laryngotomy tube may be removed on the day of operation, but not for some hours after the patient has regained consciousness.

Division of the Tissues of the Tongue.—Scissors with long handles and blunt at the point are usually employed to separate the tongue from its attachments. Kocher, however, recommends the cautery for this purpose, as it enables the tissues to be divided without bleeding and the operator can see better what he is doing. The cautery, too, when employed at a dull red heat, seals up the blood vessels and lymphatics, and tends to diminish the subsequent absorption of septic products from the mouth.

RESECTION OF THE TONGUE WITH THE SIMULTANEOUS RESECTION OF THE MEDIAN SEGMENT OF THE LOWER JAW.—This operation is usually performed in cases in which the growth is situated in front at the frænum and is fixed to the bone.

The Operation.—A median incision is carried down through the lower lip to the hyoid bone.

Assuming that the section must involve the entire thickness of the jaw, the tissues are raised from the bone on one side, and the jaw is divided with a Gigli saw at a safe distance from the disease.

By forcible retraction of the cut margins the floor of the mouth is easily examined and the limits of the disease recognised. The vessels and nerves can be seen too before division.

The tissues are next raised on the opposite side and the jaw again divided.

The bone surfaces are held apart and the tissues divided in the floor of the mouth well wide of the disease.

The section is now extended through the muscles beneath the growth and the diseased parts detached.

The loss of substance in the jaw is made good by an artificial support corresponding

in shape to the part removed. This diminishes the difficulty in swallowing, and reduces the sufferings of the patient to a minimum (Kocher).

In a considerable proportion of these cases removal of the entire thickness of the jaw is not necessary. If the alveolar border be excised, the remaining part can often be left, and this is an enormous advantage, as the continuity of the bone is preserved (Caird).

THE PHARYNX AND TONSIL.

The operative surgery of malignant growths of the pharynx must necessarily be considered in connection with its three subdivisions, viz., the naso-pharynx, the buccal pharynx, and the laryngeal pharynx.

The operations for growths originating in the naso-pharynx have been described in connection with the surgery of the upper jaw (see p. 71).

The present section is concerned with the main procedures applicable to the buccal and laryngeal segments of the pharynx.

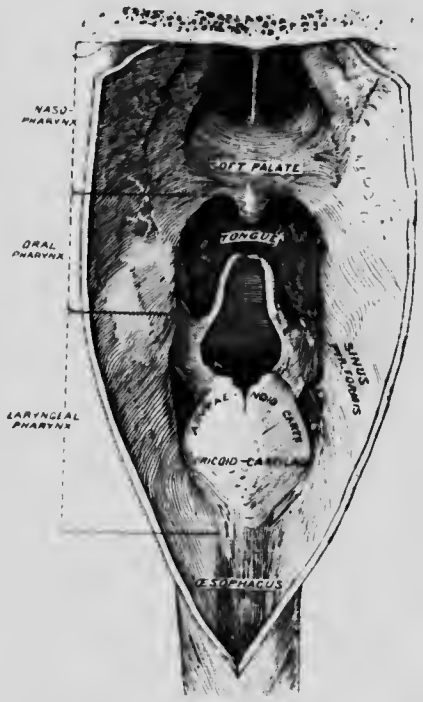

FIG. 59.—The pharynx opened from behind. The three sub-divisions of the pharyngeal cavity will be noted. The extent of each is indicated in the figure. The sinus pyriformis corresponds to the recess at the outer side of the laryngeal entrance.

The Buccal Pharynx intervenes between the soft palate above and the entrance to the larynx below (Fig. 59). It is usual to include with it the tonsil and the pillars of the fauces on each side as well as the posterior part of the tongue, viz., the segment intervening between the epiglottis and the circumvallate papillæ. Cancer originating in this part of the tongue is very apt to be overlooked until it has made considerable progress, its earlier development taking place without symptoms of pain or difficulty in swallowing; indeed, it is by no means unusual to find many of these cases so far advanced that no operation can be undertaken for their removal with any prospect of success. The epiglottis is frequently involved by the backward extension of these growths.

The Laryngeal Pharynx extends from the level of the laryngeal inlet to that of the lower border of the cricoid cartilage (Fig. 59). It presents on each side a recess between the larynx and the pharyngeal wall, below the greater cornu of the hyoid bone, which is known as the pyriform fossa. This space lies between the rigid wall provided by the ala of the thyroid cartilage and the upper aperture of the larynx, bounded by the arytæno-epiglottidean fold. It is accessible to palpation with the finger introduced through the mouth. Growths originating within this area are apt

to develop insidiously, and may escape recognition until the glands in the neck are markedly enlarged. An obscure glandular swelling at one side of the neck may, in fact, be the first evidence of a growth in the sinus pyriformis. A growth here may perforate the ala of the thyroid cartilage and occasion a swelling capable of being recognised externally. Advancing inwards, it will encroach upon the larynx and give rise to œdema of the surrounding mucous membrane and fixity of the corresponding vocal cord. The mass tends to spread over the pharyngeal aspect of the cricoid cartilage rather than into the laryngeal cavity. By extending circularly it may considerably narrow the lumen of the pharynx. These are formidable growths, seeing that their early recognition is so rare and that their removal will necessarily entail a total laryngectomy.

Another group of epitheliomatous growths in this segment of the pharynx tends to involve the tissues at the laryngeal entrance. These growths may originate in the epiglottis or in the arytæno-epiglottidean fold, the former site being the commoner. Growths in this locality are usually recognised early, as they very quickly produce symptoms, *i.e.*, hoarseness; difficulty in swallowing and in breathing (Trotter).

SOME POINTS CONCERNING OPERATIONS UPON THE PHARYNX.—1. Good access is necessary, so as to enable the operator to gauge exactly the extent of the disease and to remove it without encroaching too closely upon its advancing margin.

2. As the upper part of the pharynx is a passage common to the digestive and respiratory tracts, operations performed in connection with it are apt to be attended by serious consequences both as regards swallowing and respiration. Swelling of the mucous membrane of the arytæno-epiglottidean folds may come on very rapidly after operations near the laryngeal inlet and threaten suffocation. Still more serious is the tendency of septic broncho-pneumonia to supervene as the result of blood, septic discharges, or food gaining entrance to the upper air passages.

3. Owing to the great importance of preserving as fully as possible the power of swallowing, preference will be given to those operations which, other things being equal, inflict the minimum of damage upon the muscles presiding over deglutition as well as the nerves by which these muscles are supplied.

4. No operation for the removal of malignant disease involving the pharynx can be regarded as complete unless supplemented by a thorough removal of the lymphatic vessels and glands which drain the diseased area. In some cases the lymphatics are cleared away at the same time that the primary growth is removed. In other cases the excision of the pharyngeal growth is followed after an interval of ten or fourteen days by a dissection of the glandular area. However, this order of procedure may be reversed; that is, the lymphatic dissection may first be performed, the external carotid artery and its main branches being ligatured at the same time; then, after an interval of some days, the primary growth is removed.

OPERATION ROUTES.—The pharynx may be reached from the front, *i.e.*, through the oral aperture, or by a median division of the lower jaw, or by incisions in the suprahyoid or infrahyoid region of the neck. It may be opened also from the side by exposing and dividing the constrictor muscles.

ANTERIOR OR MEDIAN OPERATIONS. 1. THROUGH THE ORAL APERTURE.—If the disease in the buccal segment of the pharynx is of limited extent, as, for example, an epithelioma or sarcomatous growth of quite small dimensions involving the tonsil, it may be possible to reach and remove it by this route. It will be advisable

to perform a preliminary laryngotomy and plug the pharynx over the laryngeal inlet.

The procedure will be greatly facilitated by splitting the cheek on the side of the disease. The line of incision extends from the angle of the mouth backwards and slightly downwards as far as the anterior border of the masseter muscle, and the divided facial vessels are secured.

A gag is introduced on the opposite side, and the jaws are widely separated. With the head and shoulders of the patient moderately raised and the divided tissues of the cheek retracted by an assistant, a good view is obtained of the fauces and tonsil, the base of the tongue, and the epiglottis. The tongue may be held forwards either by a loop of silk introduced about an inch behind its tip or by special tongue forceps.

FIG. 60.—Subhyoid Pharyngotomy. The superficial tissues have been divided and the muscles exposed which are attached above to the hyoid bone.

The growth is now removed by dividing the healthy tissues around it with scissors, or, if preferred, the cautery may be employed for this purpose.

Certain sarcomata originating in the tonsil resemble encapsulated tumours, so that by making an incision in their vicinity they may be shelled out. This method of removal is not recommended, as it may result in portions of the growth being left behind. It is better to incise the tissues freely all round.

Bleeding does not usually occasion difficulty; it may be arrested by forcipressure and the firm application of gauze compresses to the cut surface.

After this operation there is danger of swelling of the mucous membrane surrounding the entrance to the larynx taking place suddenly. With this contingency in view, it will be desirable to leave the laryngotomy tube *in situ* for at least forty-eight hours, or, if it is removed early, help should be forthcoming if suffocation is threatened.

The wound in the cheek is carefully adjusted. On its mucous aspect several interrupted sutures of catgut are introduced, and its cutaneous margins are approxi-

mated by sutures of silkworm gut and horsehair. The suture line is painted over wit' collodion.

i this as in other operations involving the pharynx the patient is made to lie i few days afterwards with the head low, so as to diminish the risk of blood and septic fluids entering the air passages. Where swallowing is painful or difficult liquid nourishment may be administered by a nasal tube; nutrient injections also are very useful.

2. KOCHER'S TRANSMAXILLARY OPERATION.—This procedure has been fully described in connection with the operative treatment of cancer of the tongue. It affords good access to the tonsillar region and the buccal segment of the pharynx through the wide gap resulting from the division and retraction of the two segments of the lower jaw (p. 109).

3. SUBHYOID PHARYNGOTOMY.— In this operation access to the pharynx is

FIG. 61.—Subhyoid Pharyngotomy. The omo-hyoid, sterno-hyoid, and thyro-hyoid muscles have been divided on each side and the thyro-hyoid membrane exposed.

FIG. 62.—Subhyoid Pharyngotomy. The thyro-hyoid membrane has been divided and the epiglottis drawn out through the wound. The aperture thus provided leads into the buccal segment of the pharynx.

provided by creating a breach between the front of the epiglottis and the base of the tongue by means of an incision traversing the thyro-hyoid membrane.

If the epiglottis is healthy, its integrity is preserved; but if invaded by a malignant growth, its removal will be necessitated.

As the pharynx is opened just above its laryngeal segment, the operation is well adapted for growths in this locality, viz., in the extreme posterior part of the tongue, the epiglottis, the arytæno-epiglottidean folds, the arytænoid cartilages, the sinus pyriformis, and the adjoining posterior wall of the pharynx.

Although this operation may be performed with local anæsthesia, *i.e.*, infiltration of the skin and subcutaneous tissues with a 2 per cent. solution of novocain and adrenalin and the subsequent application of a 5 per cent. solution to the mucous membrane, general anæsthesia is to be preferred as a general rule.

A preliminary laryngotomy facilitates the operation, and the retention of the tube for thirty-six to forty-eight hours afterwards does away with the danger of suffocation from sudden development of œdematous swelling of the submucous tissue at the laryngeal entrance. During the operation blood may be prevented from entering the

air passages either by inclining the patient with the head downwards or by introducing a plug over the laryngeal inlet.

The Operation. The patient is inclined with the head slightly downwards, and the neck is moderately arched forwards by a suitable pillow or sand-bag.

The superficial incision is about 4 inches in length, and runs transversely beneath the hyoid bone. Some superficial veins are divided and secured by forceps.

The platysma having been divided, the muscles ascending to the hyoid bone are exposed on each side, viz., the sterno-hyoid, omo-hyoid, and thyro-hyoid, and are divided at a little distance from their insertions (Fig. 61).

The thyro-hyoid membrane is now exposed; it is thick and strong in the middle line, but gradually thins out on each side. Before dividing it the thyro-hyoid bursa will be opened. The membrane is divided opposite the lower border of the hyoid bone and not close to its upper attachment, *i.e.*, into the upper border of the bone, so that sufficient of it may be available subsequently for retaining sutures. Division of the membrane at a still lower level is to be avoided for fear of wounding the internal laryngeal nerve on one or both sides.

The fatty tissue behind the membrane is now exposed, and the tip of the finger pressing directly backwards in the wound recognises the lower tapering portion of the epiglottis descending towards the central notch of the thyroid cartilage. By raising the hyoid bone and deepening the wound in a backward and upward direction in front of the epiglottis the mucous membrane will be reached at its reflection from the tongue to the epiglottis. If the membrane should not appear, it may be easily rendered evident by the index finger of an assistant introduced into the mouth pressing it backwards in front of the epiglottis.

The anterior aspect of the epiglottis being now exposed, its free border is secured by a hook and drawn out through the wound (Fig. 62). If its removal is indicated owing to invasion of disease, this can be done by dividing its stalk low down near the thyroid cartilage and by making an oblique incision on each side, a hook being employed at the same time to dislocate it outwards.

The growth within the pharynx is removed with scissors or the cautery, and bleeding is carefully arrested by pressure, but if this seems inadequate, the more obvious bleeding points may be secured with ligatures of fine catgut.

The subhyoid wound is closed in strata. The mucous membrane margins are first approximated, if possible, by a few sutures of catgut. The next succeeding sutures connect the margins of the thyro-hyoid membrane, and to facilitate their approximation the pillow or sand-bag is removed from behind the neck, and the chin of the patient is depressed. The infrahyoid muscles are now sutured, sufficient of them having been left in contact with the hyoid bone to serve for this purpose. Finally, the superficial part of the wound is closed with fine silkworm gut.

4. SUPRAHYOID PHARYNGOTOMY. The patient lies on the back with the occiput slightly lowered and the neck supported behind by a pillow or sand-bag.

The cutaneous incision extends between the anterior margins of the sterno-mastoid muscles, and as it sweeps across it is directed about ½ inch above the hyoid bone, with a slight upward convexity. The subcutaneous tissues and the platysma are divided, and obvious bleeding vessels are seized with forceps.

The submaxillary salivary glands are exposed, and their lower borders are retracted upwards. The mylo-hyoid muscles are detached from the hyoid bone, and the intermediate tendon of the digastric is freed from its attachments on each side. The

incision is then carried deeply through the genio-hyoid and the genio-hyo-glossi muscles. At this stage the cutting edge of the knife is directed upwards slightly, so as to reach the buccal cavity in front of the epiglottis. The division of the above muscles is followed by the descent of the hyoid bone, and through the resulting gap a good exposure of the pharynx is obtained in the vicinity of the base of the tongue, the fauces, tonsils, and epiglottis.

If the disease is in the base of the tongue, the latter may be seized and dislocated well out into the submaxillary wound, whereupon the extent of the excision required may be readily determined. The wound is sutured in strata, and a drainage tube is inserted into each lateral angle. The chief disadvantages of this operation are that it does not afford sufficiently free access to the area of the disease, owing to the limited dimensions of the suprahyoid aperture, and that in cases of malignant ulceration in front of the epiglottis the suprahyoid wound may extend into the infiltrated area.

5. TRANSHYOID PHARYNGOTOMY.—A preliminary laryngotomy is performed to facilitate the anæsthesia and ensure tranquil breathing after the operation has been completed.

With the patient in the same position as in the last operation, an incision is directed in the middle line from a point an inch below the chin to the upper border of the thyroid cartilage. The superficial tissues and the deep fascia are divided, and the incision is prolonged through the median raphé between the mylo-hyoid muscles.

The interval between the genio-hyoid muscles is identified, and on each side of the middle line the muscular tissue is detached from behind the hyoid bone to a slight extent, and the bone itself divided with narrow-bladed shears.

The hyoid segments are drawn aside by two sharp hooks, and a space from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches is obtained. Still keeping in the middle line, the incision is deepened in the direction of the glosso-epiglottidean mucous membrane above and the thyro-hyoid membrane below. If very free access is required, one-half of the hyoid bone may be removed.

The mouth cavity is opened in front of the epiglottis. This step is facilitated by introducing a finger into the mouth and bulging the mucous membrane into the wound. The diseased area is removed with scissors or the cautery, the epiglottis being included if it has been implicated by the growth.

The wound is closed in strata as far as possible, interrupted sutures of catgut being employed for this purpose. Some gauze packing is also introduced, the free ends being brought out below. The laryngotomy tube is removed after twenty-four or forty-eight hours. The patient is fed by a soft nasal tube.

OPERATIONS BY THE LATERAL ROUTE; HIGH LATERAL PHARYNGOTOMY.—In certain cases of malignant disease of the buccal segment of the pharynx the procedures just described are not well adapted, notably those in which the disease has been followed by metastases in the deep cervical glands situated in the vicinity of the angle of the jaw. In such instances the best approach to the disease is from the side of the neck. Two courses are open to the surgeon: either to remove the glands and resect the diseased part of the pharynx at the same time or to excise the glands first and after an interval of seven or ten days open up the wound and remove the pharyngeal growth.

Malignant disease situated in the upper part of the pharynx may extend beyond this so as to implicate the immediately adjoining parts, such as the posterior part of the tongue and the palate.

The form of operation which meets the requirements of such cases is described in detail under the heading of "Growths of the Tonsil" (p. 120). It is to be noted, however, that, if the disease in the pharynx has extended to the fold of mucous membrane passing from the upper to the lower jaw, its removal will be followed by great difficulty in opening the mouth owing to the resulting cicatricial contraction. This may be prevented to some extent, however, by removing the posterior or vertical segment of the jaw.

Operations upon the laryngeal segment of the pharynx are often very difficult and complicated by reason of the fact that malignant growths which have originated in the pharyngeal wall may have spread to the arytæno-epiglottidean fold, the arytænoid cartilage, or over the posterior part of the cricoid cartilage. In the removal of such growths the resection will include not only a portion of the pharynx, but the larynx as well either in part or completely.

The following procedures are applicable when the disease in the pharynx is situated below the level of the hyoid bone.

LOWER LATERAL PHARYNGOTOMY.—Preliminary Measures.—(1) Careful disinfection of the mouth is imperative. (2) The question of the injection of antibacterial sera or polyvalent vaccines, with the object of increasing the resistance of the patient, will deserve serious consideration. (3) As the nutrition of individuals suffering from pharyngeal cancer is usually very imperfect, and seeing that the administration of food after the operation is attended by difficulty, the performance of gastrostomy as a preliminary measure may be deemed advisable. (4) Tracheotomy will be necessary.

Steps of the Operation.—*The Superficial Incision* lies just in front of the sterno-mastoid muscle, and extends from a point on a level with the tip of the greater cornu of the hyoid bone downwards for a distance varying from 3 to 4 inches. The superficial tissues and the deep fascia are divided, and the sterno-mastoid muscle is fully retracted.

Exposure of the Pharynx.—The large vessels are retracted outwards with the sterno-mastoid muscle. The omo-hyoid muscle at the lower and inner part of the wound will probably require division. The remaining pretracheal muscles are retracted inwards. The superior thyroid vessels directed to the apex of the lateral lobe of the thyroid gland will now be recognised in the wound. They are doubly ligatured and retracted. The fibres of the inferior constrictor muscle will be observed at the bottom of the wound, and may be made more evident by rotating the larynx towards the opposite side. During the course of this dissection all lymphatic glands which are encountered are removed.

Opening into the Pharynx.—This is facilitated by rotating the thyroid cartilage and pushing the apex of the lateral lobe of the thyroid gland downwards; the wall of the pharynx is brought well into view, and is divided behind the ala of the thyroid cartilage and in the long axis of the wound.

A finger introduced into the cavity will enable the operator to form an accurate estimate of the extent of the disease. This is excised, and great care is taken to cut wide of the infiltrated area. If it extends forwards so as to implicate the larynx, the area resected will need to be correspondingly extensive.

Closure of the Wound.—The aperture in the pharynx is closed as far as is possible by sutures of catgut. The wound in the superficial tissues is partially closed by sutures arranged in strata, drainage being freely provided for by gauze and rubber tubing. The greater part of the wound will probably heal by granulation.

The Administration of Nourishment.—For details the reader is referred to "Resection of Tumours of the Tonsil" (p. 123).

EXCISION OF GROWTHS OF THE TONSIL.—The tonsil may be approached through the oral aperture if the condition to be dealt with is of a simple nature such as abscess, hypertrophy, or a small benign growth. The facilities for dealing with the tonsil by the buccal route may be greatly increased by dividing the cheek from the angle of the mouth backwards to the anterior border of the masseter muscle.

If the tonsillar growth, however, is of a malignant character, except perhaps in a very early stage, such methods of approach are insufficient, as it is impossible to see the limits of the disease after the first incision has been made owing to the bleeding. If an extensive resection is necessary, there is great danger of wounding the large vessels of the neck, more especially the internal carotid artery, and, moreover, this line of approach leaves untouched the lymphatic glands which are liable to be implicated.

The chief obstacle encountered in approaching the tonsil from the neck is the lower jaw at the junction of its horizontal and vertical rami. Different procedures have been devised for getting over this difficulty; those more generally practised are—(*a*) Division of the horizontal ramus of the jaw in front of the masseter muscle followed by retraction of the vertical ramus backwards and outwards and of the horizontal ramus forwards; (*b*) division of the jaw as before followed by resection of the vertical ramus and disarticulation; (*c*) the same procedure as the last, except that, instead of disarticulating, the bone is sawn across above the attachments of the masseter and internal pterygoid muscles, leaving behind the condyle and the coronoid process. (*d*) The masseter and internal pterygoid muscles are detached respectively from the outer and inner aspects of the lower jaw at its angle. The area of bone so exposed is cut away piecemeal with suitable bone-cutting forceps, the muscles being subsequently restored into position.

The following operation is well adapted for dealing with malignant growths which involve the tonsil, and in which the lymphatic glands contiguous to the angle of the jaw are possibly the seat of metastases.

Preliminary Measures.—(1) The condition of the mouth is carefully attended to (see p. 101). (2) It is probably a wise precaution to aim at increasing the resistance of the patient by the injection of a polyvalent vaccine a week or ten days beforehand.

Anæsthesia.—This is immediately preceded by an injection of $\frac{1}{100}$ gr. of atropine with a view to diminish the amount of mucus secreted in the mouth and throat.

Gas, followed by ether, is first administered by the mouth. Laryngotomy or high tracheotomy is then performed, and the pharynx is plugged far back with gauze. For the remainder of the operation chloroform is administered through the tube.

UPPER LATERAL PHARYNGOTOMY.—The table is inclined so that the patient's head and shoulders are raised to some extent and brought well over to the side on which the operator stands. This attitude serves to diminish venous hæmorrhage.

The Superficial Incision.—This extends from the tip of the mastoid process along the anterior border of the sterno-mastoid muscle to the level of the thyroid cartilage, and, if necessary, a second incision may be carried forwards from this into the submaxillary region. The superficial tissues and deep fascia having been divided, the

sterno-mastoid muscle is exposed throughout the wound and fully retracted. The common facial vein, if seen, is divided between ligatures.

The Lymphatics.—Commencing at the lower angle of the wound, the carotid sheath is opened, and all the connective tissue and lymphatic glands which are exposed are progressively raised from the vessels. In this dissection the submaxillary salivary gland is taken away and in doing so the facial artery must be ligatured and divided twice, viz., in the deep part of the wound near the origin of the vessel from the external carotid and in front of the masseter muscle where it crosses the lower border of the jaw in close association with the vein.

Clamping the External Carotid Artery.—At this stage it is advisable, with the intention of preventing unnecessary bleeding, to apply a clamp to the external carotid artery close to its origin. Crile's clamp or Makin's intestinal clamp, having its blades ensheathed with rubber and the spring weakened, may be employed (Upcott).

The structures in the submaxillary triangle are now clearly exposed. The digastric and stylo-hyoid muscles are seen passing downwards obliquely beneath the angle of the jaw to the hyoid bone. The hyo-glossus muscle is recognised with its fibres directed from the greater cornu of the hyoid bone and the stylo-glossus approximating it above. Lower down the hypoglossal nerve is seen crossing inwards (Fig. 55). More deeply placed than the digastric muscle is the stylo-pharyngeus muscle; it must be displaced backwards together with the glosso-pharyngeal nerve by which it is closely accompanied. The superior and middle constrictor muscles are exposed in the floor of the wound. The index finger is insinuated beneath the angle of the jaw, and an endeavour is made to free the space between the internal pterygoid muscle and the pharyngeal wall.

All bleeding is arrested, and when the wound is rendered as dry as possible, it is packed with gauze impregnated with sterilised vaseline.

Division of the Jaw.—Two holes are drilled in the lower jaw near its lower border about ½ inch apart, and just in front of the masseter muscle. The bone is then sawn through obliquely midway between the drill apertures, the plane of section passing from without inwards and backwards. The ascending ramus is drawn outwards, ·t, if difficulty is experienced in doing so, the internal lateral ligament may be ·ided.

With the finger tip the lingula, *i.e.*, the prominent lip of bone which marks the entrance to the inferior dental canal, is recognised, and, a blunt hook having been passed around the inferior dental nerve, it is drawn forwards and divided. If the inferior dental artery is seen, it should be secured by a ligature.

Removal of the Growth.—A finger introduced into the mouth localises the anterior margin of the growth. About ½ inch further forwards the pharynx is opened with scissors, and the aperture is extended upwards and downwards well beyond the corresponding limits of the growth.

The operator having substituted a fresh glove for that on the infected hand, the tonsillar margin of the wound with forceps and draws it backwards. Two incisions are now made from before backwards respectively above and below the growth, whereupon it can be drawn out into the wound and the final section made at a safe distance from its posterior border.

In order to diminish the risk of infection, the ulcerated surface may be cauterised as soon as it is exposed in the wound. The cautery, too, may be employed in the removal of the growth.

Closure of the Pharyngeal Wound.—The aperture in the wall of the pharynx may be sutured either partially or completely with catgut in two strata, and in doing so

care should be taken not to invert the edges of the mucous membrane. The sutures of the first row are interrupted and of the matrass type, and are introduced from below upwards, their ends being left long so as to enable the upper and more inaccessible part of the wound to be drawn down. They are very efficient in arresting bleeding from the wound margins. Even with a large aperture in the wall of the pharynx, an attempt should be made to close it by sutures. The employment of matrass sutures when possible is advantageous, as broad surfaces are brought into contact, and rapid union is promoted.

The vaseline gauze packing is now withdrawn, and the clamp is removed from the external carotid artery. If any vessels bleed, they are ligatured with fine catgut. If any of the deep muscles in the wound have been divided, they should be brought together and sutured. The two segments of the jaw are connected with a stout suture of silver wire.

The wound is closed except at the upper part, which is left open to admit a large rubber tube around which some gauze is packed. A second smaller tube may be placed in the lower angle of the wound.

COMMENTS.

Post-operative Disability. — Limitation of the movements of the jaw is a very constant sequela of operations upon the tonsillar region of the pharynx. Various causes tend to bring it about; the more important are—(*a*) damage to the muscles of mastication and deglutition and their nerves of supply and (*b*) the formation of unyielding scar tissue, which is often considerable when the healing of the wound takes place to a large extent by granulation.

The movements of the lower lip also may be limited after the operation if the depressor labii inferioris and the depressor anguli oris muscles are paralysed. This undesirable condition will result if the lower fibres of the cervico-facial division of the facial nerve are divided. In addition to the unsightly deformity of the mouth, there is great inconvenience caused to the patient by the tendency of the lower lip to be caught between the teeth in mastication. This, of course, may be due in some measure to the loss of sensation in the lip following division of the inferior dental nerve.

Owing to the unavoidable damage inflicted upon the nerves of the pharyngeal plexus, there is post-operative paralysis of the muscles of the soft palate on the same side. This leads to difficulty in swallowing, and interferes with distinct articulation.

Post-operative Pain in the Jaw.—This is caused by irritation of the inferior dental nerve, and, in order to prevent it, it is advisable to divide the nerve as described above. The division of this nerve causes paralysis of the mylo-hyoid and the anterior part of the digastric muscle, but this does not appear to have any bad effect on deglutition.

Removal of the Tracheotomy or Laryngotomy Tube may be attempted after twenty-four hours.

Avoidance of Septic Pneumonia.—This is, without doubt, the greatest danger of the operation, and may result from the entrance of blood and septic products into the

air passages at or subsequent to the operation. The chief measures to be employed in order to prevent it are—(*a*) the most careful cleansing and disinfecting of the mouth beforehand; (*b*) preliminary laryngotomy or tracheotomy followed by plugging of the pharynx; (*c*) a hypodermic injection of atropin which diminishes the salivary secretions.

The Administration of Nourishment.—This is carried out for some days most satisfactorily through a soft rubber tube passed from the nose into the œsophagus.

Sepsis in the Wound.—An acute septic infection of the wound may be followed by cellulitis which spreads rapidly along the connective tissue planes of the neck. Apart from the dangerous consequences resulting from the absorption of septic products and a general infection or bacteriæmia, there is an undoubted risk of secondary hæmorrhage in such cases.

The chief means available for diminishing septic troubles are—(1) preliminary cleansing of the mouth; (2) the application of the cautery to the ulcerating surface of the growth before or during its removal; (3) blocking the open lymph spaces in the wound by means of sterile vaseline; (4) the daily syringing of the wound with some mild antiseptic solution; (5) efficient drainage of the wound; (6) allowing the patient to sit up in bed and the frequent use of an antiseptic mouth wash; (7) the employment of polyvalent vaccines or antibacterial sera; (8) the application of tincture of iodine to the wound surfaces. We can speak highly of this precautionary method, as we have found it of undoubted value in promoting rapid healing.

The Lymphatic Glands.—Where these are not markedly diseased they may be dealt with at the same time that the primary growth is removed, but if the glandular enlargement is considerable, the operation had better be divided into two stages, so as to avoid infection of the large wound in the neck. The glands are first removed, and then after an interval of a week or ten days, when a protective layer of granulation tissue has developed in the wound, the removal of the tonsil may be undertaken.

THE ŒSOPHAGUS.

ŒSOPHAGOTOMY.—Indications.—This operation is most frequently performed for the extraction of foreign bodies which have become impacted in the tube, such as coins, dentures, etc. It has been performed also for the purpose of facilitating the dilatation of certain fibrous strictures of the œsophagus.

If the operation has for its object the removal of a foreign body, it is essential to convince one's self immediately beforehand that the latter is present in the œsophagus. It is quite possible that it may have passed onwards as the result of previous efforts to dislodge it and have either reached a lower level or entered the stomach. The œsophagoscope or an examination by means of the fluorescent screen will clear up these points.

Steps of the Operation.—*The Superficial Incision.*—The head is slightly raised and the site of operation rendered prominent by means of a cushion or sand-bag placed behind the neck. The incision in the skin is directed along the anterior border of the sterno-mastoid muscle on the left side from the sterno-clavicular articulation to the level of the upper border of the thyroid cartilage. The platysma and deep

fascia having been divided, the anterior border of the sterno-mastoid muscle is clearly defined and retracted backwards. At this stage one or more superficial veins may require division between ligatures.

Exposure of the Trachea.—The pretracheal muscles, omo-hyoid, sterno-hyoid, and sterno-thyroid, are now exposed (Fig. 63). The first of these usually requires division; the others are drawn inwards. This brings into view the well-marked pretracheal layer of the deep cervical fascia, which must be freely divided. The thyroid gland is now exposed, and while the sterno-mastoid muscle and the common carotid artery are drawn outwards, the lateral lobe of the gland is dislocated forwards and inwards. This exposes a deep cavity in the floor of which the finger will recognise the cervical vertebræ, and a careful inspection will reveal the inferior thyroid artery passing

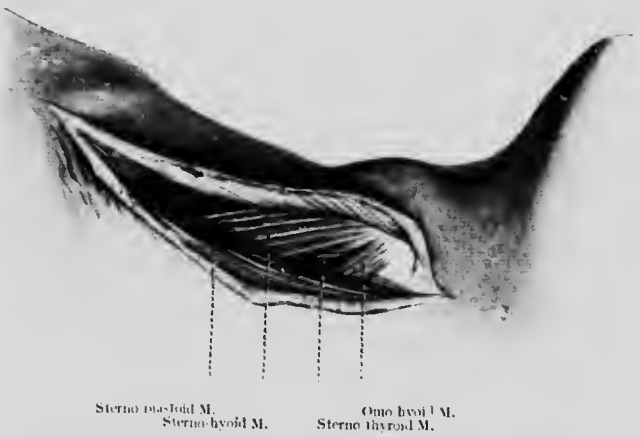

FIG. 63.—Cervical Œsophagotomy. The superficial tissues together with the platysma and the deep cervical fascia have been divided and the anterior border of the sterno-mastoid muscle defined. To the inner side of this will be observed the three flat muscles named respectively, sterno-hyoid, sterno-thyroid, and omo-hyoid.

inwards horizontally from behind the common carotid (Fig. 64). One of the thyroid veins, accessory or middle thyroid, may also be exposed. Both vessels will require to be divided between ligatures. The trachea is exposed deep in the wound, and is readily identified by the finger owing to its firm consistency.

Exposure and Division of the Œsophagus.—The œsophagus will be found between the trachea and the vertebræ, and if the wound is sponged dry and well illuminated, the muscular coat of the tube will be rendered visible. It is seized with two pairs of hæmostatic forceps and drawn forwards, and in making the incision care is taken to incise it rather nearer its vertebral than its tracheal aspect so as to avoid the recurrent laryngeal nerve which ascends vertically in the tracheo-œsophageal sulcus. The aperture is enlarged to the necessary extent with blunt-pointed scissors.

Removal of the Foreign Body.—If this is smooth, without any projecting irregularities, it may be extracted straightway with suitable forceps; but if the foreign body is provided with sharp metallic spikes, very great care must be taken to first disengage it before applying traction.

Closure of the Œsophageal Wound.—Provided the wall of the œsophagus is healthy,

an attempt should be made to close the aperture. Catgut is employed for this purpose; and, if possible, the sutures are arranged in two strata, traversing respectively the mucous and muscular tunics. If one row of sutures only is introduced, it should traverse the muscular coat, avoiding the mucous membrane, lest its margins should become everted and prevent union.

The wound in the superficial tissues is closed in the greater part of its extent. A drainage tube is passed down to the level of the sutures in the œsophagus, and emerges

FIG. 64.—Cervical Œsophagotomy. The lateral lobe of the thyroid gland has been raised and drawn inwards. The inferior thyroid artery, which runs inwards behind the common carotid artery, has been doubly ligatured and divided. The œsophagus will be observed in the depth of the wound; it lies behind the trachea, and the left recurrent laryngeal nerve occupies the tracheo-œsophageal sulcus.

through the lower angle of the wound. If thought advisable, some gauze may be introduced also around the tube.

COMMENTS.

Difficulties attending the Operation.—If the foreign body has been present in the œsophagus for some days, it may possibly have excited inflammation in the surrounding tissues (periœsophagitis), and this will occasion considerable difficulty in approaching the trachea and identifying the œsophagus, as the parts will be indurated and more or less matted together. The operator will require, under these circumstances, to proceed with great caution, aided by good illumination of the depths of the wound.

Identification of the Œsophagus.—This is usually easy when once the trachea has been exposed, as the œsophagus lies between it and the vertebræ behind. Its recognition may be rendered easier, however, by opening the mouth with a gag, drawing the tongue forwards, and passing an olive-headed bougie down to the region of the

wound. If the foreign body is lodged in the cervical stage of the œsophagus, its presence here will of course render the identification of the latter much easier.

The Aperture in the Œsophagus. This must be made with care and precision, the tissues being cleanly cut, not torn or lacerated. The aperture, too, must be of adequate size to permit of the easy extraction of the foreign body, and not necessitate tearing and unnecessary stretching of the margins of the wound.

Extraction of the Foreign Body.—The method of carrying out this part of the procedure has been alluded to already. With sharp-pointed objects it will be necessary first to dislodge them. This may be attempted with a suitably shaped blunt dissector, all attempts at forcible manipulations being studiously avoided, the chief danger of course being perforation of the trachea and the establishment of a tracheo-œsophageal fistula. This would be a serious accident owing to the risk of subsequent pulmonary complications (broncho-pneumonia; gangrene of the lung). It may require several minutes to dislodge the body from its resting-place before it will be safe to attempt its extraction.

Post-operative Complications.—One of these has just been alluded to, viz., inflammation of the lung by the extension of infection along the bronchial tubes. Another complication which may supervene is deep cellulitis in the neck, which tends to become diffuse, and may possibly extend to the mediastinum. Its onset will be most effectually prevented by providing for good drainage of the wound and by not attempting to close it to too great an extent by sutures. No matter how carefully the aperture in the œsophagus may have been sutured, there is always considerable risk of leakage.

After-treatment. The chief difficulty will be encountered with young subjects. The head and shoulders should be slightly raised, and both the head and neck maintained as steady as possible.

Fluid nourishment is alone permissible for a few days. A ready way of administering it is by a soft rubber tube passed from the nose down into the œsophagus, the utmost care being taken not to inflict injury on the suture line. If much difficulty attends the taking of nourishment by the natural way, rectal injections may be administered.

After two or three days attempts may be made to swallow liquids. The tendency of these to escape through the neck wound, assuming that the œsophageal aperture is partially or completely patent, may be diminished or largely prevented by the temporary pressure of a pad of wool or gauze.

In cases where the œsophageal wound is left completely open it may be utilised subsequently for catheterisation and the feeding of the patient. After ten days, food of a more solid consistency may be given by the mouth.

If the amount of discharge escaping from the wound is considerable, the dressings should be changed two or three times daily.

THE LARYNX AND TRACHEA.

THYROTOMY.—This operation is usually required for intralaryngeal growths limited to the vocal cords, and the removal of which through the mouth is not feasible. It is sometimes performed for the relief of stenosis of the larynx following injury or syphilitic disease. In the latter case great judgment is necessary, as the extra freedom

in breathing may be obtained at the expense of loss of the function of the larynx with regard to its capacity for preventing the inhalation of fluids. The rigidity of the arytænoid cartilages and the resulting loss of mobility of the vocal cords which bound

FIG. 65. Thyrotomy. The larynx has been exposed by dividing the overlying tissues in the middle line. This has been followed by a high tracheotomy; a tube has been introduced and a piece of rubber tubing leads from it to an apparatus for the administration of chloroform. The laryngeal interior is viewed from the side, and at its lower part a small piece of sponge, secured by long silk threads, serves to block the passage and prevent blood from trickling down into the trachea. The vocal cords on the left side are clearly seen. The reader will obtain a good idea from this figure of the amount of access provided by thyrotomy for dealing with disease within the larynx.

the rima glottidis tend to promote a certain degree of laryngeal insufficiency, and this may prove the determining cause of serious and possibly fatal bronchitic trouble.

Instruments.—The special instruments required are suitable scissors of the angular pattern for dividing the thyroid cartilage—but if this is ossified, a saw will be required;

indeed, this is probably the better instrument as a rule—retractors with teeth or sharp hooks to retract the ala of the thyroid cartilage after division; the actual cautery, and a tracheotomy tube.

Preliminary Tracheotomy. Whenever it is possible the tracheotomy immediately precedes the laryngeal operation.

Chloroform is the anæsthetic usually employed. The anæsthetist should take care that the laryngeal reflex is present to enable the patient to cough up any fluids. The chloroform should also be discontinued towards the close of the operation so that the patient may recover consciousness by the time the last sutures have been put in.

The neck of the patient is supported behind by a firm cushion or sand-bag; the chin is raised and maintained in this position by the anæsthetist.

A slight inclination of the table in the Trendelenburg position is advisable in certain cases where it is not intended to perform tracheotomy.

Steps of the Operation.—*The Superficial Incision* follows the middle line exactly, and extends from the lower border of the hyoid bone to the lower border of the isthmus of the thyroid gland. This latter is divided between two forceps if necessary.

The tissues are incised in successive strata, and bleeding vessels are secured by hæmostatic forceps; these latter further serve as useful retractors in drawing aside the muscles and fasciæ.

High Tracheotomy.—This procedure is performed according to the method described in another section (p. 139). A tube is introduced and secured by tapes, which are tied behind the neck. Hahn's sponge cannula has been the one chiefly employed, but many authorities advocate an ordinary tube. It is provided with a projecting piece, to which can be connected a piece of rubber tubing leading to an apparatus for administering chloroform.

Opening of the Larynx and the Intralaryngeal Manipulations.—The thyroid cartilage having been exposed, is divided strictly in the middle line, so that no damage may be inflicted upon the vocal cords. A median incision is made with a sharp scalpel and the section completed with angular scissors, one blade of which is introduced through an aperture in the thyro-hyoid membrane. In adults section of the cartilage is sometimes difficult owing to calcification, but it may be readily accomplished by means of a fine saw of the pattern originally devised by Hey. The median section is prolonged well upwards into the thyro-hyoid membrane, and the epiglottis and the wound margins are drawn widely apart with retractors or sharp hooks. Should the access thus afforded be insufficient, the laryngeal incision may be carried downwards through the cricoid cartilage and the upper two rings of the trachea.

In order to diminish the sensitiveness of the laryngeal mucous membrane and the subsequent oozing of blood, the laryngeal interior is painted with a 2 per cent. solution of cocain with adrenalin.

A small round piece of marine sponge or folded gauze held by a stout silk ligature is introduced into the interior of the larynx and down into the commencement of the trachea. It fills the lumen of the latter immediately above the tracheotomy tube and prevents blood from trickling down into the bronchi (Fig. 65).

If thought advisable, a second plug, with ligature attached, may be passed from below upwards into the pharynx, so as to shut off all communication with this region.

The manipulations which are carried out within the larynx necessitate good illumination of the cavity, and, as a rule, it will be advisable for the operator to be provided with a head mirror and electric lamp of Clar's pattern.

If a neoplasm is to be removed, this must be done thoroughly, and no considerations for the future functional efficiency of the vocal cords must weigh for a moment against this. On all sides of the growth the section is made carefully in healthy mucous membrane. Should the necessary extent of the operation be such as to interfere seriously with the functional efficiency of the larynx, the question of the advisability of laryngectomy will have to be considered.

The removal of papillomata is sometimes rendered very difficult by reason of their friability. They are most readily detached by means of small scissors curved on the flat. The bleeding points should then be successively touched with a fine galvano-cautery. This serves the double purpose of arresting the bleeding and destroying any portion of the growth which may have been left behind. Papillomata of the larynx tend greatly towards recurrence, and many cases have been recorded in which operations through the mouth have had to be repeated several times. One operation, however, performed as above, usually suffices for a permanent cure.

Closure of the Wound.—The plug having been removed from the trachea and all obvious bleeding arrested by fine catgut ligatures supplemented by hæmostatic forceps and pressure with gauze tampons, the two segments of the thyroid cartilage are brought together and retained in correct apposition by means of two or three sutures of chromicised catgut.

The alæ of the thyroid cartilage may be accurately united with silkworm gut, the sutures not entering the cavity of the larynx.

Additional sutures may be required for the divided thyro-hyoid and crico-thyroid membranes.

The superficial tissues are approximated by means of interrupted sutures of silkworm gut and horsehair.

The tracheotomy tube should, as a rule, be removed at the conclusion of the operation; but it may be deemed advisable in certain cases to leave it in for a longer period, more especially if there is reason to anticipate inflammatory swelling of the laryngeal mucous membrane, but such an eventuality is unlikely to occur. If the tube is removed early, the possible necessity for its reintroduction should be borne in mind, and it should be kept at hand so as to be immediately available if required. The skin wound over the tracheal aperture should not be closed, owing to the risk of surgical emphysema.

COMMENTS.

The effect of this operation on the voice is determined by the degree to which it is necessary to interfere with the vocal cords, but even in cases where one cord has been entirely removed for intrinsic cancer the voice commonly recovers when the wound cicatrises, and may, in fact, be much better than before the operation.

In addition to its possible effects upon the voice, thyrotomy for papillomata may be unsatisfactory in consequence of the tendency which these have to reappear.

LARYNGOTOMY.—In this procedure an opening is made into the larynx through the crico-thyroid membrane, and a tube is introduced.

It is seldom performed except as a preliminary measure to certain operations in which it is desired to prevent the entrance of blood into the air passages, such as excision of the tongue for cancer, excision of the upper jaw, operations upon the tonsil and pharynx, etc. When the laryngotomy has been performed the pharynx

is plugged with a folded mass of gauze passed back through the widely opened mouth so as to lie behind the epiglottis and completely occlude the passage.

The Superficial Incision is made vertically and accurately follows the middle line from the level of the central notch of the thyroid cartilage to a point just below the anterior arch of the cricoid. The subcutaneous tissues are divided, and any superficial vessels which bleed are immediately secured with clip forceps.

Exposure of the Crico-thyroid Membrane. The sterno-hyoid muscles are recognised in the wound, and the median incision is deepened between them so as to enable their opposing margins to be drawn aside. The finger identifies the crico-thyroid membrane, and by a little careful dissection it may be clearly exposed in the interval between the diverging crico-thyroid muscles.

Division of the Crico-thyroid Membrane and the Introduction of the Tube. The incision of the membrane is made in the transverse direction and close to the upper margin of the cricoid cartilage, as by so doing the crico-thyroid arteries will probably escape injury.

The tube, which is compressed from above downwards so as to present an oval outline on cross section, is introduced and retained *in situ* by tapes tied behind the neck.

COMMENTS.

The operation is not suited to children owing to the small space available between the cricoid and the thyroid cartilage.

The chief advantages of the procedure are the ease and rapidity with which it can be performed.

The division of the crico-thyroid membrane may be followed by sharp bleeding from the small crico-thyroid arteries, but as a rule it ceases when the tube is introduced, owing to the pressure which this exerts on the divided vessels.

The tube is usually removed at the conclusion of the main operation, but occasionally it may be allowed to remain in until the following day.

COMPLETE LARYNGECTOMY OR RESECTION OF THE LARYNX.

General Considerations. This operation is indicated in cases of malignant disease of the larynx when less extensive procedures are obviously inadequate, and in which there is a good prospect of being able to remove the disease and dissect away the lymphatic glandular areas on one or both sides of the neck. As it is a severe procedure, it should not be undertaken unless the general condition of the patient is favourable. Its performance would be attended by serious risk if there were any symptoms pointing to bronchitis, broncho-pneumonia, asthma, or chronic nephritis.

Preparatory Measures. The general condition of the patient will require careful attention, and special precautions must be taken to diminish the risk of sepsis from the mouth and teeth. These have been already dealt with in connection with the operative surgery of the tongue (p. 101).

Anæsthesia.—Ether is administered by the open method during the earlier stages of the operation, but when the larynx has been detached above and drawn forward

anæsthesia is carried out most conveniently by means of chloroform given with a Junker's inhaler.

The Steps of the Operation. *The Cutaneous Incisions.* The head and shoulders are raised by means of a sand-bag placed behind the first dorsal vertebra, and the head is made to incline slightly backwards.

The incisions are arranged so as to permit of the reflection of two flaps consisting of the superficial tissues and afford good access both to the larynx and the various struc-

FIG. 69.—Laryngectomy. The superficial tissues in the form of two flaps have been raised and turned aside. The flat pretracheal muscles have been resected on the left side. On the right side the omo-hyoid and sterno-hyoid muscles have been divided close to the hyoid bone and turned downwards, bringing into view the sterno-thyroid and thyro-hyoid muscles. The superior thyroid artery has been exposed on the left side with its superior laryngeal and crico-thyroid branches.

tures concerned in the operation. Two incisions are made transversely across the neck, the upper at the level of the hyoid bone and the lower a finger's breadth beneath the anterior arch of the cricoid cartilage. The extremities of both incisions overlie the anterior borders of the sterno-mastoid muscles. They are subsequently connected by a third incision, which accurately follows the middle line of the neck (Fig. 70). The two flaps thus outlined are raised, and consist of the superficial tissues together with the platysma muscle. Good illumination of the wound throughout the operation is imperative, and some surgeons prefer artificial light in a darkened operating

theatre. A Clar's head lamp is the best for the purpose, but the daylight need only be suppressed to a slight extent.

Exposure of the Larynx.—The superficial veins, especially the anterior jugular, will require division between ligatures. The deep cervical fascia and the flat muscles overlying the larynx and trachea are now exposed; the muscles include the

FIG. 67. Laryngectomy. The larynx has been fully exposed from the front, and the flat muscles have been excised on each side. The superior laryngeal and crico-thyroid arteries have been doubly ligatured and divided and the right lateral lobe of the thyroid gland drawn aside in an outward direction. The larynx is represented pulled over to the left side by means of a sharp hook. This lateral traction has brought into view the inferior constrictor muscle on the right side, which at this stage of the operation is divided vertically close to its laryngeal attachments.

anterior belly of the omo-hyoid, the sterno-hyoid, the sterno-thyroid, and the thyro-hyoid.

These pretracheal muscles conceal the larynx, and must be excised so as to expose the latter and facilitate the subsequent stages of the operation. The section is commenced above, and is most easily accomplished by first dividing the deep cervical fascia in front of the sterno-mastoid muscle and introducing a flat, blunt dissector beneath the omo-hyoid and the sterno-hyoid muscles. In doing so the subjacent thyroid gland should be carefully avoided. These two muscles are raised, and are again cut across lower down where they emerge from beneath the sterno-mastoid muscle. The deeper muscles, viz., the sterno-thyroid and thyro-hyoid are likewise excised as

represented in Fig. 66. The thyroid gland is now exposed and by ligaturing the crico-thyroid vessels on each side, the gland can be readily detached from the sides of the thyroid cartilage. The deep fascia above the thyroid isthmus is divided transversely at the level of the cricoid cartilage in order to permit of this part of the gland being pushed downwards, but, if necessary, the isthmus may be divided in the middle line and separated from the trachea on each side by blunt dissection. The divided portions of the thyroid gland will require to be ligatured carefully so as to avoid hæmorrhage. If a pyramidal lobe is found ascending from the isthmus, it will be divided at its basal attachment. Unless it is necessary to resect portion of the trachea, it is better to avoid any extensive detachment of the surrounding tissues. The first ring, however, is clearly defined.

The mobilisation of the thyroid gland renders the lateral portions of the larynx accessible. By drawing the larynx inwards and the thyroid gland outwards the fibres of the inferior constrictor muscle of the pharynx are well brought into view and are divided close to their thyroid and cricoid attachments with suitably curved scissors, but care is taken not to open into the pharyngeal cavity at this stage. The lateral thyro-hyoid ligament is divided just above the cornu of the thyroid cartilage (Fig. 67).

This stage of the operation affords a favourable opportunity for clearing away the lymphatic glands and vessels which are more immediately related to the diseased area. Although it may not be possible to detect any gland enlargement, nevertheless it is better to assume that in all cases of extrinsic cancer of the larynx the glands lying within the jugular sheath are involved and should be removed. This lymphatic dissection no doubt creates an extensive wound, and large tissue spaces are rendered accessible to septic invasion, but at the same time the risk incurred may be largely diminished by a careful aseptic technique.

The glands in front of the crico-thyroid membrane are removed without difficulty. Those in relation to the sheath of the main vessels are exposed by retracting the sterno-mastoid muscle on each side, incising the deep fascia over the vessels, and detaching the glands together with their associated lymph vessels from below upwards to the level of bifurcation of the common carotid artery.

The Laryngeal Blood Vessels.—The blood vessels which are mainly concerned in the operation are the superior laryngeal and crico-thyroid branches of the superior thyroid artery and the inferior laryngeal branch of the inferior thyroid artery on each side.

The inferior laryngeal artery ascends behind the crico-thyroid articulation, and is usually ligatured at a later stage of the operation before the larynx is detached from the trachea. The two other arteries, viz., the superior laryngeal and the crico-thyroid branches of the superior thyroid, must be ligatured before the opening of the air passages. The crico-thyroid artery is secured opposite the crico-thyroid membrane; it is doubly ligatured and divided. The superior laryngeal artery is most easily secured by drawing apart the hyoid bone and the thyroid cartilage. This renders the thyro-hyoid membrane tense so that the vessel is easily recognised. There is no necessity to preserve the internal laryngeal nerve.

The Laryngeal Extirpation.—The further steps of the operation are much facilitated by the ligature of the vessels, so that the danger of blood entering the air passages is not great.

The laryngeal extirpation is commenced above by the division of the thyro-hyoid membrane, and this is effected as in the procedure of subhyoid pharyngotomy, the epiglottis being left in connection with the larynx.

Before opening into the pharynx the large wound in the neck is plugged on each side of the larynx with strips of gauze, so as to diminish the risk of infection. Deep narcosis is necessary at this stage to prevent reflex coughing when the mucous membrane is being divided. On opening the pharynx the mucous membrane is painted with a 5 per cent. solution of cocain, and it will be advisable to employ a suction apparatus, such as Hudson's syringe, to remove mucus and saliva from its interior.

Fig. 68.—Laryngectomy. This figure represents a stage in the separation of the larynx from its connections. The thyro-hyoid membrane has been divided above and the inferior constrictor muscle with the pharyngeal mucous membrane on each side. Forceps grasp the divided thyro-hyoid membrane and a loop of silk ligature exerts traction upon the epiglottis. The interior of the pharynx is seen, also the entrance to the larynx and the mucous membrane covering the posterior aspect of the cricoid cartilage.

The thyro-hyoid membrane is freely divided on each side, and by drawing the thyroid cartilage forwards the entrance to the larynx is well exposed. The surgeon then proceeds to detach the mucous membrane of the pharynx along the posterior border of the ala of the thyroid cartilage and transversely across the posterior aspect of the cricoid cartilage, the thyroid cartilage being well drawn forwards meanwhile by a stout [illegible] of silk passing through the median portion of the thyro-hyoid membrane (Fig. 69). The mucous membrane is divided transversely at the level of the upper

border of the cricoid cartilage on its posterior aspect. Just here the membrane is somewhat adherent, but lower down its connections are looser, and at the level of the commencement of the œsophagus the tissue intervening between it and the trachea is quite loose, and the detachment can be readily accomplished with the help of a dry muslin swab. When the larynx has been thus detached from the surrounding structures it can be drawn forwards, and, as the commencement of the trachea has been

Fig. 68.—Laryngectomy. The larynx has been detached completely from its surroundings, except below where it still remains in continuity with the trachea. The level of section of the latter is represented by an interrupted black line. The pharynx has been partially closed by connecting together the cut margins of the inferior constrictor muscles and the subjacent mucous membrane. The superior thyroid artery and portion of the lateral lobe of the thyroid gland is seen in relation to the wall of the pharynx on each side.

already made quite free, the larynx may be completely detached by a transverse section immediately below the cricoid cartilage (Fig. 69).

Before this step is carried out, however, an attempt must be made to close the pharyngeal wound and thereby diminish the wound area open to infection.

Closure of the Pharynx.—The pharyngeal aperture has roughly the shape of a triangle, with its base above at the root of the tongue and its sides corresponding to the mucous membrane of the sinus pyriformis on each side.

The closure of the pharyngeal passage is an important step in the operation, for upon its satisfactory accomplishment much of its success depends. Before proceeding with this stage, however, a rubber feeding tube, with a diameter of 8 or 9 mm. and about 24 inches in length, is passed by way of the nose, the more capacious side being selected, and is guided along the œsophagus into the stomach. As a precaution the tube had better be secured to the wall of the pharynx by a suture of fine catgut, so as to prevent any possibility of its being coughed up during the first four or five days succeeding the operation, before the margins of the pharyngeal wound have united.

The margins of the mucous membrane are brought together by suture, and in passing the needle care is taken not to allow it to traverse the membrane, but the submucous tissue. A second row of sutures is passed through the pharyngeal muscles (Fig. 69).

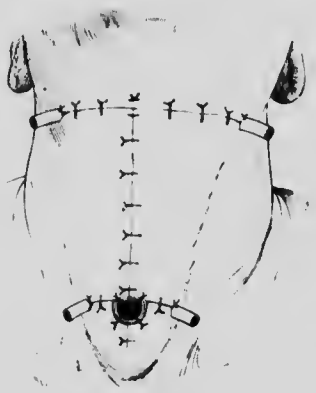

FIG. 70.—Laryngectomy. The superficial flaps have been restored into position and connected by interrupted sutures of silkworm gut. The cut margin of the trachea has been fixed by suture to the skin. Drainage tubes appear at the lateral angles of the wounds on each side. Those at the lower angles are not always necessary.

Before cutting the trachea across a stout loop of silk ligature is passed through its wall just below the line of section in order to prevent its retraction. The recesses of the wound are carefully packed with gauze. The tracheal section is then made immediately below the cricoid cartilage.

Fixation of the Trachea.—Formerly the procedure adopted consisted in making an aperture in the superficial tissues above the suprasternal notch, drawing out the trachea through it, and fixing it by sutures. In order to render the trachea sufficiently mobile for such displacement, the surrounding tissues had of necessity to be detached for some distance, with the result that in many cases a portion of the trachea underwent necrosis, and having parted company with the cutaneous margins, receded deeply into the wound. Under such circumstances a ring of cicatricial tissue would intervene between the skin and the [illegible] and the contraction which this would undergo in healing would determine a certain degree of stenosis. A better procedure consists in fixing the stump of the trachea to the margins of the wound made by prolonging the median cutaneous wound downwards towards the suprasternal notch. This does not necessitate any detachment of the surrounding tissues from the trachea sufficient to endanger its vitality.

The anterior and lateral margins of the tracheal aperture are connected with the margins of the median suprasternal incision. The two rectangular flaps are brought together at their lower margins, and are connected with the posterior part of the tracheal aperture.

Closure of the Wound: Drainage.—All protecting gauze tampons are removed, and the entire wound is inspected in order to make certain that all possible sources of bleeding have been dealt with. As a final precaution, the entire wound area is swabbed with tincture of iodine, a measure which we have found most useful in promoting primary healing, and from which we have not observed any bad effects. Extensive packing of the wound with gauze is to be avoided, but strips of gauze or pieces of rubber tubing may be introduced at the upper angles of the wound in the direction of the

deep recesses beside the pharynx. With the exception of the sites of emergence of the drains, the wound margins are approximated with silkworm gut sutures. The head and neck are enclosed in the dressing. A tube is placed in the trachea with some gauze next the skin, so as to avoid injurious pressure by the flange of the tube. In some of our cases, however, we have dispensed entirely with the tracheal tube.

COMMENTS.

Advantages of Total Laryngectomy.—The operation just described may be regarded as possessing the following advantages: (1) It provides for a complete dissociation of the alimentary and respiratory passages, and in this way it shows a marked improvement over the older forms of laryngeal resection, in which attempts were made to preserve the connection between the pharynx and the tracheal passage. The communication between these two was the main cause of the high mortality which attended laryngectomy in bygone years. (2) With the pharynx shut off in the manner described above, the soft nasal tube may be retained *in situ* as long as may be necessary to permit of complete healing of the wound. This simple device removes one of the greatest obstacles to the successful nursing of these cases. (3) The lymphatic glands may be dealt with at the same time that the primary growth is resected. This is a material advantage, as it avoids the possibility of further infiltration of the cancer if the glands are first removed, and it obviates the marked disturbance of the anatomical relationships of the neck which would necessarily follow the process of cicatrisation of the wound were the laryngectomy first performed.

Aseptic Technique.—It should be possible to maintain a perfect degree of asepsis in the isolation of the larynx and the removal of the lymphatic glands. In the later stages of the operation when the larynx is being severed from its connections, the large wound in the neck should be protected by gauze, and this should be retained pending the introduction of the sutures into the pharynx.

Complications.—**(1) Hæmorrhage.** This is not likely to occur if the vessels are properly secured before closing the wound. If bleeding to any marked extent should take place, the safest course would be to re-open the wound, ascertain its source and apply a ligature to the vessel.

(2) Bronchitis.—This may be regarded as one of the chief dangers of laryngectomy. With a view to prevent its occurrence the most scrupulous care should be taken to prevent blood or liquids from entering the air passages during the operation. The temperature of the operating theatre should be maintained at the proper level and precautions taken to prevent chill in removing the patient from the theatre to the ward. The surface of an ulcerating epithelioma of the pharynx or larynx is always foul and the adjoining mucous membrane, although apparently healthy, must be regarded as infected. Should these surfaces be exposed to the chilling influences of cold air the probability of bacterial invasion would be considerably augmented.

(3) Sepsis.—The occurrence of sepsis will be recognised by the usual signs, and notwithstanding all the precautionary measures which have been recommended to prevent it, it may occasionally supervene. A careful supervision of the wound should be maintained, and if there are any evidences of collections of pus or sero-purulent fluid they should be evacuated and suitable drainage provided at the earliest possible moment.

After-Treatment. It is usually advisable to keep the patient slightly under the influence of morphia for the first twenty-four or forty-eight hours after the operation. Nausea is not common, but if it occurs it will be necessary to resort to the introduction of fluids by the rectum until it subsides. In the absence of nausea and vomiting, however, liquids may be given through the nasal tube shortly after recovery from the anæsthetic. Saline solution in small quantities is given first, then milk and water, and as the case progresses, milk, beef tea, thin cornflour and egg flip will be tolerated. On each occasion after food has been given a little water should be passed down the tube to wash it clean and keep its lumen free.

The temperature of the room should be maintained at about 70° F. Mucus projected from the tracheal opening or through the tracheotomy tube, should be deftly removed by the nurse with as little disturbance of the patient as possible. This is an important detail, especially when the patient is trying to procure sleep. As a means of removing tracheal mucus, a suction apparatus is better than sponges or muslin wipes. One of the simplest and most efficient is that made from an ordinary enema syringe attached "tail on" to a piece of thin glass tubing with an internal diameter of 3 mm. or 4 mm. If the wound becomes septic and the discharges at all profuse, absorbent dressings are awkward and bulky and need, if small, to be changed frequently. Under such conditions the suction apparatus acts admirably, and in the hands of a skilful nurse it may be depended upon to keep the patient comfortable and prevent septic discharges from getting into the trachea.

The Voice.—It does not follow that because the larynx is removed the patient will consequently be voiceless; there are various devices by means of which he may be able to speak. One of these is quite simple, and may be imitated by any one who first holds his breath and then tries to form words. There is no true voice, but with some practice every sound ordinarily emitted may be imitated in a kind of whisper, indeed, patients usually are so satisfied with this speaking device that they do not trouble to seek a better one.

A method whereby a strong voice may be obtained consists in conducting a rubber tube into the pharynx through the nose. At the proximal end of the tube a small reed is attached which "speaks" when air is blown through. For convenience the air may be blown by connecting the outer end of this rubber tube to the tracheotomy tube. With this apparatus, a patient without a larynx may address an audience.

A still better device was discovered by a patient whose larynx had been extirpated. He found that by gulping down air he could distend his œsophagus, and that in letting the air escape he could make a sound precisely like a belch. With some practice he succeeded in so modifying the unmusical belch that it became an extremely good imitation of a voice which he had no difficulty in making heard across a large hall. It is somewhat difficult for patients to acquire this trick, but the difficulty is by no means insuperable. The absence of the cricoid cartilage favours the entry of air into the œsophagus.

HEMILARYNGECTOMY. This operation is but seldom performed at the present time. Though at first sight it would not appear to be such a serious procedure as total extirpation, nevertheless, the risk attending it is equally great, owing to the fact that the respiratory passage still communicates with the pharynx, while its protective mechanism has been interfered with to a serious extent. Furthermore, while it is not impossible to obtain good results with hemilaryngectomy in so far as the laryngeal apparatus is concerned, the difficulty of obtaining laryngeal "sufficiency" while avoiding stenosis is very great.

TRACHEOTOMY.

Indications. Tracheotomy is performed most frequently in cases of emergency due to obstructed respiration such as may occur with croup and diphtheria. It may be necessary in cases of laryngitis of the syphilitic or tuberculous form. It is sometimes performed as a preliminary measure in removal of the larynx for malignant disease or as a palliative procedure when the latter has reached an advanced stage. It may be required for the removal of foreign bodies in the air passages.

HIGH AND LOW TRACHEOTOMY. These procedures have been named respectively with reference to the isthmus of the thyroid gland. In high tracheotomy the tube is introduced through an opening in the trachea above the thyroid isthmus; in low tracheotomy the trachea is exposed and opened between the isthmus and the suprasternal notch. This operation, however, is seldom performed, as it is more difficult owing to the increasing depth of the trachea as it approaches the root of the neck and the greater complexity of the structures with which it is related. It is easier in children than in adults as the isthmus of the thyroid gland is relatively larger and lies at a higher level in the child. In the adult the rapidly increasing depth of the trachea as it approaches the root of the neck greatly adds to the difficulty of this operation.

Instruments.—Scalpels; dissecting and hæmostatic forceps; blunt dissector; retractors; sharp hook; tracheotomy tube of suitable size with tapes attached; trachea dilating forceps or a tracheotomy director; suction apparatus to remove diphtheritic membrane from the trachea.

HIGH TRACHEOTOMY. A sand-bag is placed behind the neck in order to render the laryngeal region prominent. A good light is very desirable; and if the operation has to be performed at night, the illumination provided by an electric head lamp is a great advantage.

In the case of a child the chest is wrapped round with a sheet or a large towel, and the arms are included, but the chest should not be subjected to pressure.

Chloroform is the anæsthetic usually employed, and as a rule its use is attended by safety during the operation, and when this has been performed the child usually falls asleep. It sometimes happens that the administration of an anæsthetic is followed by a sudden increase of dyspnœa, and the surgeon should, in anticipation of this, have everything ready for the prompt introduction of the tube. The anæsthetist keeps the head steady with the chin raised and in a straight line with the suprasternal notch. The surgeon recognises the prominent anterior arch of the cricoid cartilage as it is a valuable landmark.

The Cutaneous Incision is made accurately in the middle line, and extends from the level of the crico-thyroid membrane downwards for 1½ inches. The superficial tissues are progressively divided and bleeding vessels secured with clip forceps. The two anterior jugular veins are sometimes exposed in the wound as they descend close together. If possible, they are drawn aside out of the way; but if they cause inconvenience, they had better be divided and ligatured with fine catgut.

Exposure of the Upper Rings of the Trachea.—The deep fascia is divided accurately in the middle line, and at the same time the inner margins of the sterno-hyoid muscles are exposed and drawn aside. The index finger introduced into the wound defines the cricoid cartilage, and lower down the isthmus of the thyroid gland is seen

overlying the trachea, but somewhat obscured by the investing pretracheal fascia. This latter may be regarded as constituting a sort of suspensory apparatus for the gland, and must be divided to permit of the isthmus being pushed down. The division is most readily accomplished by picking up the fascia where it overlies the cricoid cartilage and incising it transversely for about ½ inch. Through the gap so made a blunt dissector or the handle of the scalpel is introduced, and the isthmus gently displaced downwards, bringing into view the upper three or four tracheal rings.

Fig. 71.—High Tracheotomy. The upper rings of the trachea have been exposed by dividing the deep fascia transversely at the level of the cricoid cartilage and pushing down the isthmus of the thyroid gland. A sharp hook has been inserted beneath the cricoid cartilage in the middle line and the knife is held with its sharp point in contact with the trachea preparatory to transfixing it and cutting from below upwards.

Incision of the Trachea and Introduction of the Tube.—While the assistant draws down the thyroid isthmus, the surgeon inserts a sharp hook deeply beneath the cricoid cartilage exactly in the middle line, and steadies the trachea (Fig. 71). Holding the hook with his left hand, and a sharp pointed scalpel in his right, and with the ulnar margin of the latter resting on the upper part of the sternum and the knife held vertically in the same way as a pen in writing, the trachea is pierced with a sudden stab and the incision prolonged upwards towards the cricoid cartilage. This is usually followed by an attack of coughing and the expulsion of some bloodstained mucus.

If available, a tracheotomy director, similar to that represented in Fig. 72, is introduced into the trachea, and hooks up the lower angle of the aperture. The sharp hook is now removed from beneath the cricoid cartilage; and if a bivalve tube is at hand, the inner tube is withdrawn and the outer held with its blades compressed as represented in Fig. 72. It is then carefully introduced into the trachea, and the tapes attached to it tied behind the patient's neck. As this is being done the tracheotomy director is removed. At first the introduction of the tube into the trachea excites

Fig. 72.—High Tracheotomy. A curved tracheotomy director has been inserted between the margins of the tracheal incision, and slight traction has been made upon the lower angle of the wound in order to steady the trachea and draw it forwards slightly. The bivalve portion of the tracheotomy tube is held in the left hand and its blades are being compressed in the act of introduction.

coughing, but when this has subsided the inside tube may be introduced and the patient put back to bed.

LOW TRACHEOTOMY.—The cutaneous incision extends from the lower border of the cricoid cartilage to the suprasternal notch, and accurately follows the middle line of the neck. As the superficial tissues are being divided the two anterior jugular veins should be looked for and avoided. They are most easily manipulated by seizing each with clip forceps devoid of toothed extremities and drawing them apart after the intervening fascial layer has been divided. If they cannot be thus dealt with, they had better be doubly ligatured and cut across.

Exposure of the Trachea. When the deep cervical fascia has been divided the surgeon looks for the interval between the sterno-thyroid muscles. Their opposing margins are seized with clip forceps and drawn aside to a slight extent. The inferior thyroid veins descend from the thyroid isthmus in the fatty tissue in front of this part of the trachea, and they too will require to be pushed aside or divided between ligatures. The thyroidea ima vessels also, if present, will require to be ligatured and divided. By means of a little blunt dissection the trachea may now be exposed.

Division of the Trachea and Introduction of the Tube. The trachea is steadied by means of a sharp hook introduced below the thyroid isthmus and divided, the knife being introduced vertically low down near the sternum and the section prolonged upwards for ½ to ¾ inch. The tracheal opening is maintained patent by the handle of the scalpel, which is introduced through the slit-like wound and rotated through half a circle, or, still better, the opening may be rendered patent and the trachea steadied by means of a suitable tracheotomy director. That represented in Fig. 72 is very useful for this purpose. The tube is then introduced in the same way as has been already described in high tracheotomy and secured by tapes behind the neck.

COMMENTS.

Some Points with reference to the Surgical Technique.—1. All instruments likely to be required should be at hand, so as to be immediately available if necessary. A momentary delay in the operation may be attended by fatal consequences.

2. The control of bleeding as far as possible during the operation should be the aim of the surgeon. This is best attained by securing the larger superficial veins before division or by pushing them aside and by depressing the isthmus of the thyroid gland instead of dividing it in the attempt to expose the upper tracheal rings. Large veins are related to the upper border of the isthmus, and their division would entail very free bleeding.

3. After the trachea has been exposed it is steadied by a sharp hook as above described, but on no account should the hook be withdrawn until the tube has been introduced or the trachea steadied by a tracheotomy director such as that represented in Fig. 72. If the trachea should escape from the grasp of the hook, it would of necessity recede deeply, with the result that the aperture, if made, would be drawn to a lower level and concealed by the overlying tissues. Hæmorrhage would increase owing to renewed venous engagement, and some of the blood would almost certainly be drawn into the trachea and add greatly to the already urgent dyspnœa.

4. In making the tracheal incision the knife should be well controlled, especially in children, so as to prevent its point from penetrating too deeply and perhaps wounding the œsophagus. The incision is usually accomplished by first piercing the trachea and then cutting from below upwards. This latter precaution is particularly advisable in the low operation, as a downward cut in the immediate vicinity of the suprasternal notch might be attended by risk considering the large blood vessels which are found at this level—the innominate artery and the left innominate vein.

5. Before introducing the tracheotomy tube in cases of diphtheria it should be noted if a membrane is present within the trachea. If so, it should be removed by means of special forceps or a suction apparatus before the tube is inserted.

Removal of the Tracheotomy Tube.—It is desirable that the tube should be removed at the earliest moment, as its retention for more than a few days is likely to render its removal difficult. As a rule it can be dispensed with from the third to the fifth day

and this is largely rendered possible in diphtheritic cases by the early administration of antidiphtheritic serum. The difficulties which are encountered in attempts to withdraw the tube after it has been *in situ* for a lengthened period are due to various causes, of which the most frequent are masses of granulation tissue within the tracheal aperture, cicatricial narrowing, bending of the trachea, paralysis of the vocal cords, or a condition of spasm of the glottis.

High and Low Tracheotomy contrasted.—The high operation is performed in the great majority of cases on account of its greater ease of execution.

The low operation is not so difficult in children as in adults; it is sometimes indicated for disease occupying the lower part of the cavity of the larynx in order that the tracheal aperture may be removed from this as far as possible.

Post-operative Hæmorrhage.—Severe hæmorrhage after some days has occasionally occurred with fatal consequences. Such an accident has usually resulted from ulceration into one of the large vessels caused by the end of the tracheotomy tube. It is obviously more likely to occur after the low than the high operation, and is best avoided by employing suitable tubes both as regards curvature and length and by not allowing them to remain in too long.

TUBERCULOSIS OF THE CERVICAL LYMPHATIC GLANDS.

PATHOLOGY.—Sources of Infection. The frequency with which tuberculous disease involves the lymphatic glands in the neck is not surprising when one considers the numerous sources from which the infective organisms may be derived. The buccal cavity is, without doubt, the most common of these sources owing to the great frequency with which carious processes involve the teeth and inflammatory affections engage the tonsils. The nasal fossæ and the middle ear are other sources from which tubercle bacilli are not infrequently derived.

The Extent of the Glandular Involvement varies.—In some instances the number of glands involved is small; they are very indolent, well circumscribed, painless, and tend to run a very chronic course: but estimates formed by palpation as to the number of glands affected are apt to be very erroneous.

In other instances the number of glands implicated is considerable, and the disease is apparently of a more acute type. Several groups may enlarge, and both sides of the neck may participate in the diseased process.

In a large percentage of cases the tendency of the disease is to progress. Thus the primary tuberculous deposit after a variable interval undergoes caseation, the caseated mass softens, and presently a chronic abscess develops. By this time the gland will probably have reached a considerable size, and as inflammatory changes approach its periphery, there succeeds a periadenitis, and this causes the gland to acquire adhesions to the parts by which it is immediately surrounded. As the process of caseation and suppuration continues to extend, the chronic abscess soon becomes periglandular; and if near the cutaneous surface, it gradually makes its way towards this. The clinical signs of a superficial chronic abscess are now quite distinct, and gradually the skin is implicated, assumes a bluish, livid colour, and, with the destructive changes persisting, it gives way, and the abscess contents are discharged. The abscess cavity shrinks, but does not close; a troublesome sinus remains, and may persist for an indefinite

period, partly in consequence of the diseased residue of the gland and partly as the result of mixed infection which so frequently happens in these cases.

In cases which are submitted to treatment for tuberculous disease in the cervical glands the extent to which the pathological changes just outlined have advanced is subject to considerable variation.

1. One or more glands are obviously involved. They are quite movable and painless, and do not occasion any trouble.

The number of glands involved is greater. They may be closely grouped together, forming a distinct cluster, but they are movable and have not coalesced with each other, nor have they acquired adhesions to the surrounding tissues.

The number of glands enlarged is probably considerable. The disease has advanced to the periglandular tissues, and the individual glands have more or less coalesced with each other. Those situated more superficially are soft and fluctuating.

4. This is a stage in advance of the preceding. The suppurative process in the glands has involved the subcutaneous tissue, and may have undermined the skin to a considerable extent. This condition is rather common in the neck, and requires to be recognised so that appropriate treatment may be applied. In such cases the mere evacuation of such subcutaneous abscesses is not enough, because their starting point is a gland more deeply placed. The gland is situated beneath the deep fascia, and communicates with the abscess perhaps by a narrow aperture in the latter. To render treatment effective, the diseased gland must either be excised or its remains removed as completely as possible by means of the curette.

5. In a still more advanced stage of the disease suppuration in the glands and the subcutaneous tissue will have been followed by the spontaneous discharge of the abscess contents. Sinuses persist, and the skin by which they are surrounded is of a bluish colour and undermined.

OPERATIVE PROCEDURES.—The ideal form of treatment which should be aimed at as far as possible is excision of all glands which are obviously diseased as well as those about which there is a reasonable suspicion of their being infected.

When suppuration has occurred, but is still confined to the gland, an attempt may be made to remove the latter completely; but if this seems inadvisable, the abscess may be incised and drained, or the incision may be followed by a thorough scraping of the tuberculous gland tissue.

When suppuration has reached the periglandular tissues and threatens the skin these less radical methods of treatment will be applicable, but later on complete excision may be possible when the abscess walls have healed and cicatrised.

Radical Measures.—The progressively increasing tendency of the disease to lead to disintegration in the glands first involved and to spread beyond these to other glands more remotely placed is in itself a strong argument in favour of radical operative measures as soon as the diagnosis is clear. No doubt in some instances, more especially those in which the disease is limited to a few glands and is very chronic in character, the natural forces of the body may succeed in arresting its progress and bringing about a spontaneous cure; but it is impossible to tell in what cases this satisfactory termination will occur, and, besides, in not a few cases in which a spontaneous cure may be expected the disease may suddenly take on increased activity and involve many neighbouring glands within a short time.

Another danger must be considered, viz. the possibility of infection extending from these glands in the neck to more remote parts of the body, such as the bones and

joints, the lungs, or the meninges of the brain. There is the possibility too of the disease becoming generalised. In these cases the bacilli, together with the caseating debris of a tuberculous gland, find their way into the lumen of a vein, and are carried into the general circulation.

GENERAL CONSIDERATIONS CONCERNING OPERATIONS FOR THE REMOVAL OF TUBERCULOUS CERVICAL GLANDS. The primary sources of infection should be looked for and treated in all cases. Carious teeth may need removal or stoppings. Enlarged tonsils had better be removed, and if post-nasal adenoids are present, they should be curetted away.

It is possible that it would be wise as a routine measure to have the opsonic index estimated in the case of individuals affected with tuberculous glands. Then, assuming that the index was low, the proper course would be to administer tuberculin in order to increase the resistance of the patient. This precautionary measure would appear to be indicated more especially in those cases in which the disease in the glands had progressed rapidly, and where both sides of the neck were implicated.

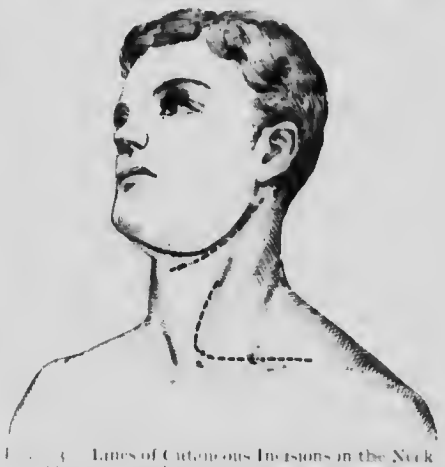

Fig. 73.—Lines of Cutaneous Incisions in the Neck. The incisions here represented are those most frequently employed for the removal of tuberculous glands situated respectively in the submaxillary region, the carotid triangle and the supra-clavicular fossa.

Anæsthesia. Nitrous oxide gas followed by ether is undoubtedly the safest anæsthetic, but it has the disadvantage of causing venous engorgement and rendering the operation troublesome on account of haemorrhage. Chloroform has not this objection, and consequently it is preferred by many as an anæsthetic in operations upon the neck, although its administration is attended by greater risk. With an experienced anæsthetist the risk, however, is probably insignificant.

The Cutaneous Incision.—A good cosmetic result is most desirable in operations performed upon the neck. With this end in view incisions should be made as far as is possible in the natural creases and in the direction of the lines of cleavage of the skin.

In the submaxillary region the best incision is one which in the form of a curve extends with its convexity downwards from a point just below the jaw in front of the sterno-mastoid muscle downwards to the level of the tip of the greater cornu of the hyoid bone and upwards to a point near the symphysis menti (Fig. 73).

The best incision for the exposure of glands in the upper part of the anterior triangle is that recommended by Kocher. It extends obliquely downwards and forwards across the neck from a point just below the tip of the mastoid process in the direction of the body of the hyoid bone or the upper border of the ala of the thyroid cartilage. It passes about ½ inch below the angle of the lower jaw (Fig. 73).

For glands situated in the upper part of the posterior triangle a suitable incision is one which follows the anterior border of the trapezius muscle. It may be combined with the previous incision by extending this la'' across the upper part of the sterno-mastoid muscle (Fig. 74). The flap included between the two limbs of this incision is raised, and the subjacent glands which extend from the anterior triangle beneath the sterno-mastoid muscle into the upper part of the posterior triangle can be exposed and removed.

Glands in the supraclavicular fossa are exposed by an incision directed horizontally above the clavicle. Should it be necessary to remove in addition the glands in the lower part of the anterior triangle, this incision may be carried forwards to a point opposite the sterno-clavicular articulation and made to curve upwards in front of the sterno-mastoid muscle.

FIG. 71.—Extensive Curved Incision extending from the submaxillary region across the upper part of the sterno-mastoid muscle and downwards in front of the anterior border of the trapezius muscle. This incision provides access to diseased glands in front, beneath and behind the upper part of the sterno-mastoid muscle.

It is well that the incision in the neck should be sufficiently free to enable the glandular dissection to be carried out with good exposure of the deeper parts. Attempts to remove tuberculous glands through a small cutaneous wound must be strongly condemned as the operation is thereby rendered more difficult: glands that have caseated are very liable to rupture and their contents to escape into the wound. The risk of hæmorrhage is much increased by attempting to operate within a confined space in which it may be impossible to see what tissues are being divided.

OPERATIVE TECHNIQUE. There are few operations which provide a better test of operative skill than those in which masses of glands adherent to the surrounding tissues and matted together have to be removed from the region of the neck. Not alone should the operator be capable of conducting the operation throughout with a rigid observance of the principles which regulate aseptic surgery, but he should possess also a minute knowledge of the anatomy of the part.

Injury to Nerves to be avoided.—As far as it is possible those nerves which come within the zone of the operation should be protected from injury. It may be that in many instances they cannot be preserved, and that their division is necessary. In the case of sensory nerves this is not very serious. Of course the cutaneous areas supplied by the divided nerves will be rendered anæsthetic, but it is surprising how sensibility tends to return in many cases in the course of time. An unpleasant result may follow, however, if the central end of the divided nerve becomes adherent to the cicatrix of the wound. The latter may subsequently become so acutely tender that it may be necessary to resect the scar and a segment of the adherent nerve.

If a sensory nerve must be divided, its two ends should, if possible, be held aside

until the completion of the operation and then connected by a suture of very fine silk. Division of motor nerves is more serious, and should never happen if measures can be taken to prevent it.

The following sensory nerves are most exposed to injury: the great auricular; the superficial cervical and the descending supraclavicular branches of the cervical

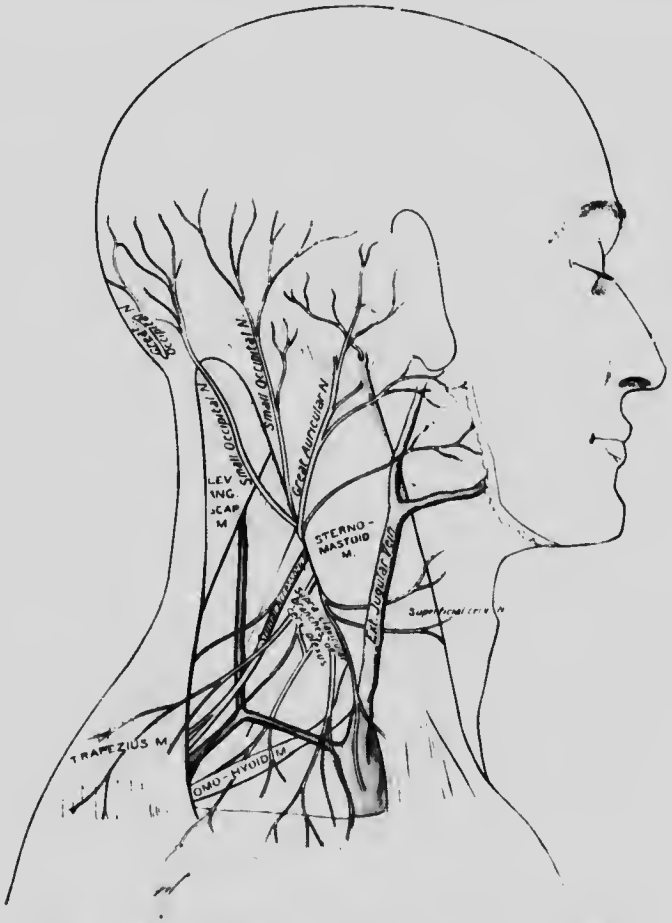

FIG. 75.—Diagram to illustrate the respective directions and areas of distribution of the chief Sensory Nerves derived from the Cervical Plexus. The position and direction of the external jugular vein are also represented

plexus. Their course and direction are clearly indicated in the diagram represented by Fig. 75.

The motor nerves which are chiefly concerned are the spinal accessory and the facial nerve.

The spinal accessory nerve may suffer injury in the upper part of its course in the anterior triangle, or lower down after it has emerged from beneath the sterno-mastoid

muscle and proceeds to cross the floor of the posterior triangle on its way to the deep surface of the trapezius.

In the first of these situations the nerve very frequently is found to lie in the midst of a cluster of diseased glands at the outer side of the internal jugular vein and below the prominent transverse process of the atlas vertebra. With a little patience and by careful dissection the glands can usually be got away, leaving the nerve intact. The

FIG. 70. Dissection of the Common Carotid Artery and the Structures with which it is related in the Carotid Triangle of the Neck. The internal jugular vein is closely applied against the outer aspect of the artery and both are overlapped by the sterno-mastoid muscle, which in the figure appears moderately retracted. The superior thyroid artery is seen in front of the common carotid, and this latter vessel is crossed by the superior thyroid vein.

best way to ensure its safety is to expose it as early as possible in the course of the operation and draw it aside by means of a blunt hook while the glands are being surrounded preparatory to their dislodgment.

The risk of wounding the nerve is probably greater in its course across the posterior triangle. Its identity can be established as a rule by noting the sudden twitch of the trapezius which occurs when it is caught or pulled aside.

This nerve supplies portions of the sterno-mastoid and trapezius muscles. In addition, the sterno-mastoid receives filaments from the second and third cervical

nerves, and the trapezius some branches from the third and fourth. Although these muscles do not become completely paralysed when the nerve is divided, yet the loss of power, especially in the trapezius, may be considerable and occasion an appreciable degree of drooping of the shoulder on that side.

The facial nerve is most exposed to injury when the operation aims at the removal of glands situated beneath the parotid fascia in front of the ear, but even here the

FIG. 77.—Dissection of the main vessels of the Anterior Triangle of the Neck at the level of bifurcation of the Common Carotid Artery. The external carotid artery will be observed disappearing beneath the digastric muscle, at which level it gives off its occipital branch and is crossed from without inwards by the hypoglossal nerve. The large internal jugular vein lies further outwards, and one of its larger tributaries, the common facial vein, is represented taking an oblique course superficial to the external carotid artery. The sterno-mastoid muscle has been retracted slightly in order to bring into view the spinal accessory nerve. This latter is closely related beneath the muscle to the sterno-mastoid branch of the occipital artery.

nerve is not likely to suffer serious damage so long as the dissection does not implicate the substance of the parotid gland, but keeps strictly to its superficial aspect.

One of the branches of the cervical division of the facial nerve is occasionally wounded, and, as the injury is followed by paralysis of the depressor labii inferioris and very obvious loss of power in the lower lip, the utmost care should be taken to avoid such an accident. However the paralysis is often but of temporary duration the loss of power becoming less and less manifest with the lapse of time.

The nerve just indicated comes off from the cervical division of the facial nerve usually a short distance below the angle of the lower jaw. It curves upwards over this bone just in front of the masseter muscle, and communicates with the supra-mandibular branch of the facial nerve, forming a loop; it is known as the ramus anastomoticus collo-mandibularis. It must be noted, however, that its origin from the cervical division of the facial nerve is subject to some variability, as it may come off as low down as the tip of the greater cornu of the hyoid bone.

This nerve is most liable to be divided in reflecting the superficial tissues in the submaxillary region in order to reach those glands which are situated beneath the horizontal ramus of the jaw and in the deep recess between this bone and the sterno-mastoid muscle. Other nerves which may be exposed to injury are the phrenic, the pneumogastric, the sympathetic, and the descendens hypoglossi. With the exception of the last, which may undoubtedly be divided in clearing away glands from the anterior triangle, the others are very unlikely to suffer damage. Their presence and relative positions should nevertheless be borne in mind when dealing with diseased glands in their respective districts.

Hæmorrhage; Entrance of Air into Veins, etc.—The chief difficulty which attends the removal of glands in the neck is due to hæmorrhage, principally venous, which wells up and obscures the view of the operator. Oozing from small vessels is often free, and must be controlled by the dexterous manipulation of gauze swabs by the assistant throughout the course of the operation.

Of the larger vessels those which are most liable to injury are the common facial vein and the internal jugular vein (Fig. 77). The former of these is usually exposed in the upper part of the anterior triangle, and, as it comes very much into the way, it will require to be doubly ligatured and divided.

The internal jugular vein demands the careful attention of the operator when removing diseased glands from the anterior triangle. It is a useful rule to expose the vein as soon as possible in operations in this region and then proceed to remove the numerous glands which are closely related to it, keeping the vessel throughout in full view. In the majority of instances the glands can be lifted off the vein, and considerable help will be afforded in doing this if a dry swab be rolled around the index finger and employed to push aside the individual glands and free them from their surroundings.

When a gland lying deeply in the wound appears to resist these efforts to dislodge it, care should be taken to divide all the tissues quite down to the gland, because it is only by doing so that the process of enucleation is rendered easy. If in the course of delivering the gland resistance be encountered, it may be overcome by dividing the resisting tissue as close as possible to the gland, and a sharp scalpel is the best instrument for this purpose. On no account should bands of tissue deeply situated beneath an enlarged mass of glands be divided with scissors, unless two pairs of forceps are first applied, because, owing to the traction exercised on these resisting bands, any blood vessels contained within them will be stretched and their lumina obliterated. Veins so pulled upon appear white, and resemble white bands of tissue. Even the internal jugular vein may be so altered in appearance by forcible traction as to be quite unrecognisable as such. Assuming that the vessel were wounded ever so slightly, as soon as the tension was relaxed copious hæmorrhage would take place, and it is exactly under these conditions that the risk of air entering the vessel is greatest.

If such an accident should happen, it would probably be recognised by the peculiar

whistling sound which accompanies the sudden inrush of air. A compress should be firmly applied to the wounded part and some sterile saline solution poured into the wound. As long as this contains sufficient fluid in contact with the vessel no more air can enter. The site of the wound is seized with hæmostatic forceps and securely occluded. The best course then will be to proceed with the removal of the glands and leave the wound in the vein to a later stage of the operation.

The most appropriate method for dealing with the vein will depend upon the extent of the injury which it has received. A small puncture may be closed by catching the wounded part and drawing it out sufficiently to permit of lateral ligature being applied, but this method is apt to be attended by risk through slipping off of the ligature when the tension within the vein increases, as may readily happen in efforts to vomit after the patient is put to bed. A more efficient way to close the aperture in the vessel is to sew it up with fine catgut passed in slender round-bodied needles, the vein itself being compressed meanwhile on both sides of the wound. Should the vein be almost completely divided, the safest plan probably would be to complete the division, having first secured the vessel above and below, and apply a ligature of catgut to each end.

Very marked adhesion of glands to the internal jugular vein may render their detachment impossible, but this is more likely to be the case when the glandular disease is of a malignant character than when it is tuberculous. Under these circumstances the best plan will be to expose the vein fully at the upper or lower part of the adherent mass and divide it between ligatures. The adherent segment is then lifted away with the glands, and as soon as these are freed all round the vessel is again ligatured and the adherent segment removed.

When a softened tuberculous gland which is adherent to the internal jugular vein is being removed it may rupture, and its contents may flow over the wound. The matter which escapes should be carefully swabbed away and the contents of the gland gently pressed out until all are removed. The wound is then well flushed with a stream of hot saline solution and swabbed dry. The remains of the gland are snipped away, except that part which is adherent to the vein. This is gently scraped with a curette and swabbed with pure carbolic acid, the excess of acid being subsequently removed with a little absolute alcohol.

Wound of the Thoracic Duct. – This accident may occur in the process of removing glands at the root of the neck on the left side. It may possibly be recognised at the time by seeing some turbid or milky fluid escaping from the wounded vessel. It was held for many years that wound of the thoracic duct would inevitably prove fatal, but the accident has occurred on several occasions without any serious consequences. One reason for this may be explained by the peculiar method of termination of the duct. Instead of opening at the junction of the subclavian and internal jugular veins on the left side as a single trunk, it may first divide into a series of branches, each of which terminates separately. It may happen, therefore, that one only of these terminal offshoots of the main duct may be wounded. Again, even assuming that the main duct were divided, a fatal result need not necessarily follow, as the communications between the lymphatic and venous channels which exist in other parts of the body might succeed in draining away the contents of the main lymphatic channel.

The plan of treatment to be employed when the thoracic duct is wounded will depend upon the circumstances of the case. If the main duct is completely torn across, it would be best to seize it with forceps or apply a ligature. Successful attempts to suture the two ends of the duct have been published, but such results must be

quite exceptional and are not within the range of possibility in the great majority of cases. Another method of treatment consists in plugging the wound firmly with gauze.

The Sterno-mastoid Muscle.—The anterior border of this muscle is the main guide to the large vessels of the neck, viz., the common carotid artery, with its two terminal branches, and the internal jugular vein. It is enveloped by the investing layer of the deep cervical fascia, and it is only by dividing this latter and drawing the muscle backwards that the more important structures in the anterior triangle of the neck can be exposed and dealt with. In the removal of tuberculous or malignant glands, therefore, from the anterior triangle, the anterior border of this muscle should be clearly defined by dividing the deep fascia in front of it and then drawn backwards by a suitable retractor. In the upper part of the neck the lymphatic glands which lie along the outer and posterior border of the internal jugular vein may enlarge and form a prominent mass beneath the sterno-mastoid. It may be possible to remove them by freely opening up the anterior triangle in front of the muscle, displacing this backwards, and dissecting the glands from off the internal jugular vein and from around the spinal accessory nerve. The procedure may be facilitated occasionally by making another incision in the posterior triangle behind the sterno-mastoid muscle, defining its posterior border, and dissecting beneath it until the two wounds are brought into communication, care being taken not to divide or injure the spinal accessory nerve. Another method of facilitating the dissection is to make a transverse division of the muscle high up to enable the lower part being turned aside while the dissection is being carried out. Subsequently the margins of the divided muscle should be carefully approximated with catgut sutures.

Drainage.—The wounds left after excision of masses of glands in the neck are sometimes considerable, and there is a tendency for blood to ooze from the smaller vessels after the wound is closed. This tendency is increased if the operation is succeeded by forcible efforts at retching. There may be also a flow of lymph into the wound cavity from the numerous lymphatic vessels which have been divided. This has been very marked in some instances (lymphorrhœa). For these reasons it is usually essential to introduce a drainage tube of rubber or glass for at least twenty-four hours after the operation. The tube may be made to emerge from between the wound margins at a dependent point, but better drainage may be obtained by making a counter-opening at some distance from the main wound. For instance, when glands have been removed from the upper part of the anterior triangle a counter-opening may be made behind the sterno-mastoid muscle.

Closure of Wounds in the Neck.—Seeing how important it is to prevent unsightly scarring of the neck, wounds in this region must be sutured in such a way that their margins will be subjected to the minimum of tension subsequently. This end is best attained by approximating the deeper tissues by a certain number of interrupted sutures. Thus the deep fascia and the platysma should be carefully adjusted in this way before attempting to close the skin wound. This precaution enables the cavity left after the dissection to be reduced greatly in size, and the sterno-mastoid muscle, which tends to recede, is drawn forwards to its proper level. The cutaneous margins, too, will be found to come together without any effort. The best means of retaining them in accurate contact is probably by introducing a series of horsehair sutures or fine interrupted sutures of silkworm gut. We frequently use a continuous sub

cuticular suture for neck wounds, and Michel's metallic clips are very well adapted also for wounds in this region.

The approximation of the cutaneous margins may be difficult if in the removal of the glands it has been found necessary to excise an area of diseased skin. It may be possible, however, to bring them into accurate contact by undermining the wound margins freely all round before passing any of the sutures.

The Dressing.—Strips of sterile gauze supplemented by layers of absorbent wool or gamgee tissue are applied to the wound, and as a rule the dressing should exert a moderate pressure. The retaining bandage should include the head and the shoulders.

OPERATIONS ON THE THYROID GLAND.

ANATOMY.—The thyroid gland together with the larynx and trachea the lower part of the pharynx, and the cervical portion of the œsophagus, is lodged in the visceral compartment of the neck, *i.e.*, the space bounded by the vertebræ, prevertebral muscles, and prevertebral fascia behind, the depressor muscles of the hyoid bone and the pretracheal fascia in front, the sterno-mastoid muscles and the main vessels of the neck, with their accompanying nerves, on each side.

The gland possesses a definite fibrous investment which sends septa into its interior. The large branches of the thyroid vessels lie immediately beneath this membrane, and it is pierced by the arteries and veins which enter and leave the gland. This latter is connected with the surrounding parts by a very loose cellular tissue, which permits of a free up-and-down range of movement under normal conditions, but movement may be limited or abolished by adhesions resulting from inflammation or malignant infiltration originating in the gland.

FIG. 78. Dissection of the Chief Veins in connection with the Thyroid Gland. The superior thyroid vein on each side joins the internal jugular vein above the pointed extremity of the corresponding lateral lobe. The inferior thyroid veins below are connected respectively with the right and left innominate veins. Certain accessory thyroid veins will be observed on the right side passing from the gland to the internal jugular vein. A well-developed specimen of a persistent thymus gland was present in this subject; its upper part is seen in the interval between the basal portion of the goitre and the supra-sternal notch.

The Outer Fibrous Capsule of the Thyroid Gland.—The pretracheal layer of the deep cervical fascia which lies subjacent to the corresponding muscles forms the anterior boundary of the visceral compartment of the neck, and is known as the outer fibrous capsule of the thyroid gland. In the operation of thyroidectomy this investing layer, unless in the presence of adhesions, must be divided and the subjacent space freely opened so as to permit of the forward dislocation of the goitre (Fig. 82). The

prevertebral layer of the deep cervical fascia forms the outer fibrous capsule of the thyroid behind. The parathyroid glandular bodies are closely related to this layer of fascia, and their preservation can only be assured by retaining it and by pushing it aside in the process of dislocating the posterior rounded part of the goitre forwards from its cellular cavity.

Blood Vessels.—The *superior thyroid arterial branches* enter into and the corresponding veins emerge from the upper pointed extremity of the lateral lobe. Unless in goitres which reach a high level, it is usually easy to isolate these vessels collectively and divide them between forceps or ligatures close to the gland.

The *inferior thyroid artery* is the most inaccessible of the vessels as it lies deeply in the neck, passing inwards behind the common carotid artery in order to reach the deep aspect of the gland. It is usually secured after the goitre has been dislocated forwards, and can be recognised then, as a rule, as a pulsating cord passing from without inwards in the direction of the trachea (Fig. 83). Owing to its close proximity to the recurrent laryngeal nerve, especially on the right side, its division and ligature are attended by some risk of wounding this nerve.

Fig. 79.—Transverse Section through a Diffuse Parenchymatous Goitre. The compressing effects of the enlarged thyroid lobes on the trachea and œsophagus are clearly seen.

The *inferior thyroid veins* emerge on each side from the gland at its lower rounded extremity (Fig. 78). They converge to a single trunk, which terminates in the corresponding innominate vein.

Accessory Thyroid Veins. These are somewhat variable in size and number. They emerge from the gland along its outer rounded border, and proceed outwards to the internal jugular vein, having pierced the outer fibrous capsule. These veins are always looked for and divided between forceps or ligatures before any attempt is made to dislocate the goitre forwards during thyroidectomy.

The Recurrent Laryngeal Nerves.—These are related to the deep aspect of the lateral lobe of the thyroid on each side. The nerve on the left side ascends in the tracheo-œsophageal sulcus (Fig. 64); that on the right side takes a more oblique course from beneath the first part of the subclavian artery to reach the lower border of the cricoid cartilage. It may run superficial to or beneath the branches of the corresponding inferior thyroid artery. When the enlarged lateral lobe of the thyroid is dislocated forwards, this nerve may be drawn forwards close to the trachea, a circumstance which renders injury to it all the more likely unless due care is exercised.

The Parathyroids are small bodies, not larger than a pea as a rule, which are embedded in the outer thyroid capsule and lie in relation to the deep or vertebral aspect of the gland. There are usually two on each side.

PATHOLOGY.—The form of operative procedure employed in a case of diseased

thyroid will depend largely on the nature and extent of the pathological condition present. From the operative standpoint it is mainly of interest to ascertain if in a given case of goitre the enlargement is of a *diffuse*, uniform type in which one or both lateral lobes participate or of a *partial* nature, due to solid adenomatous masses or cystic growths embedded in the thyroid parenchyma, and if these are capable of being enucleated (nodular goitre).

It is of very great practical importance also to decide if with a goitre there are coincident symptoms of thyroid intoxication (hyperthyroidism). These are indicated mainly by greatly accelerated action of the heart, pulsation of the blood vessels in the neck and in the thyroid itself, a high degree of nervousness, and muscular tremors. Considerable risk attends operation in these cases, the main danger being dependent upon the condition of the heart (toxic myocarditis). This form of goitre is sometimes alluded to as "exophthalmic," but the term is unfortunate, as the disease may exist in a marked degree without any noticeable exophthalmos. In this country it is known as Graves' disease. Owing to the extreme degree of vascularity of such goitres, their treatment by excision of one lateral lobe may be attended by great difficulty and danger owing to hæmorrhage. For these reasons surgical treatment is sometimes carried out in two stages, viz., a preliminary ligature of the superior thyroid vessels and subsequently excision of one lateral lobe. Goitres which have been the seat of inflammation (strumitis and peristrumitis) may be very difficult to treat operatively owing to adhesions between the gland and its outer capsule, and this may have fused with the surrounding tissues in the neck.

Malignant Disease affecting the thyroid gland may be removed without untoward difficulty if at the time of operation it is in an early stage, but at a later period, when the growth has spread in a peripheral direction by a process of infiltration of the adjoining tissues, it may be so fixed that the question of its removal cannot be seriously entertained.

THYROIDECTOMY.—This procedure consists in a partial removal of the thyroid gland. Complete excision must not be attempted owing to the danger of myxœdema supervening. As a rule one lateral lobe is removed, and occasionally the isthmus, when enlarged and connected with the opposite lateral lobe by a narrow junction, is removed at the same time.

Indications.—The following are the chief conditions for which thyroidectomy may be undertaken: (*a*) diffuse colloid goitres in which both lateral lobes are implicated, the enlargement being more marked on one side than on the other: on section the mass presents uniformly distributed small nodular masses—diffuse follicular goitre; (*b*) certain cases of exophthalmic goitre; (*c*) malignant goitres in which the disease is as yet limited to the gland.

Contraindications.—These apply mainly to the following: (1) very large goitres associated with a feeble condition of the heart, the right ventricle being probably hypertrophied and dilated and the lungs emphysematous; (2) malignant disease which has extended beyond the limits of the gland.

Instruments.—In addition to the ordinary instruments required for operative work, it is desirable to have a suitable blunt dissector; that used by Professor Kocher is especially to be recommended. A large supply of clip forceps will be necessary, as the vessels are very numerous and must be carefully secured before division.

Preparatory Measures. These are mainly indicated in cases associated with excited heart action and nervousness. The patient should be kept at rest for several days preceding the operation. The terror incident to the induction of anæsthesia should be overcome as far as possible by reassurances on the part of the operator.

Anæsthesia. As a rule a general anæsthetic is to be recommended in this operation. Atropin, $\frac{1}{120}$ of a grain, is administered half an hour beforehand, and the anæsthetic consists of nitrous oxide gas followed by ether, which is given by the open method.

Kocher prefers local anæsthesia, and usually employs novocain. He finds this useful more particularly when the inferior thyroid artery is being secured, as it enables him to judge if the recurrent nerve is in danger. Recently hedonal has been employed as an anæsthetic in goitre cases, and has proved very satisfactory.

General anæsthesia by the intratracheal insufflation of ether has recently been employed with gratifying results, and the following advantages have been claimed for it: (1) the anæsthetist is out of the way of the operator; (2) there is no respiratory embarrassment when the trachea is dragged upon or distorted; and (3), as the aeration of the blood remains perfect, there is no congestion of the veins of the neck and a complete absence of cyanosis.

Individuals in whom the administration of a general anæsthetic is attended by grave risk should be deemed unsuited to undergo the operation of thyroidectomy.

FIG. 80.—Kocher's Curved Incision across the lower part of the Neck in Thyroidectomy.

THE OPERATION.—In the procedure about to be described it is assumed that the enlargement is of moderate extent, and that the parts mainly involved are the right lateral lobe and the isthmus.

The attitude of the patient is represented in Fig. 81. The table is inclined to a slight extent so as to raise the head and shoulders. A pneumatic pillow or sand-bag is placed behind the neck, arching it forwards and rendering the goitre more prominent. Finally, by means of a suitable frame attached to the table a sterilised sheet is applied so as to extend from the area of the operation over the frame, concealing the face of the patient and the anæsthetist.

The Superficial Incision is directed transversely and with a slight downward convexity, crossing the middle line about midway between the cricoid cartilage and the suprasternal notch, but its level will vary in different cases, depending upon whether the goitre is situated high up or low down in the neck.

The incision extends for some distance over the sterno-mastoid muscle on each side, and may require to be prolonged upwards also to some extent on the affected side. Before dividing the skin two or three scratches may be made across the path

of the incision by the scalpel or needle; they ensure accurate coaptation of the wound margins when the sutures are being introduced.

The incision is extended through the subcutaneous tissue and platysma, and these

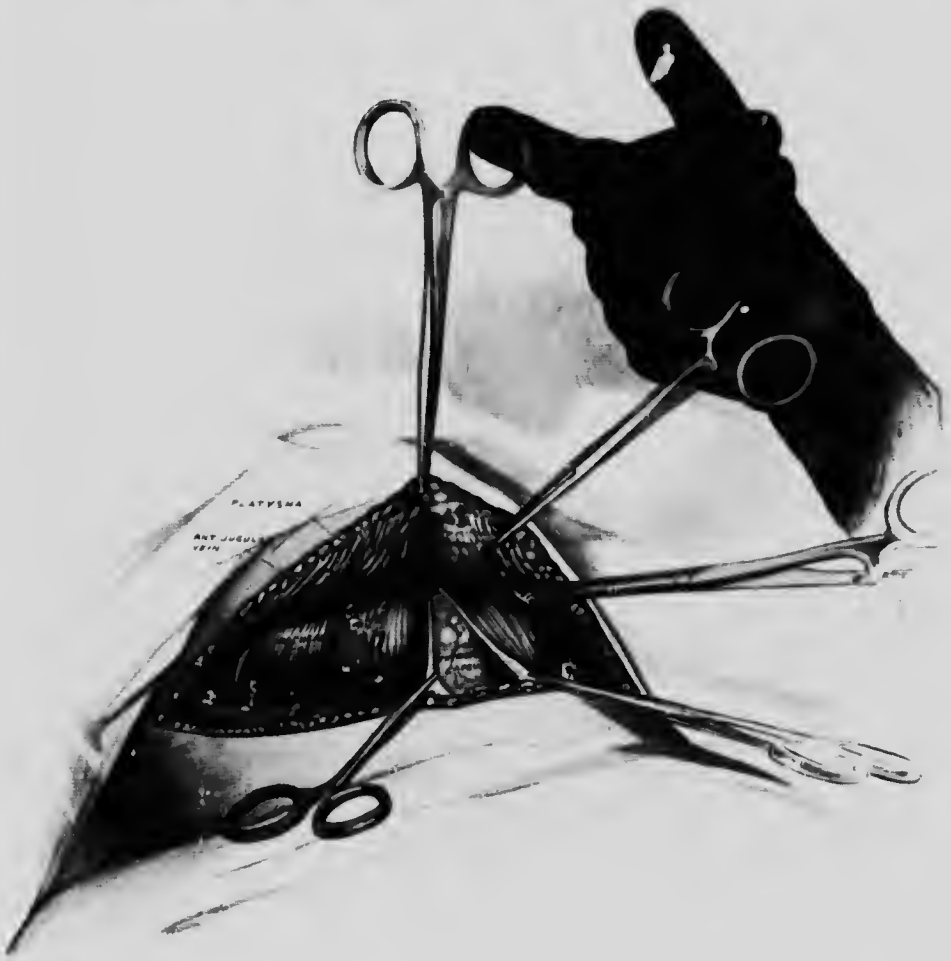

FIG. 81.—Thyroidectomy by Kocher's Curved Incision. The superficial tissues have been reflected and drawn upwards. The chief superficial veins have been doubly ligatured and divided. The deep cervical fascia in the middle line, between the contiguous margins of the sterno hyoid muscles has been split vertically. This has enabled the muscles to be drawn apart with resulting exposure of the goitre within its fibrous capsule. This and the two succeeding figures have been drawn from stereoscopic photographs kindly taken for me during operation by Dr. C. Arthur Ball. The head of the patient has been shut off from the field of operation by a screen.

are raised with the skin in the form of a flap, exposing the pretracheal muscles and the deep cervical fascia by which they are invested (Fig. 81). The anterior jugular veins come into view now, and should be divided between ligatures. The external

jugular vein usually escapes injury, as it descends outside the lateral extremity of the wound.

The median interval between the sterno-hyoid muscles is identified, and the deep cervical fascia is divided at this level in a vertical direction.

A blunt dissector is insinuated beneath the flat pretracheal muscles from the middle line outwards as high up as possible close to their upper attachments, so that their nerves of supply may be preserved. Two long-bladed forceps are applied, and the muscles thus undermined are divided transversely in the intervening interval.

The divided muscles, held by forceps, are raised and turned downwards. Should

FIG. 82.—Thyroidectomy. Elevation forwards of the goitre. This figure also has been drawn from a stereoscopic photograph taken during operation. The superior thyroid vessels and also two accessory thyroid veins have been ligatured and divided.

the sterno-thyroid muscle have escaped, it will require to be divided before proceeding further.

The outer fibrous sheath of the goitre is now exposed. It overlies the large glandular mass, and several large veins may be seen beneath it ramifying over the tumour. A non-vascular area having been selected, the membrane is seized by two pairs of forceps, divided, and the aperture freely enlarged, whereupon the operator gains access to the proper interspace to be followed in the process of delivering the goitre from out of its recess.

Dislocation of the Goitre.—A finger inserted beneath the capsule sweeps over the anterior surface and outer border of the goitre. If a middle thyroid vein is encountered passing outwards to join the internal jugular, it is divided between two clip forceps and subsequently ligatured. The outer border of the lateral lobe being

free, one or both index fingers are passed beneath it at its middle, and push it forwards into the wound. As the dislocation proceeds the posterior part of the thyroid capsule and all surrounding loose connective tissues are sponged away carefully from the goitre. Up to this stage respiration is sometimes impeded owing to pressure on the

Fig. 83. Thyroidectomy. Dislocation of the goitre forwards from its recess in order to obtain access to the interior thyroid vessels. The common carotid artery and the lateral aspect of the trachea are faintly represented in the deep shadow of the wound. Drawn from a stereoscopic photograph.

trachea, but as soon as the thyroid tumour is dislocated the breathing becomes much easier and quieter.

The Thyroid Vessels. The principal thyroid vessels must now be dealt with. The *superior thyroid artery and vein* are found at the apex of the lateral lobe; the *inferior*

thyroid veins (Fig. 78) leave the goitre at its lower basal extremity, and are rendered prominent when the latter is dislocated forwards; the *inferior thyroid artery* is deeply placed in the prevertebral region, where it is directed inwards from beneath the common carotid artery to the deep aspect of the gland (Fig. 64). Veins of considerable size may be found along the upper border of the isthmus. The *thyroidea ima vessels* may be present at its lower border.

The Superior Thyroid Vessels.—The apex of the enlarged lateral lobe is seized and gently drawn downwards and forwards. The superior thyroid vessels are thus brought into view and divided between clip forceps. The upper extremities of the divided vessels had better be ligatured at this stage, and in doing so care should be taken to relieve the tension on them as the ligature is being tightened, so that they may not slip from out of its grasp and bleed vigorously. As far as is possible, in dislocating the goitre and ligaturing its vessels care should be taken not to tear any of these, as the resulting hæmorrhage obscures the field and infiltrates the surrounding lax tissues to such an extent that the various structures in the wound cannot be clearly recognised.

The Inferior Thyroid Veins.—These vessels, usually of large size, are brought into prominence by tilting the basal portion of the goitre forwards. They are divided between forceps and the central ends are immediately secured by ligatures.

The Inferior Thyroid Artery. The goitre, being now comparatively free, is displaced further forwards and inwards, and in doing so the capsule and all loose tissue are stripped away from it so as to safeguard the parathyroids which are intimately related to it on its deep aspect. The inferior thyroid artery is recognised as a pulsating cord extending from the inner and deep aspect of the common carotid artery in the direction of the trachea (Fig. 83). The recurrent laryngeal nerve on the right side is related to it before it breaks up into its terminal branches, sometimes running beneath, sometimes in front of the artery. The safest method of securing the artery is to follow it to the gland and seize its terminal branches with two or more clip forceps. In securing these vessels the nerve may be seen, but more frequently it is not recognised.

The Thyroid Isthmus. The inferior thyroid artery having been secured and divided, the operator proceeds to deal with the isthmus. Its upper border is first defined, and the communicating vessels which sweep along it are divided between forceps. A blunt dissector is gently insinuated between the isthmus and the trachea, and when the former is sufficiently detached it is seized with special forceps and crushed. A ligature is applied to the crushed part, and the affected lobe is cut away at a safe distance from the ligature.

When the isthmus is bulky it may be necessary to tie it in sections, or it may be drawn forwards and divided, the vessels in its cut surface being subsequently secured by ligatures. Another method of dealing with the isthmus is to divide it and secure the contained vessels with a continuous overlapping suture.

The goitre mass is now completely detached. Any visible bleeding vessels are secured by clip forceps and ligatured. All other vessels which have been temporarily secured by forceps are also ligatured. The wound is flushed with hot, sterile saline solution and wiped dry.

Drainage.—A drainage tube, preferably of glass with numerous perforations, is introduced through a small puncture in the vicinity of the suprasternal notch. There is always more or less oozing of blood after the operation, and unless adequate drainage be provided for, a hæmatoma may develop.

Closure of the Wound.—The divided extremities of the pretracheal muscles are

connected by a number of interrupted sutures, and when this is being done it is well to lower the chin by removing the support from behind the neck. The margins of the deep fascia also are connected along the middle line. Some additional sutures may be made to connect the cut margins of the platysma. They help materially to take the tension off the cutaneous wound and prevent the cicatrix from stretching subsequently. The skin edges are connected by some sutures of silkworm gut supplemented by Michel's metallic clips, or, if preferred, a subcuticular suture may be employed. Kocher introduces a continuous suture of very fine silk. Fine silkworm gut and horsehair are very suitable also for closing wounds in the neck.

The Dressings.—The cutaneous surface surrounding the wound having been wiped over with tincture of iodine or a spirituous solution of biniodide of mercury, the dressings are applied. These consist of some sterile strips of muslin and several pads of gamgee tissue. The retaining bandage should take in the head and upper part of the chest and be applied with a moderate degree of pressure.

These dressings are renewed after twenty-four hours, the drainage tube is removed and another dressing, less bulky, is applied.

Fig. 81.—Kocher's curved incision closed by means of Michel's clips after thyroidectomy. Drawn from a photograph.

THYROIDECTOMY FOR MEDIAN GOITRES.—The transverse incision curved with a slight downward convexity is well suited for these cases.

The goitre having been exposed as before, the further course of action must be decided upon, viz., as to whether the enlargement of the isthmus is capable of being dealt with by enucleation or whether its resection should be undertaken.

If the median enlargement is connected to the lateral lobe on each side by a narrow isthmus, the simplest procedure would be to apply lateral ligatures and remove the intervening mass, care being taken in doing so to secure the blood vessels at its upper and lower borders.

If the connections of the median growth with the lateral lobes are broad and ill defined, the procedure may be more difficult. Interlocking ligatures are passed at one side and an incision made between the tumour and the corresponding lateral lobe. The tumour is then gently detached from the front of the trachea and drawn over towards the opposite side, where ligatures are again applied, the thyroid tissue having been previously crushed if thought desirable and the tumour removed.

Median goitres are frequently of the cystic or the adenomatous type, and being well circumscribed, can be removed by enucleation. The technique of this procedure is described below (see p. 167).

EXOPHTHALMIC GOITRE.—In this variety of goitre the glandular enlargement

is not usually very marked; indeed, there may not be much evidence of goitre, although the symptoms otherwise may be pronounced. These goitres are, as a rule, very vascular, and the vessels have thin walls, in consequence of which they are liable to tear when seized with forceps. Another feature of the exophthalmic variety of goitre is its by no means infrequent association with inflammatory changes, etc., strumitis and peristrumitis, which result in the gland acquiring adhesions to the surrounding structures. The pronounced vascularity and the occasional adhesion of the thyroid gland in this type of goitre tend to render the operation of thyroidectomy both difficult and dangerous.

Individuals who have suffered from exophthalmic goitre for some time are very unfavourable subjects for operation, but when the disease is submitted for treatment in an early stage the dangers attending operative measures are not very great; consequently it is highly desirable that cases should be submitted to surgical treatment before marked degenerative changes in the heart and other organs have taken place. These changes are the result of the toxic secretion of the thyroid, which is taken up in large quantity by the circulation. When once they have occurred it cannot be expected that any surgical measure can successfully restore the affected organs to their normal condition; the changes remain permanently.

The chief surgical measures which are employed at the present day are ligature of the thyroid vessels and partial excision of the diseased gland. The former measure acts beneficially by limiting the blood supply and interrupting the main paths of secreto-motor impulses passing along the nerves which closely accompany the superior thyroid arteries.

The resection operations usually aim at the removal of half of the gland, the larger lateral lobe being selected with a view to suppress the chief source of the toxic secretion.

The division of the cervical sympathetic nerve recommended by Jaboulay or the resection of the cervical portion of the nerve together with its ganglia, as practised by Jonnesco, has not been followed by results sufficiently satisfactory to warrant the more general adoption of either of these procedures.

Surgical treatment should always be preceded by and employed in conjunction with medical measures, the chief of which are rest and freedom from excitement, attention to the general nutrition, the administration of heart tonics, and certain forms of thyroid medication, such as antithyroidin (Mobius); rodagen, a powder prepared from the milk of thyroidectomised goats; thyroidectin, etc. Exposure of exophthalmic goitres to X-rays has been recommended.

Suprarenal extract has been employed with a considerable degree of success: it helps to slow the pulse; but it should be used with caution, seeing that its administration increases the strain upon the heart muscle.

It would be most desirable to be able to tell beforehand if a persistent thymus gland existed in individuals affected with exophthalmic goitre, as it would appear that such an association is frequently present in cases which terminate fatally during or very soon after operations on this form of goitre. In cases of exophthalmic goitre therefore, which are submitted for surgical treatment, the possibility of a persistent thymus should not be overlooked; and if evidence of such be obtained, a thyroidectomy should either be refused or an attempt made to remove the thymus as a preliminary measure. The specimen of goitre represented in Fig. 77 was obtained from a female cadaver in the Anatomical Department of Trinity College. A well-marked thymus gland was present, but no facts relative to the history of the case could be obtained.

LIGATURE OF THE THYROID VESSELS. Ligature of the superior thyro-

arteries is extensively practised at the present time and has been strongly advocated by Professor Kocher for some years. The surgical measures may be limited to ligature alone, but very frequently this is combined with the resection of one lateral lobe.

Ligature of the Superior Thyroid Arteries. This procedure has been employed mainly in cases of rapidly developing parenchymatous goitres in young subjects, in vascular goitres, and in cases of Graves' disease. Kocher has recommended ligature of both superior thyroid arteries as a preliminary measure, and it would appear to cause a marked amelioration in the symptoms and to facilitate the subsequent excision. Another procedure is that in which the lateral lobe on one side is removed and the superior thyroid artery ligatured on the opposite side.

The site selected for the application of the ligature to the superior thyroid vessels is either just above the summit of the corresponding lateral lobe of the gland, or this latter may be surrounded by the ligature and included with the vascular bundle. This latter procedure has been well described by Dr. Jacobson (*Surgery, Gynæcology and Obstetrics*, November, 1910), and is termed "pole ligation." Both upper horns are ligatured.

The Superior Thyroid Artery is ligatured as follows: An incision is made in front of the sterno-mastoid muscle from the level of the greater cornu of the hyoid bone downwards for 3 inches. The superficial tissues and the deep cervical fascia are divided, and the incision extended deeply between the sterno-mastoid and the omo-hyoid muscle. The artery as well as the upper pole of the gland will be recognised in the depth of the wound. The corresponding vein is closely associated with the artery, and both are included in the ligature. As these vessels are easily torn, they should be gently manipulated in the attempts to pass the ligature. Clip forceps with mouse-toothed points are not to be recommended in thyroid operations, as they tend to tear the thin-walled vessels and cause hæmorrhage.

The Inferior Thyroid Artery is most readily exposed by the usual curved incision of Kocher. The thyroid gland is first exposed, as in the ordinary thyroidectomy operation, and dislocated forwards. The artery is recognised deep in the wound, where it passes inwards behind the common carotid artery. This incision has the advantage of providing access to the superior thyroid artery at the same time.

POLE LIGATION.—The procedure to which the term "pole ligation" has been applied by Jacobson has for its object the application of a ligature to the superior thyroid vessels which at the same time includes the upper tapering extremity of the lateral lobe and its fascial investment. A ligature so applied will intercept the principal nervous afferent channels to the corresponding lateral lobe and occlude the main lymphatic trunks by which the toxic secretion of the gland passes away into the circulation.

The Operation. The cutaneous incision will be made either transversely across the neck at the level of the mid-point of the thyroid cartilage or obliquely in front of the sterno-mastoid muscle. The superficial tissues, including the platysma, are drawn aside, and the anterior border of the sterno-mastoid muscle defined. By dividing the deep fascia in front of the latter the muscle is loosened and retracted, and at the same time the omo-hyoid muscle is exposed; it overlies the gland, and must either be drawn inwards or divided.

The muscles are well retracted and the tapering extremity of the gland clearly defined. The ligature, which consists of linen thread, is passed by means of a large curved pedicle or aneurysm needle. On the right side the needle is passed from within outwards, the gland having previously been freed by a careful blunt dissection. On the left side it will be more convenient to pass the needle from without inwards. The loop of ligature is disengaged from the eye of the needle and the instrument withdrawn. The loop is now cut and the two ligatures are separated somewhat and tied; the intervening space will measure from $\frac{1}{4}$ to $\frac{1}{2}$ inch.

The displaced muscles are restored to their proper places and retained by some sutures of fine catgut. The cutaneous margins of the wound are finally brought together by a subcuticular suture. Drainage is not necessary.

COMMENTS.

This operation seems to be applicable to a large class of cases, including those in which the symptoms of Graves' disease are not as yet very pronounced and not of sufficient intensity to warrant a thyroidectomy; it is also applicable to the acute form of exophthalmic goitre and the chronic forms of the disease in which various secondary symptoms have supervened, such as dilatation and degeneration of the heart, disease of the kidneys, etc. In cases in which the symptoms are very pronounced, and the patient's condition grave, it will be advisable to apply medical measures before attempting the ligature operation.

THYROIDECTOMY FOR EXOPHTHALMIC GOITRE.—Preparatory Measures. The patient should be kept at absolute rest in bed for some days before the operation, so as to render the heart's action as quiet as possible and diminish the general state of nervousness which is often so marked.

A preliminary ligature of the superior thyroid vessels may be considered advisable with a view to diminish the activity of the gland.

Anæsthesia. A general anæsthetic is indicated as a rule. Ether is administered by the drop method, and is preceded by a hypodermic injection of atropin, $\frac{1}{120}$ grain, and morphin, $\frac{1}{6}$ grain. None but a skilled and experienced anæsthetist should be allowed to undertake this responsible part of the operation.

With the object of calming these patients, Ferguson recommends the administration of chloretone. He gives from 30 to 60 grains of the drug within two hours before the operation. "It makes the patient very drowsy, and she does not know anything about the anæsthesia."

THE OPERATION. The steps of the operation are similar to those already described. The following points, however, should be strictly observed: —

1. *Free Exposure of the Goitre* is essential, as it enables the process of dislocation and ligature of the thyroid vessels to be carried out with greater facility. The transverse curved incision has the disadvantage of not providing very free access to the apex of the lateral lobe. An anterior angular incision, on the other hand, although not so good from the cosmetic standpoint, provides more room, and facilitates the later steps of the operation. It commences over the sterno-mastoid muscle opposite to the upper border of the thyroid cartilage. At first it inclines inwards, and then follows the median line to the suprasternal notch. The angular flap thus outlined includes the platysma muscle, and is reflected outwards.

2. The thyroid gland should be handled as little as possible. All squeezing and rough manipulation must be carefully avoided, so as to prevent any sudden increase of toxic secretion from finding its way into the circulation.

3. The thyroid vessels should be exposed and divided with the utmost care and gentleness, as hæmorrhage is one of the dangers of these operations. Owing to the great number of the vessels and the extreme thinness of the veins, hæmorrhage is difficult to avoid.

COMMENTS.

Accidents and Complications: Hæmorrhage.—This may occur primarily, *i.e.*, during the operation, or may recur after the wound has been closed. Primary hæmorrhage is sometimes troublesome, and when profuse it may be the cause of a fatal termination. It is most likely to be free and to be attended by serious consequences in thyroidectomy for exophthalmic goitre. Apart from the seriousness resulting from the amount of blood lost, that which escapes into the wound infiltrates the meshes of the loose tissue which invests the inferior thyroid artery and the recurrent laryngeal nerve, and renders their recognition difficult or impossible, and so increases the risk of wounding the nerve.

Hæmostasis should therefore be as perfect as possible, and this end is best attained—(1) by keeping between the thyroid and its fascial sheath and by not cutting into the glandular tissue; (2) by exposing the thyroid vessels in regular order and securing them by clip forceps before they are divided; (3) by operating without excessive speed and guided by an accurate knowledge of the anatomy of the thyroid gland and its surroundings.

Delayed hæmorrhage usually results from the slipping of a ligature or from a vessel which, failing to bleed after the removal of clip forceps, has been left without a ligature. The sudden increase in tension within the vessels which occurs during efforts to vomit is calculated to excite fresh bleeding after the patient has been put back to bed. Should delayed hæmorrhage take place and be profuse, the best course to adopt would be to remove the dressings, reopen the wound, and secure the bleeding point. Plugging with gauze as a means of arresting bleeding after thyroidectomy is not to be recommended.

Sepsis.—With a rigid observance of aseptic technique the risk of septic infection in the wound is very small. Its onset is undoubtedly promoted by imperfect drainage and by surrounding large masses of thyroid tissue with ligatures. As far as is possible bulky ligatures should be avoided, and massive portions of tissue should be crushed before a ligature is applied.

If septic changes should take place in the wound, it must be freely opened and thorough drainage established. Hot boracic fomentations frequently applied will be found very useful under such circumstances.

Pneumonia.—This is a serious complication, as it may rapidly lead to a fatal termination in a patient in whom the thyroidectomy has been preceded by difficulty in respiration, and in whom the heart's action has been consequently impeded.

Injury of the Recurrent Laryngeal Nerve.—The risk of wounding this nerve and the best methods of preventing it have been already alluded to in the description of the operation. The nerve is more exposed to danger on the right than on the left

side, as it takes a more oblique course to reach the larynx. On the left side the nerve runs straight upwards in the sulcus between the trachea and the œsophagus, and is more likely to escape danger when the inferior thyroid artery is being secured.

Shock There is sometimes a very evident degree of shock following thyroidectomy. It is observed most frequently after the operation for the exophthalmic form of goitre, and may be rapidly succeeded by a fatal termination. It will be combated most successfully by the administration of normal saline solution by the rectum.

After-treatment. After the patient has been put to bed it is good practice to administer from 1 to 2 pints of saline fluid by the rectum and repeat it two or three times during the succeeding twenty-four hours. Saline solution is particularly valuable after operation in cases of hyperthyroidism. If it is not retained when given per rectum, it may be administered subcutaneously.

Morphin, from one-sixth to a quarter grain, will be given to allay pain and prevent restlessness.

The head and neck are maintained as steady as possible during the first few days following the operation.

A rise of temperature immediately following upon the operation is by no means rare, and does not necessarily depend upon septic influences. It seems to be caused by the absorption of an extra amount of thyroid secretion. It may also occur as the result of a hæmatoma developing in the wound.

Distressing palpitation of the heart may be relieved by cold applications over the precardial region.

Mortality.—The mortality resulting from thyroidectomy in cases of diffuse adenomatous goitre is almost *nil*. Kocher's statistics, which appear to be incapable of being improved upon, show a mortality of only 3 in 1,000.

Thyroidectomy for exophthalmic goitre, however, has been attended by a considerable mortality. In cases which terminate fatally death usually takes place within thirty-six or forty-eight hours after the operation. The fatal tendency would appear to depend to some extent, if not mainly, upon the coincident enlargement of the thymus gland which is often observed in cases of exophthalmic goitre. In a recent publication by Dr. Charles Mayo the operative treatment of exophthalmic goitre is credited with very satisfactory results. In his hands the mortality has fallen from 4 to 2 per cent. Kocher had nine deaths in 149 cases.

Difficulty with Respiration may occur during the operation, and is usually due to pressure upon the trachea exerted by the tense overlying muscles and cervical fasciæ. It is relieved, as a rule, when these have been divided, but much more effectually when the lateral lobe of the gland has been dislocated forwards. In cases associated with urgent dyspnœa prompt relief may follow the median division of the thyroid isthmus. Tracheotomy, however, is not to be recommended as a means of affording relief of respiratory distress in cases of goitre. Not alone may it fail to achieve the object for which it was intended, owing to the trachea being compressed low down, but when performed in conjunction with thyroidectomy it will lead to septic infection of the wound and cellulitis, which may be fatal.

Tetany.—This occurs in consequence of the removal of the parathyroid bodies. To prevent its occurrence the utmost care should be exercised when performing

thyroidectomy to spare the parathyroids. The need for the precaution becomes all the more obvious when one realises that in some instances, when one lateral lobe of the thyroid has been removed, the remaining lobe may continue to enlarge, and may require partial resection at a subsequent date if its pressure effects are causing serious inconvenience.

Difficulties attending Thyroidectomy. In an ordinary case the chief difficulty is encountered in dealing with the thyroid blood vessels, but with care and increasing experience in thyroid surgery this causes but little trouble. It is very likely to prove embarrassing when dealing with the exophthalmic variety of goitre.

Adherent goitres may prove very difficult to remove, as they do not lend themselves to ready dislocation from out of the deep prevertebral recess in which they are lodged. In dealing with them there may be great trouble with bleeding vessels, and the danger of wounding the recurrent laryngeal nerve is increased. The safest way to proceed is by a process of careful dissection, exposing all tissues thoroughly and applying clip forceps before cutting. In some of these cases the operation may be rendered easier by dividing the isthmus early and carrying the dissection from within outwards instead of in the opposite direction, as is usually done. The safety of the recurrent laryngeal nerve may be rendered more certain in cases of adherent goitre by adopting the resection procedure of Mikulicz.

MIKULICZ'S RESECTION OPERATION. Assuming that the goitre has been exposed, the isthmus divided, and the superior thyroid vessels ligatured, the upper part of the mass is detached from the trachea. While an assistant compresses the inferior thyroid artery one or more interlocking ligatures are passed through the lower segment of the lateral lobe. These are tied and the upper part of the goitre removed. The portion which is left behind occupies the deep recess beside the trachea and œsophagus, and protects the recurrent laryngeal nerve and the inferior thyroid artery.

ENUCLEATION OF ADENOMATOUS MASSES AND CYSTIC GROWTHS OF THE THYROID GLAND. There are no reliable statistics available from which to ascertain the relative proportions of diffuse parenchymatous goitres to those in which the thyroid enlargement is due to cysts and circumscribed adenomatous growths. The latter variety of goitre no doubt is fairly common. The nature of the thyroid enlargement in any given case may be gauged mainly by its extent and by its contour. Thus the cystic and adenomatous varieties of goitre are usually those in which the glandular enlargement is confined to one lobe mainly or to the isthmus. Encapsulated tumours too have a decided tendency to become superficial and to project more or less distinctly on the anterior aspect of the goitre.

The extent to which cysts and benign adenomata may involve the thyroid is subject to considerable variability. There may be one or several of these tumours, and both lobes may be affected.

For this class of goitre excision or partial thyroidectomy is not always advisable, one of the chief objections to this procedure being that, if one lobe of the thyroid be removed, the remaining lobe may continue to develop in size and ultimately require operative treatment.

The alternative to partial excision of this form of goitre consists in enucleating the encapsulated masses while preserving as far as possible the healthy glandular tissue. In some cases this is a sufficiently simple matter, but more frequently it is

rendered troublesome or even dangerous owing to the amount of hæmorrhage which takes place during the process of enucleation.

The Operation. *Exposure of the Goitre.*—This part of the operation is performed in precisely the same manner as in thyroidectomy. The gland is exposed in front, but no attempt is made to dislocate it or encroach further upon its surroundings, so as to avoid unnecessary trauma and diminish hæmorrhage as far as possible.

The Enucleation.—The cyst or adenoma may be quite superficial or embedded in the gland some little distance beneath the surface. The overlying tissue is divided, visible vessels being avoided when possible and those that are cut being immediately secured by forceps. The growth is easily recognised, as a rule, owing to the difference in tint of its surface as compared with that of the normal thyroid gland, and by the definite stratum of loose tissue by which it is surrounded. The growth having been well exposed from the front, is enucleated by the finger or by means of a flat, blunt dissector. During these manipulations hæmorrhage may be free or even embarrassing. The walls of the cavity are seized at several points with clip forceps, and are drawn forwards towards the superficial wound as much as possible, the cavity being turned inside out as it were. Pressure exerted by the fingers against the goitre from behind renders this step much easier. In addition to clip forceps, gauze tampons packed into the cavity help to arrest free oozing from vessels of capillary size.

The larger vessels, which have been secured by forceps, are now ligatured with catgut or fine silk, and the walls of the cavity as well as the margins of the aperture leading into it are brought together by deep sutures. Cavities of considerable extent may require to be drained, and for this purpose a perforated glass tube is very suitable. It is passed to the bottom of the recess, and the margins of the latter are brought together around it by a purse-string suture or by a few interrupted sutures.

When multiple growths are present the space left after the enucleation of the first may be utilised for the removal of those near at hand. If, on the other hand, the adenomatous masses are numerous and scattered throughout the gland, it may be necessary to reach them through several independent incisions. The removal of cysts may be facilitated by evacuating their contents before attempting to detach the cyst wall. Should the latter be so adherent that its removal would be attended by free hæmorrhage, an alternative procedure may be employed, viz., to attach the margins of the cyst wall to the skin and insert a drainage tube, the object of this being to promote the gradual closure and obliteration of the cyst. The chief objection to this method is that the presence of the tube is calculated to lead to septic changes in the cyst cavity. Failing enucleation in such cases, a partial resection of the gland, a resection-enucleation operation, would probably be the best measure to adopt.

RESECTION-ENUCLEATION.—This operation differs from enucleation in that some of the thyroid tissue which is expanded over the surface of the tumour is removed with the latter.

The anterior aspect of the lateral lobe of the thyroid gland on the affected side is exposed, as already described in connection with thyroidectomy.

The isthmus is defined, and having been carefully detached from the trachea, it is crushed and ligatured. An incision is next made through the isthmus on the side of the growth, and the latter is recognised where it presents on the cut surface.

By means of a blunt dissector inserted here the overlying glandular tissue is detached from the anterior aspect of the tumour along two lines directed respectively

upwards and outwards and downwards and outwards. The glandular tissue thus detached is crushed with forceps, ligatures are applied to the crushed parts, and two sections made close to these.

The encapsulated growth and the overlying portion of thyroid tissue are drawn forwards and outwards. The growth is enucleated on its deep aspect from that part of the lateral lobe of the gland which is related to the trachea and œsophagus. Farther out the thin stratum of tissue which covers the tumour is crushed along a line connecting the outer extremities of the two incisions already made.

The growth, together with the overlying part of the thyroid gland, is thus removed, but that part which is related to the side of the trachea and œsophagus as well as the recurrent laryngeal nerve is left intact.

As the operation proceeds all bleeding vessels are seized with forceps and subsequently ligatured. Finally, the exposed raw surface is diminished in size by connecting its anterior and posterior margins with a few sutures.

SECTION III

THE THORAX

THE OPERATIVE SURGERY OF BREAST CANCER.

SURGICAL ANATOMY. The Mammary Gland in the Adult is embedded in the subcutaneous fatty tissue, and is somewhat irregular in shape. Its main part or body

FIG. 85.—Dissection of the Supraclavicular Region and the Inlet to the Axilla. The inner half of the clavicle and part of the subclavius muscle have been removed. The subclavian vein continuous externally with the axillary vein is seen passing towards the thorax in front of the scalenus anticus muscle. The subclavian artery lies behind this muscle and has at its outer side the large cords of the brachial plexus. The clavicular head of the pectoralis major muscle has been detached and turned downwards. It presents in relation to its deep surface branches of the thoracic axis artery and the external anterior thoracic nerve. The cephalic vein is exposed between the deltoid and pectoralis major muscles as it passes upwards and inwards to open into the axillary vein.

is pyramidal. By its flat basal surface it extends from the second to the sixth rib and is related to the fascia overlying the pectoralis major muscle; in addition to this

it is related to the aponeurosis of the rectus abdominis and to the external oblique muscle below, to the serratus magnus and the outer margin of the pectoralis minor muscle externally, a loose layer of tissue intervening (retromammary tissue). Besides this main portion of the gland, straggling offshoots extend from it into the adjoining fatty tissue, inwards close to the margin of the sternum, upwards and outwards into the axilla. The axillary process of the gland may extend as far upwards as the upper margin of the third rib, coming into close relationship with the anterior or pectoral group of the axillary glands. During the earlier stages of lactation it is sometimes recognisable as a distinct swelling, and possesses considerable practical importance. Isolated portions of gland tissue have been found beneath the pectoral fascia in direct contact with the fibres of the pectoralis major muscle (Heidenhain and Stiles). It will be seen, therefore, that the peripheral limits of the mammary gland are very irregular and ill defined, and that they circumscribe a wide area, which by no means corresponds to what one is accustomed to regard as the circumferential limit of "the breast"; in other words, if an incision is made circularly so as to circumscribe the general projection of the breast, it will be found that a not inconsiderable amount of tissue of the gland will be situated outside the line of section.

The lobules of the gland are surrounded by a vascular and richly cellular interglandular connective tissue, which is continuous at the periphery of the mamma with the retromammary and supramammary tissue. This latter is connected with the deep aspect of the skin by means of fibrous septa which were designated by Sir Astley Cooper the "suspensory ligaments" of the breast.

The Lymphatics of the Breast. Both the acini and the ducts of the gland are surrounded by a network of lymphatic vessels (periductal and periacinous lymphatics), and these communicate freely with the lymph vessels which ramify in the interglandular tissue separating the gland lobules (interlobar lymphatics). These latter communicate with the lymphatics which lie in the subcutaneous tissue and with those which run in the retromammary tissue and traverse the pectoral fascia. The subcutaneous or supramammary lymphatics also bring the vessels of the gland into free communication with the networks in the skin, the "suspensory ligaments" serving as conducting paths for the vessels which pass to and fro. Efferent vessels lead away from the peripheral margin of the gland to the axillary glands, the majority passing to the anterior or pectoral group and thence to the central and deep glands which are arranged along the anterior and inner aspects of the axillary vessels. Some of the efferent vessels from the gland, however, pass directly to this deep group without being intercepted on the way. Certain of the lymphatics from the inner part of the mamma betake themselves to the anterior mediastinal glands which are situated alongside the internal mammary vessels. A few of the lymphatics which leave the gland pass to the infraclavicular group which is situated in the pectoral region, between the deltoid and pectoralis major muscles and alongside the termination of the cephalic vein. The lymphatic systems of the two mammary glands appear to communicate by means of certain vessels which cross the middle line.

Pathological Considerations. Cancer originating in the breast remains for some time a local disease; *i.e.*, it is confined to the segment of the breast within which it originated, and if its presence could be determined in this early stage, its complete removal by operation would be a simple matter. However, cancer in the breast, as elsewhere, tends to spread beyond the immediate confines of its starting point. Thus it progressively infiltrates the adjoining segments of the breast; it reaches the

overlying skin, which it may infiltrate in a diffuse manner, or manifest itself in the form of small nodular growths; it forms metastases in the axillary glands, and it may subsequently involve those in the supraclavicular fossa and in the mediastinum as well. According to Sampson Handley, cancer cells originating in the breast have a great tendency to grow along the lymphatics which are in connection with the growth. These cells grow and multiply within the lymphatics, and gradually spread in all directions away from the mammary tumour. This is what he terms cancerous permeation of the lymphatics. This mode of spread of breast cancer is apparently most obvious in the direction of the deep or retromammary fascia which invests the muscles beneath the breast. This fascia contains a dense lymphatic plexus, and Handley's

FIG. 86.—Lines of cutaneous incision in the radical operation for the removal of a cancerous breast. In the figure here represented, the growth is supposed to have its site in the vicinity of the nipple.

researches have demonstrated the fact that this is one of the most important structures concerned in the spread of the disease, and he emphasises the necessity of removing it over a wide area extending from the clavicle above to the substernal region below and from the sternum internally to the mid-axillary line externally.

When conducting an examination of the cancerous breast with a view to ascertain if operative measures are indicated particular attention should be given to the extent of the tumour itself, its mobility or fixity to the retromammary fascia and the pectoral muscle, the presence of enlarged glands in the axilla or in the supraclavicular fossa, and the condition of the skin overlying the growth.

The following conditions may be regarded as contraindicating the radical operation: the glands in the axilla markedly enlarged, more especially if the supraclavicular glands are enlarged also; fixity of the breast to the pectoral muscles, or perhaps to the chest wall; extensive involvement of the overlying skin with or without ulceration.

The really important consideration in connection with breast cancer is that of early diagnosis. It is only by treating these cases in an early stage that the results of operative treatment can be improved.

THE MODERN RADICAL OPERATION FOR BREAST CANCER is an extensive procedure, and entails the removal *en masse* of the following tissues: the mammary gland with a liberal amount of overlying skin; the deep pectoral fascia corresponding to a wide area limited by the clavicle above, the mid-sternal line internally, the mid-axillary line externally, and a horizontal line two fingers' breadth below the tip of the ensiform cartilage below; the sterno-costal portion of the pectoralis major and the pectoralis minor muscles; the lymphatic glands, fat and connective tissue in the axilla and surrounding the main vessels and nerves as high as the first rib, where the axilla communicates beneath the clavicle with the root of the neck.

Instruments.—One medium and one large scalpel; dissecting and hæmostatic forceps; blunt dissector; aneurysm needle or ligature carrier; scissors, straight and angular; retractors; needles; ligatures; sutures; drainage tube.

THE OPERATION.—Preliminary Details, etc.—The usual methods of cleansing and disinfecting the skin over a wide area including the neck, front, and side of the chest, epigastric region, upper arm, and axilla, will be employed. We recommend the application of tincture of iodine to this area on the morning of the operation, and again when the patient has been placed on the operation table. The arm is held away from the body by an assistant, or, better still, it may be allowed to recline on a side support connected with the operation table. The head of the patient and the anæsthetist are shut off from the operator by a screen arrangement, as represented in Fig. 87. The arm is enveloped by a sterile towel, and the trunk, with the exception of the area concerned in the operation, is protected by a sterile sheet.

The Superficial Incisions.—The lines of incision which we usually employ in a typical case of cancer in the upper and outer quadrant of the breast are represented in Fig. 86. They are so arranged as to surround the diseased segment of the breast in an elliptical or irregularly circular fashion; the included area of skin has the growth opposite its centre, and extends beyond the tangible confines of the indurated mass freely on all sides. The upper limb of this elliptical incision is extended upwards and outwards in a curved direction over the anterior axillary fold to the upper part of the arm. The lower or outer limb of the ellipse is prolonged downwards and inwards to a point situated in the middle line of the abdomen about 2 inches below the tip of the ensiform cartilage.

Exposure of the Axilla and its Contents.—The skin, together with a thin layer of the subcutaneous fatty tissue overlying the axillary outlet, is reflected and turned aside. Bleeding vessels are immediately secured with hæmostatic forceps, and the margin of the latissimus dorsi tendon is defined in the posterior axillary fold (Fig. 87). The axillary vein and the large brachial nerves are exposed by dividing the deep fascia in front of the tendon at the outer extremity of the wound. The skin and subcutaneous tissue are next reflected in the subclavicular region and between the inner limb of the ellipse and the mid-sternal line. In doing so numerous vessels will require forcipressure, and the utmost care must be taken not to detach any glandular tissue of the breast, but to keep close to the skin. The interval between the clavicular and costo-sternal portions of the pectoralis major muscle is defined. The next step consists in dividing the costo-sternal portion of the pectoral muscle close to its humeral

attachment. The left index finger of the surgeon is inserted from below underneath the great pectoral muscle at the inner side and in front of the axillary vein, and its costo-sternal portion is divided close to the humerus (Fig. 88). The cut muscle is retracted towards the chest, and at the same time some branches of the axillary vessels are exposed and divided between hæmostatic forceps. As the muscle is raised the pectoralis minor and the costo-coracoid membrane above it are brought into view (Fig. 89). Some branches of the thoracic axis artery and vein which pass through the membrane will require to be divided, the vessels having been first secured by forceps.

FIG. 87.—The Radical Operation for Breast Cancer. The superficial tissues overlying the axillary outlet have been raised and turned aside. At this stage of the operation certain landmarks may be noted, viz., the pectoralis major muscle in front; the latissimus dorsi muscle behind, and the axillary vein at the outer part of the space. The axilla is thus opened from below at the commencement of the operation and its further dissection proceeded with as represented in the succeeding figures.

The index finger is now passed beneath the pectoralis minor muscle, and this is divided close to its insertion into the coracoid process of the scapula. On retracting the divided muscle inwards the entire axilla from the clavicle downwards will be exposed (Fig. 90).

The Clearing of the Axilla of its contained Connective Tissue and Lymphatic Glands.—With the axillary vein already exposed at its commencement, it is an easy matter to follow the main vessels and the large nerve cords upwards to the narrow passage beneath the clavicle through which the axilla communicates with the subclavian triangle of the neck (Fig. 85). The vessels and nerves are partially concealed by a quantity of loose, fatty tissue, and, in addition to this, they are invested by a membranous layer or sheath in which numerous lymphatic vessels ramify.

Commencing below, this membrane is stripped from off the nerves and vessels, and, together with the loose axillary tissue, is displaced inwards towards the chest wall. A sterile muslin swab wrapped round the finger materially assists the stripping process, and brings into view branches of the axillary vessels, which are severally divided between clip forceps, their central ends being subsequently ligatured. The chief vessels which require to be dealt with in this way proceed from the subscapular and thoracic axis branches of the axillary trunks. Especial care is taken to remove all tissue and glands at the axillary apex in relation to the axillary vein and at the

FIG. 88.—The Radical Operation for Breast Cancer. The left index finger of the surgeon has been passed beneath the pectoralis major muscle and its costo-sternal segment is about to be divided close to the humerus. The clavicular head of the muscle is usually preserved

inner side of this vessel, where the infraclavicular glands are lodged. Another recess which must be carefully cleared is the narrow, slit-like interval behind the main vessels, bounded by the subscapularis muscle externally and the chest wall covered by the serratus magnus muscle internally. The loose, fatty tissue contained within the space is readily removed from above downwards by a process of dry sponging aided by snips of the scissors, due regard being taken for the safety of the posterior thoracic nerve which supplies the serratus magnus muscle and runs down in close relationship to its outer surface. Another nerve which needs careful protection is the long subscapular; it will be found in relation to the posterior axillary wall and the subscapular group of glands as it proceeds downwards to pierce the substance of the latissimus dorsi muscle. The entire mass, consisting of the

pectoral muscles with the exception of the clavicular head of the pectoralis major, the axillary tissues and glands, is drawn inwards, and at this stage it will probably be found necessary to snip across the intercosto-humeral nerve, *i.e.*, the lateral cutaneous branch of the second intercostal nerve. The axillary dissection is now complete, and a large, thick swab rinsed out of hot saline solution is packed into the cavity while the remaining steps of the operation are in progress.

Detachment of the Breast together with its Investing Fatty Tissue, the Pectoral Muscles,

FIG. 80.—The Radical Operation for Breast Cancer. The costo-sternal portion of the pectoralis major muscle has been divided and turned aside. The pectoralis minor muscle has been brought into view as it extends outwards, rapidly tapering meanwhile, to its insertion into the coracoid process of the scapula. In the narrow space above the muscle there will be noted some branches of the thoracic axis artery and vein, and the external anterior thoracic nerve as they pierce the costo-coracoid membrane. Below the pectoralis minor muscle the axillary nerves and blood vessels have been clearly defined. The axillary glands and connective tissue have been pushed aside *en masse* in the direction of the breast.

and an Extensive Area of the Deep Fascia.—This step of the operation is commenced by reflecting the superficial tissues at the outer side of the elliptical incision already outlined. While this is being done an assistant draws the general mass of the breast inwards, and renders the area of dissection more accessible to the surgeon. In reflecting this outer flap the knife should not be carried deeply into the fatty tissue, at least, until it is certain that the peripheral limits of the breast have been passed, otherwise there is some risk of detaching portions of the gland which may escape detection and remain behind. When the superficial tissues have been reflected back as far as the mid-axillary line the plane of section is carried more deeply, so as to bring into view the deep fascia covering the serratus magnus muscle and the upper digitations of

the external oblique. During this extensive division of tissue several vessels are divided, and are immediately seized with hæmostatic forceps, a large supply of which should be at hand. A thick swab rinsed out of hot saline solution is pressed into the wound, and, traction on the breast having been removed, it falls back to its normal level.

The surgeon directs his attention next to the reflection of the superficial tissues on the sternal side of the original elliptical incision and its downward extension into the

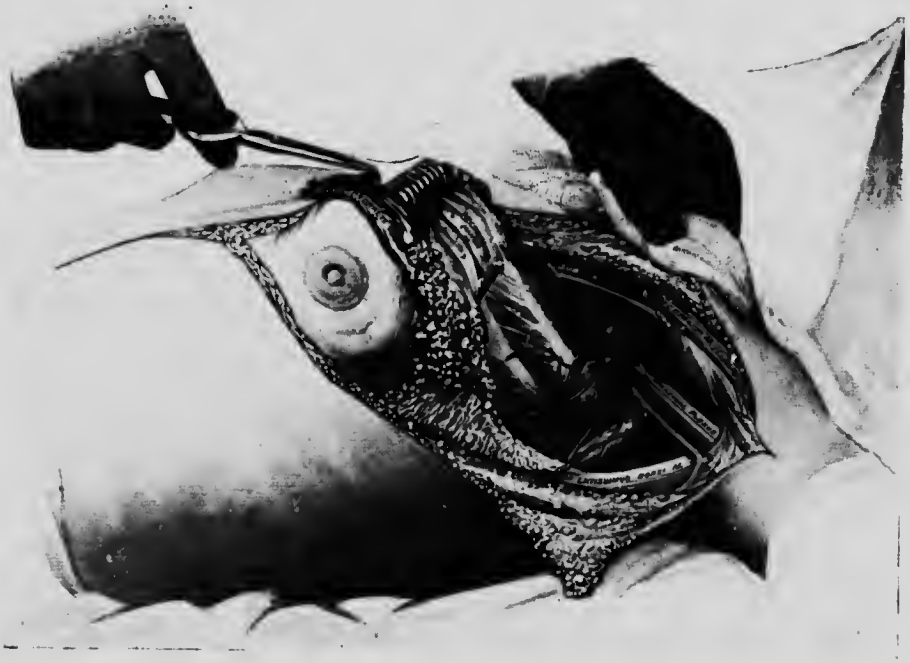

Fig. 90.—The Radical Operation for Breast Cancer. This figure represents the completed dissection of the axilla. The large vessels and nerves have been cleared of the surrounding fatty tissues with the contained lymphatic glands throughout the entire space. The long subscapular nerve which supplies the latissimus dorsi muscle and the posterior thoracic nerve which supplies the serratus magnus muscle have been carefully preserved, and are represented in the figure. The costo-sternal portion of the pectoralis major and the pectoralis minor muscle together with the axillary connective tissue and glands, have been drawn aside by a retractor. The connection of the cancer in the breast with the axillary glands and the lymphatic vessels has thus been preserved.

substernal region. While this dissection is being carried out the breast is drawn outwards. The detachment of the superficial tissues already commenced in the infraclavicular and upper sternal regions is continued downwards. A thin stratum only of the subcutaneous fatty tissue is raised, and the dissection is carried inwards as far as the mid-sternal line. Opposite the anterior extremities of the upper intercostal spaces some perforating branches of the internal mammary artery are divided and clamped. The next step consists in detaching the pectoralis major muscle from its costo-sternal attachments. This is done by commencing above in the interval between the two divisions of the muscle already defined and dividing the muscle

close to the sternal margin. Some perforating vessels are divided as the muscle is being detached. If possible, these should be exposed and seized with forceps before division, otherwise they may be torn and recede to such an extent that they may be difficult to secure. As the mass consisting of the breast and the other tissues is drawn away from the chest wall the attachments of the pectoralis minor muscle to the third, fourth, and fifth ribs are successively divided. The final steps of the dissection consist in detaching the deep fascia from the underlying muscles—serratus magnus, external oblique, and rectus abdominis—as far down as the lower limit of the incision in the

FIG. 91.—The Radical Operation for Breast Cancer. This figure represents the large wound left after removal of the breast and the axillary tissues, etc. The deep fascia has been excised over a wide area extending down over the upper part of the left rectus muscle and the upper digitations of the external oblique muscle. The serratus magnus muscle too, has been thoroughly stripped of its investing tissues. Note the posterior thoracic and the long subscapular nerves which have been preserved.

substernal region. When this has been done the entire mass, consisting of the diseased breast and the other tissues already enumerated, will be found free. The large wound is carefully inspected, and any obvious vessels which continue to bleed are caught with forceps. Several ligatures of fine catgut will be required. The branches of the axillary vessels are first dealt with, and as they are ligatured the retaining forceps are removed. Bleeding from many of the vessels divided, however, may be arrested by torsion.

Drainage of the large wound is necessary, as there may be some oozing of blood from numerous small vessels or from vessels which may recommence to bleed after the wound has been closed. A point is selected in the reflected axillary flap just in front of the latissimus dorsi muscle, and a puncture is made here with a sharp scalpel.

A rubber drainage tube is passed through the aperture and carried up towards the apex of the axilla; the tube is perforated laterally, and is retained in position by a suture of silkworm gut. It may be removed after twenty-four or forty-eight hours.

Closure of the Wound. If the wound margins come together without undue tension, four or five deep sutures of silkworm gut are passed at regular intervals so as to subdivide the main wound into a number of equal segments. These latter may be closed either by a continuous suture of fine thread or silk or, if preferred, by a number of interrupted sutures.

If the wound margins cannot be approximated throughout, the raw area left may be still further reduced by drawing in the skin margins over it by a few sutures carefully introduced and then covered with Thiersch grafts taken from the front of the thigh on the same side. An alternative method consists in leaving the raw area to granulate and then applying grafts. One advantage of this method is that as the growth of granulations proceeds the wound contracts, the ulcerating area greatly diminishes, and the surface ultimately to be grafted may be comparatively small.

The Dressing.—The sutured wound is gently wiped with a muslin swab soaked in a solution of biniodide of mercury in spirit. Tincture of iodine is then applied both to the line of suture and the surrounding skin for some distance. Some sterile gauze and pads of gamgee tissue are arranged so as to cover the front and back of the chest and extend well up into the axilla. They are secured by a broad roller bandage, and the arm is left free. We do not consider it necessary, as a rule, to maintain the arm in the abducted position during the healing process. The patient is encouraged to move the limb as soon as possible, and the results as regards the range of voluntary motion in our cases have been very satisfactory following this line of treatment.

COMMENTS.

The Avoidance of Shock must be carefully attended to in operations for the removal of breast cancer. This object is best achieved by keeping the patient warm during the operation, applying large, thick pads rinsed out of hot saline solution to the successive areas of raw tissue which are exposed, and carrying out the procedure in as expeditious a manner as is consistent with efficiency. Should symptoms of shock appear after the operation they are best overcome by the administration of warm saline solution per rectum or subcutaneously.

The Area of Tissue Excised.—The incisions in the skin are arranged, as a rule, so as to circumscribe an elliptical or irregularly circular area of integument the exact amount of which will necessarily vary in different cases. Some surgeons advocate a very wide excision of skin, corresponding approximately with the projection of the breast. We agree with Sampson Handley and Stiles, however, that such wide cutaneous excisions are not necessary in the majority of cases in which the radical operation is indicated. The central part of the excised integument overlies the mammary growth, and does not necessarily correspond with the nipple. The excised area measures, on an average, 4 or 5 inches across in breasts of normal proportions, but in very large breasts it will be proportionally extensive. Although the incisions surrounding the growth are frequently arranged in the form of an ellipse, yet under certain conditions the area outlined will present a different contour. Thus when the cancer is in the outer part of the breast the outer limb of the ellipse may assume the form of a V with its apex directed backwards. Also in cases where there are evidences

of infiltration of the skin, or where the growth is ulcerating, the cutaneous incisions must be made in such a way as to include a very wide area. Under no conditions, however, should the incisions in the skin be arranged with a view to facilitate the subsequent approximation of the wound margins.

The Approach to the Axilla.—The manner in which the axilla is exposed and cleared of its contained lymphatic glands and fatty tissue varies with different surgeons. Some commence the clearance at the apex of the space and work downwards, but we prefer to carry out the procedure in the manner already described. The point, however, on which there seems to be a fairly general consensus of opinion, is that the axilla should be approached first and the detachment of the breast subsequently effected.

FIG. 92.—The healed wound after the radical operation for cancer of the breast. This figure has been drawn from a photograph of a case ten days after operation. The range of movement of the arm was quite free. This patient remains perfectly well after an interval of five years.

Resection of the Axillary Vein.—When the axilla is opened and its contents exposed it may be found that an enlarged gland is so adherent to the axillary vein that its clean detachment is impossible. If the glandular disease is very extensive and the prospect of any improvement by further operative measures very unlikely, the surgeon may decide to close the wound and not proceed further. If, on the other hand, it were obvious that the gland could be removed with the adherent segment of the vein, this procedure may be carried out. If possible, the upper part of the vein should be preserved, so as to maintain the communication between it and the cephalic vein which normally takes place just below the clavicle (Fig. 85).

Resection of portion of the axillary vein may be followed by some œdema of the arm, but this, as a rule, tends to disappear. The swollen, brawny arm which is sometimes observed in cases of breast cancer is not really due to pressure on or obliteration of the axillary vein. As pointed out by Sampson Handley, it follows cancerous permeation of the lymphatics and the subsequent obliterative changes which take place in consequence of perilymphatic fibrosis.

The Removal of the Pectoral Muscles.—The resection of the greater part of the pectoralis major and the whole of the pectoralis minor muscle is really the key to the modern operation for breast cancer. It affords access to the entire axilla, and especially its upper part, where the subclavian and axillary vessels become continuous. It is here that the infraclavicular glands are lodged, and their complete removal is always a matter of pressing necessity.

Dangers of the Operation.—These are mainly—(1) sepsis; (2) pulmonary complications: pneumonia and bronchitis; (3) hæmorrhage; (4) shock; (5) pulmonary embolism.

The mortality directly due to the operation is very small, probably not more than 2 per cent. Septic complications are best prevented by a careful technique. They are most likely to occur in cases associated with foul ulcerating tumours, but in these the radical operation, if attempted, should be carried out in two stages, the breast being first removed and the axilla opened and cleared after a couple of weeks, when the wound has reached the stage of granulation.

Pulmonary complications will be most certainly avoided by careful anæsthesia, the substitution of chloroform for ether, and the avoidance of chill during the operation. The body of the patient should be well protected with blankets and dry sterile sheets, and the temperature of the operating theatre should not fall below 65° F.

The End Results of the Modern Radical Operation. These have undergone a marked improvement in recent years, mainly in consequence of improved operative technique and the earlier period in the course of the disease at which operative treatment is now generally undertaken. It is only by operating early that any further improvement in results can be expected, and there is no doubt that patients nowadays seek advice for tumours of the breast earlier than they did formerly. Nevertheless, of those who suffer from cancer a considerable proportion is not seen until the disease has reached a stage in which the question of diagnosis is no longer a matter of doubt. Halstead's observation on this point is worthy of mention; he sums up the situation by stating that in cases taken early two out of three patients are cured, but in cases operated upon after the axillary glands have been palpably involved three out of four patients succumb.

While the end results of operative treatment, as presented by different surgeons, show a steady improvement, yet the available statistics, as might be expected, reveal considerable discrepancies.

The results recorded by numerous observers go to show that of all the cases submitted to the complete radical operation a proportion varying from 40 to 50 per cent. presents no evidences of recurrence after three years.

Of those, however, who exceed the three-year limit without recurrence, a considerable proportion, from 20 to 30 per cent., will probably show signs of recurrence later. Such recurrence, it must be noted, is not invariably observed in the region of original tumour or its surroundings—these parts often remain free—but in the bones and in the viscera.

A review of the available statistics shows that the percentage of permanent cures falls enormously when operation is not performed until evidences of disease have manifested themselves in the axillary glands, the skin overlying the breast, the retromammary tissues and the chest wall.

In one series of cases it was found that operation in cases where the tumour was not adherent to the skin gave 32 per cent. of cures, whereas only 16 per cent. was obtained when the tumour was adherent. Where ulceration of the skin had supervened only 6·6 per cent. of recoveries was observed.

No cases have been reported as cured in which the supraclavicular glands were enlarged at the time of operation.

Ulcerating Cancers of the Breast.—In these cases the surgeon is faced with two highly unfavourable circumstances, viz., the presence of sepsis at the seat of

ulceration and metastases in the axillary glands more or less pronounced. Before undertaking operation the supraclavicular region should be examined for enlarged glands. If such are found, it will be necessary to decide if the results of the radical operation as a palliative measure are likely to warrant the undertaking.

Should examination reveal a moderate involvement of the axillary glands, and if it seems probable that the axilla can be cleared in the manner already described, the best course to follow is to operate in two stages. The first operation is directed towards the removal of the breast with a wide area of surrounding tissue; the second

FIG. 94.—Operation for Benign Tumours of the Breast. A curved incision along the outer periphery of the breast has enabled it to be raised from the chest wall and turned aside in the manner represented in the figure. The tumour has been resected by an elliptical incision and some deep sutures have been introduced. These are intended to close the wound in the gland and at the same time control oozing from the divided vessels.

operation concerns the axilla, which is thoroughly opened up and cleared of its glands and contained fatty tissue.

Before removing an ulcerating cancer of the breast every means must be employed to disinfect the ulcerated area. For this purpose we recommend the preliminary dressing of the ulcer for a few days with moist dressings of boracic lint rinsed out of a solution of peroxide of hydrogen. Just before the operation the ulcerated area is swabbed over with a 5 per cent. solution of formaldehyde. After a couple of minutes this is washed away, and tincture of iodine is applied. The surrounding skin is cleansed and disinfected in the usual way, tincture of iodine being applied just before the operation commences.

It is unnecessary to recapitulate the details of the operation as they have been so fully dealt with above. It is better not to attempt the complete closure of the large wound which is left even were this possible. It is partially closed with interrupted

sutures of silkworm gut, and warm, moist antiseptic dressings are applied. With these precautions there is no possibility of retention of septic discharges, and after a few days granulations will commence to appear in those parts of the wound which remain open.

The second or axillary stage of the operation may be undertaken about the end of the second week.

If the supraclavicular glands are enlarged so as to be readily recognised by palpation, it is doubtful if it is wise to proceed to remove them and clear the axilla at the same time. In a doubtful case Stiles recommends the exposure of the supraclavicular glands first by an independent incision in the neck. If it should then appear that the disease here is extensive, and that the glands further in beneath the sterno-

Fig. 94.—Operation for Benign Tumours of the Breast. This figure represents the completed operation. The cutaneous wound has been closed by interrupted sutures of silkworm gut. We usually introduce a drainage tube in these cases for twenty-four or forty-eight hours, as oozing of blood from numerous small vessels may be considerable and give rise to a retromammary hæmatoma unless facilities have been provided for drainage.

mastoid muscle are also enlarged, any further operative intervention must be regarded as hopeless.

PARTIAL RESECTION OF THE BREAST. The conditions which most frequently demand this procedure are localised mastitis of the lobular (parenchymatous) or interstitial variety, localised tuberculous deposits, gummata, and simple cysts of the breast.

It is well known that cancer in the breast is sometimes preceded by simple inflammatory disease, and this fact should influence surgeons in recommending resection of persisting areas of induration before malignant changes have had time to supervene. The resected part should always be submitted to a pathologist for a thorough investigation. By so doing it may be possible to ascertain the presence of malignant disease at an early stage of its existence.

Cysts within the breast are sometimes associated with intracystic papillary growths, and these may subsequently assume a malignant character.

The Operation.—*The Cutaneous Incision* which we usually employ is that recommended by Dr. Collins Warren, of Boston. It is represented in Fig. 94, where it will be observed extending along the outer limit of the breast with a slight curve directed backwards. Its upper limit lies beneath the anterior axillary fold, and it extends downwards from this for about 5 or 6 inches. Before making the incision the skin is scratched in three or four places across the line of the cut. The faint markings so made ensure accuracy in the subsequent approximation and suture of the wound margins.

Undermining and Eversion of the Breast.—The incision is progressively deepened in the subcutaneous fatty tissue until the deep fascia which covers the serratus magnus muscle is exposed. By working inwards along this stratum the margin of the greater pectoral muscle is exposed and defined. The surgeon now seizes the breast with his left hand, and rotates it in such a way as to bring its deep surface into the wound. A little further division of the retromammary tissue will enable the deep surface of the gland to be well protruded and exposed to view.

The Resection. The area to be excised can usually be determined by palpation owing to its firmer consistency as compared with the normal breast tissue. The incisions are so arranged as to circumscribe a wedge-shaped area, its base being on the deep aspect of the breast and its thin border directed towards the subcutaneous surface. The greater part of the division of tissue is effected with a scalpel, but scissors are sometimes more easily manipulated. The cut surfaces are carefully examined for bleeding vessels, and those which are observed are ligatured with fine catgut. This is an important matter, as bleeding may continue for some time unless care is taken now to arrest it as far as possible.

The Deep Sutures.—The careful introduction of deep sutures is called for in all cases. They serve a useful purpose in controlling oozing from small vessels, and by closing up the cavity they help to restore the normal contour of the breast and prevent an unsightly depression of the surface. In some cases, especially in large breasts, two rows of deep sutures may be introduced. The first row approximates the breast tissues on their subcutaneous aspect; the deeper sutures traverse the deep parts of the breast which rest against the pectoral fascia. In thin breasts one row of sutures will probably suffice (Fig. 93).

Closure of the Superficial Wound; Drainage.—As there is usually more or less oozing of blood in these cases, drainage for at least twenty-four hours is always advisable, the tube being passed well in beneath the breast. The cutaneous margins are approximated by three or four interrupted sutures of silkworm gut, their points of introduction corresponding to the scratches made across the line of skin section at the commencement of the operation. The wound margins between the interrupted sutures may be united by Michel's metallic clips or by additional interrupted sutures of silkworm gut (Fig. 94).

THE OPERATIVE TREATMENT OF EMPYEMA.

THE PLEURAL CAVITY. Some Facts concerning the Normal and Pathological Anatomy of the Pleura. The pleural cavity consists of a main part, the pleural cavity proper, with an upward extension into the root of the neck and a lower extension in the form of a tapering recess between the diaphragm and the chest wall.

The limits of the main part of the cavity will be represented with sufficient accuracy by the clavicle above and a line extending round the trunk at the horizontal level of the fifth chondro-sternal junction below. This latter is an important line, as the

capacity of the pleural cavity rapidly diminishes from this level in a downward direction. In operations, too, below this line, the diaphragm is endangered; and it is to be remembered that in many cases of purulent effusion the diaphragmatic and costal pleural surfaces become adherent to a greater or less extent, with a corresponding diminution of the costo-diaphragmatic pleural recess. With purulent collections below the diaphragm, viz., subphrenic abscess, hepatic abscess, etc., this recess also may be largely obliterated.

EMPYEMATA.—These vary in their extent. It is extremely rare for the general cavity of the pleura to be involved, as adhesions usually form to a greater or less extent and limit the area of intrapleural space available for the effusion. The greater part of the cavity between the outer surface of the lung and the chest wall, however, may be occupied by an effusion of a serous or purulent character.

Not infrequently intrapleural effusions are of comparatively limited extent, and may be variously situated: between the lung and the chest wall, between the lung and the diaphragm, between the lung and the mediastinum, or in the interlobar fissure of the lung.

The characters of the purulent exudate vary. It may be of uniform consistency, resembling ordinary pus; sometimes it is thin and watery; and not uncommonly it contains masses of coagulated fibrin entangling pus cells, which tend to block the tube and render drainage difficult. In some cases the exudate is highly offensive owing to the presence of putrefactive organisms.

Preliminary Investigation.—This is always necessary before treatment is undertaken. As a rule such investigation should include—(1) a review of the symptoms and physical signs; (2) an X-ray examination with the fluorescent screen and by means of a skiagram; (3) exploratory puncture; (4) a bacteriological examination of the exudate.

An Exploratory Puncture in cases of extensive effusion will be made at the level of the seventh or eighth intercostal space in front of the posterior axillary line. When the empyema, however, is circumscribed and of limited extent, the site selected for exploration will correspond to the area within which the physical signs and X-ray examination have revealed the presence of fluid.

The exploring needle must be suitable for the purpose. Very often the needles employed are too fine, with the result that pus, if of thick consistency, may not flow into the barrel of the syringe, or the needle may be blocked by a small plug of fibrin. The needle too should fit accurately to the syringe, and the suction should be adequate when the piston is withdrawn. A very good type of exploring syringe is that employed in spinal anæsthesia or for the injection of antidiphtheritic serum. There is no need for a general anæsthetic when carrying out this simple procedure; but should the patient be nervous and excitable, the introduction of a small quantity of some local anæsthetic fluid, such as novocain, will prove useful. The chief difficulty encountered in the introduction of the needle is that due to the thickness and toughness of the skin over the back, especially if the point of the needle is not very sharp. A minute cut or puncture made by the point of a scalpel will greatly facilitate the introduction of the needle. This latter should traverse the intercostal space close to the upper margin of the rib which bounds the space below; and if the point selected for puncture is low down, it will be advisable on clearing the intercostal tissues to incline the point of the needle upwards so as to avoid the diaphragm.

The Bacteriological Examination of the exudate should not be omitted, as it may furnish valuable information with regard to prognosis and the proper line of treatment to be followed. The evidence may point to infection of a tuberculous nature or one due to the pneumococcus. Occasionally streptococci are found. In the case of empyemata with fœtid and decomposing contents the bacterial agents will be found in large numbers, both aerobic and anaerobic.

THE EVACUATION OF THE PLEURAL EXUDATE; ASPIRATION OR THORACENTESIS.—In certain cases, notably those in which the bacteriological evidence points to the pneumococcus as the exciting agent of the pleural effusion,

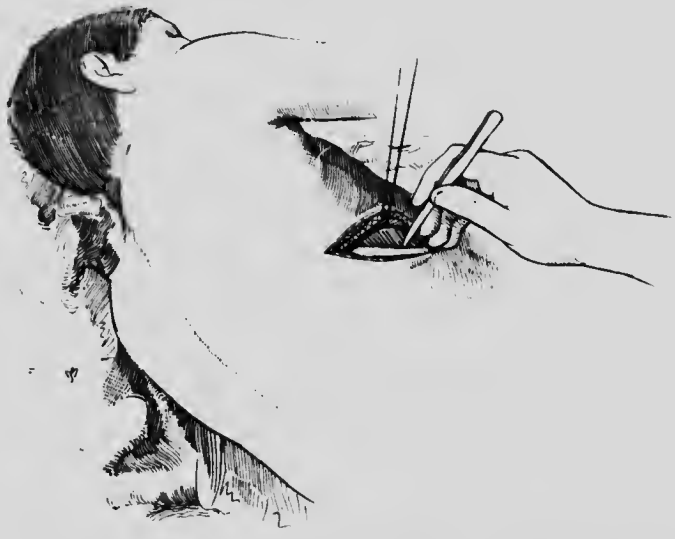

FIG. 95.—Thoractomy for Empyema. The selected intercostal space has been exposed by an oblique incision and the tissues overlying the space have been retracted. The scalpel is held with its point in contact with the intercostal tissues immediately above the rib which bounds the space below preparatory to making the incision into the pleural sac.

the removal of the exudate by aspiration may prove successful. One aspiration, no doubt, may fail, so that the process may have to be repeated.

This method of treatment has not met with much favour. One argument against it is that the protracted presence of an effusion within the pleural cavity will have the effect of compressing the lung and rendering its subsequent expansion difficult or impossible.

Aspiration is occasionally useful as a temporary measure in cases of very large effusions where the general condition of the patient is bad, as indicated by very frequent and feeble pulse, dyspnœa, lividity of the face, etc. The removal of the greater part of the exudate by aspiration will afford relief of the urgent symptoms, and when the condition of the patient has improved thoracotomy may be performed with a better prospect of success.

THORACOTOMY.—In this procedure an incision is made down to and through

the intercostal tissues, and one or more tubes are introduced for the purpose of effecting free drainage.

Instruments.—Scalpel; dissecting and hæmostatic forceps; retractors; blunt dissector; scissors; drainage tubes of varying sizes; needles; ligatures; sutures. It is advisable to have an exploring needle at hand, and, as a rule, even if the presence of pus has been ascertained some days beforehand, it is advisable to explore again before proceeding with the operation.

The Operation.—In carrying out this simple procedure care should be given to the usual aseptic details. The pleural inflammation may be due to a mono-infection,

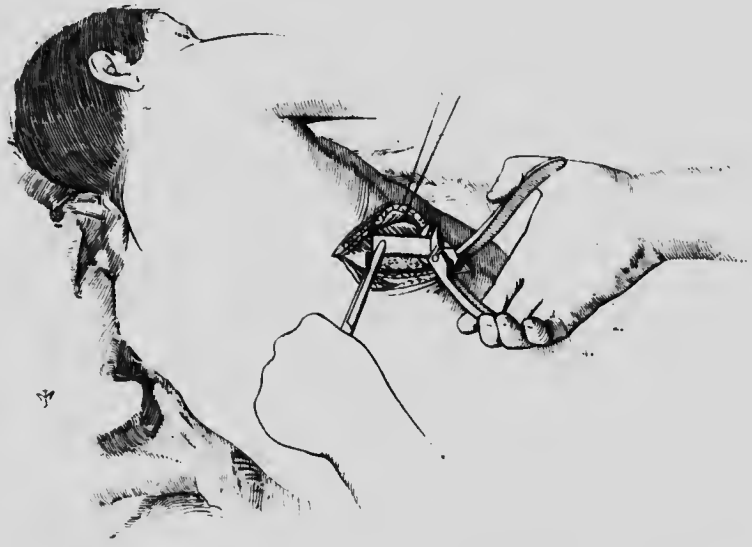

FIG. 96. Resection of a segment of a rib for empyema. The selected rib has been exposed and cleared all around. The first section has been made far back and the rib shears are represented in position as the second section is about to be made.

and the aim of the surgeon should be to prevent the ingress of other organisms or, in other words, a mixed infection.

Anæsthesia.—We usually employ local anæsthesia in the adult, and find it very satisfactory. In children it is advisable to administer a general anæsthetic, chloroform being preferable to ether, as it is less liable to excite coughing.

The patient is placed upon the operating table with the affected side of the chest uppermost, and the arm is raised and held by an assistant.

The Superficial Incision.—Assuming that the case is one of extensive effusion within the general cavity of the pleura, the level which we generally select for drainage is the seventh or eighth space in front of the posterior axillary line.

The cutaneous incision is somewhat oblique, following the direction of the selected intercostal space. After the superficial tissues have been divided the plane of section is extended more deeply through the underlying muscle, viz., the latissimus dorsi,

the fibres of which are cut across. Bleeding vessels are seized with forceps, and the wound margins are retracted so as to afford a clear view of the intercostal tissues.

Division of the Intercostal Tissues: Drainage.—The intercostal incision follows the upper border of the rib which bounds the space below. This precaution is taken with a view to avoid wounding the intercostal artery which is closely related to the lower border of the rib above. The tissues are progressively divided down to and through the pleura. This latter may be very thick and tough, and this circumstance may cause some confusion at this stage of the procedure unless its possibility is borne in mind. As soon as the pleura is opened the index finger is introduced, partly for the purpose of exploring the extent of the cavity, but partly in order to prevent the too rapid escape of the contents of the empyema.

The drainage tube selected should be as large as the space will contain without exerting lateral compression. We frequently employ two tubes, arranged side by side. They need not project into the cavity for more than 1 or 2 inches, and they are held securely in position by sutures of silkworm gut. Each suture traverses the tube, and is then carried through the subcutaneous tissue rather than through the skin, as the pain subsequently is less.

If the extent of the open wound is unnecessarily large, it may be diminished by introducing one or more interrupted sutures of silkworm gut at each angle.

The Dressing. Some folded layers of sterile gauze are placed over the drainage tube, and these are covered with large pieces of sterile gamgee tissue, which extend over the affected side and well round to the back. A large amount of discharge escapes during the first twelve hours which succeed the operation, and this may necessitate the removal of the soaked dressings and the application of fresh sterile pads.

The dressing is retained by a binder, and from the upper borders of this a strap may be carried over each shoulder, so as to prevent the binder from slipping down and allowing the dressing to become displaced.

If symptoms of shock supervene or if the general condition of the patient is a cause for anxiety, the administration of warm saline solution per rectum is to be recommended.

CHRONIC EMPYEMA.—Operative intervention is occasionally demanded for long-standing empyemata for the purpose of closing the persisting intrapleural cavity when it becomes obvious that nature's efforts alone are unable to bring this about.

The end in view may be attained by mobilising the overlying chest wall or the lung beneath, or both. The first usually requires resection of ribs and of the subjacent parietal pleura; the second may result from the removal of the thickened pleura investing the lung, in consequence of which the compressed lung expands. This procedure, which is usually spoken of as decortication of the lung, was first performed by Delorme.

The mere resection of portions of certain ribs may effect a cure in cases where the pleural cavity is small and the patients are young, with yielding thoracic walls. It will not suffice when the cavities are large and the thorax rigid. Estlander's procedure was directed to cases of this kind, and his object was to mobilise the thoracic wall over the entire extent of the cavity.

Schède recognised the necessity for dealing with the pleura, as it constituted an obstacle to healing, owing to its rigidity after the resection of the ribs. Schède recommended extensive removal of bone from the sternum to the spine.

Before undertaking these operations it is desirable to ascertain the extent of the cavity. This may be done in various ways. A flexible sound introduced through

the fistulous opening will indicate its peripheral limits, and corresponding marks may be made on the skin. X-rays also afford valuable information after washing out the cavity with bismuth emulsion.

THE ESTLANDER OPERATION: THORACOPLASTY.—The extent of the pleural cavity having been determined, the overlying ribs are resected subperiosteally.

The form of incision varies. A free incision in the direction of the rib may be made over the centre of the cavity and the overlying tissues displaced upwards and downwards. Some surgeons employ curved incisions; others adopt incisions of varying outline, resembling the capitals T, L, I, etc. If the mobilisation of the thoracic wall is sufficient, it sinks inwards, the pleural surfaces adhere, the lung yields to some extent, and the discharge of pus ceases.

A modification of Estlander's operation, performed by Wagner and others, is that in which short pieces of the ribs overlying the cavity are resected in front and behind through two vertical and parallel incisions. The intervening segment of the thoracic wall is mobilised, and sinks in towards the lung.

SCHEDE'S OPERATION.—In this procedure a large U-shaped flap is raised from the side of the chest, and those portions of the ribs which overlie the pleural cavity are excised; the subjacent parietal pleura is also removed, and the deep surface of the U-shaped flap is brought into contact with the retracted lung.

The U-shaped Incision commences in front at the level of the fourth rib beneath the outer border of the pectoralis major muscle. It is directed downwards, and reaches its lowest limit over the tenth rib in the posterior axillary line, this being the most dependent part of the pleural recess. It follows the tenth rib backwards for a short distance, and finally curves upwards to the inner side of the vertebral border of the scapula as far as the second rib. The tissues are divided down to the plane of the ribs throughout the entire extent of the incision, and then the flap is detached, all bleeding vessels being immediately seized with forceps.

The Costal Resection.—The rib segments overlying the cavity are resected subperiosteally in order to diminish the amount of blood lost. The number of ribs concerned varies, but in cases of general empyemata it is usual to carry the resection from the second to the ninth or tenth and from the cartilaginous junction in front to the tubercle of the ribs behind. The amount of bone removed will depend upon the size and extent of the cavity. The resection of each rib will be facilitated by first dividing it at its middle and then detaching each fragment in turn.

The Pleural Resection is preceded by an exploration of the cavity with the finger, and to do this it may be necessary to enlarge the orifice of the sinus. The line of incision is first made behind, and at the same time the intercostal vessels are successively ligatured. The pleura is next divided at the upper and lower limits of its exposed area and turned forwards as a flap. All spouting vessels are secured and ligatured. The front attachment of the pleural flap is finally divided, and the mass of tissue is removed. In order to diminish the risk of septic infection of the large wound area it will be advantageous to apply some tincture of iodine to the raw surfaces.

Adjustment of the Flap. The flap is carefully pressed inwards against the inner wall of the cavity. Drainage by means of one or several tubes is advisable, so as to facilitate the escape of blood, serum, and inflammatory exudate. Tamponnade with gauze impregnated with some non-toxic antiseptic, such as xeroform, in conjunction with the tubes, is to be recommended. Iodoform gauze, if employed in quantity, may cause toxic symptoms.

The flap is retained in position by some interrupted sutures of silkworm gut. It may be advisable in some cases to introduce sutures in front only and leave the posterior part of the wound open.

COMMENTS.

Schède's Operation in two or more stages may be advisable if the condition of the patient is such that the entire procedure at one sitting would probably entail too severe a strain. At the first operation portions of two or three ribs with the corresponding costal pleura and intercostal tissues are removed.

Persistence of Fistulæ. Some fistulæ may close after a time, but occasionally they persist owing to the unyielding character of the tissues in their walls. The cervical recess of the pleura may fail to undergo obliteration and occasion trouble. To ensure healing in such a case it is usually necessary to resect portion of the first rib, which, owing to its complicated anatomical relationships, renders the operation difficult. Attempts to obliterate the upper part of the pleural cavity may be assisted by resecting the lower or infraspinous segment of the scapula. The tissues detached from the bone are rendered sufficiently mobile to fall inwards and promote the closure of the cavity. When, in spite of the careful reposition of the U-shaped flap, the wound still remains open to a greater or lesser extent, various devices may be attempted to promote healing, such as Thiersch grafting and certain plastic operations.

The Results of Thoracoplasty are highly satisfactory in a large percentage of cases. The discharge of pus ceases, and the general condition of the patient undergoes a marked change for the better.

The necessity for this severe operation, however, is comparatively rare nowadays, as cases of empyema are diagnosed and submitted to treatment at an early period, when simple drainage suffices to bring about a permanent cure.

THE PERICARDIUM.

ANATOMY. The fibro-serous sac formed by the pericardium is conical in shape with its base resting upon the diaphragm and its apex above, its highest limit corresponding to the level at which the ascending stage of the aorta becomes continuous with the arch. This upper level may be indicated superficially by the central point of the manubrium sterni. The base of the pericardium slopes abruptly from behind forwards, its lowest level in front corresponding to a point a little below the base of the ensiform cartilage where the membrane is reflected from the diaphragm.

The pericardium is related on each side to the mediastinal pleura, and the lungs are closely applied against its lateral and anterior aspects. A small area of the pericardium, but somewhat variable in extent, comes into direct relationship normally with the chest wall to the left of the middle line without the intervention of the lung or of the pleural sac. This area is situated behind the anterior extremities of the fifth and sixth intercostal spaces, sometimes the sixth only and the triangularis sterni muscle.

Certain recesses are found within the sac of the pericardium. The principal of these is situated between the lower aspect of the heart and the diaphragm, and is

known as the subcardiac recess (Fig. 97). Other recesses are situated respectively at the posterior aspect of the heart, between the four pulmonary veins, at the apical extremity of the sac in front, and on each side where the membrane is related to the mediastinal aspect of the lung.

PERICARDIAL EFFUSIONS. Inflammatory effusions of a serous, sero-fibrinous,

FIG. 97.—The sac of the pericardium distended by an inflammatory exudate. This specimen was obtained in the course of some special dissections of a female subject preserved by intravascular injections of formaldehyde solution. The pericardium was much distended by a sero-purulent exudate and the heart was completely covered by a yellow shaggy layer of coagulated fibrin. Note the way in which the heart is suspended by the great vessels and the large subcardiac recess between its basal aspect and the diaphragm.

or purulent character may collect within the pericardium. In cases of wound the sac may become distended with blood.

As the capacity of the pericardial sac is considerably greater than the volume of the heart and the contained blood vessels, a considerable quantity of fluid may collect in its interior without causing any untoward symptoms, and if the effusion takes place slowly the walls of the sac gradually stretch and the fluid contents may increase to an enormous extent—two pints or even more—without causing alarming symptoms. When the effusion collects rapidly, however, it may quickly lead to a fatal issue owing to the pressure which it exerts upon the heart, but especially upon the auricles within which the blood pressure is low.

As the sac of the pericardium becomes distended it relationships undergo certain important alterations which are deserving of notice.

1. It comes into fuller relationship with the chest wall. As this takes place the anterior margins of the lungs recede, and according to some observers the lines of pleural reflection (costo-mediastinal) deviate outwards also, so that an abnormally wide area of the pericardium comes into immediate contact with the anterior chest wall without the intervention of the pleural sacs (Voinitch-Sianojentzky). This, however, is denied by others (Delorme and Mignon), who state that as the lungs recede the costal and mediastinal layers of the pleura come into contact and remain in close apposition with each other. From these conflicting statements it would appear that although a certain amount of recession of the pleural sacs may take place, yet it is not an invariable result of distension of the pericardium.

The altered relationship between the pericardium and the chest wall is recognised by percussion, which reveals an increased area of cardiac dulness, somewhat triangular in outline, broad below and tapering above. When the pericardium is very much distended the dulness may reach as high as the first rib and as low as the seventh in a transverse direction; it may extend to the right as far as the mammary line. Occasionally there is an evident bulging in the precordial region; it is observed most frequently in young subjects in whom the chest wall is very elastic.

2. The heart itself, suspended in the fluid by the great vessels, is apt to be displaced backwards and upwards, and consequently its impulse becomes indistinct or imperceptible. The diaphragm also is depressed, and the greater part of the effusion collects between it and the heart, especially if the shoulders are raised or if the patient sits up. A large amount of fluid collects also on each side, as the sac, restrained by the sternum in front and the vertebral column behind, bulges laterally and displaces the lungs, but the left more especially to an increasing extent.

The pressure exercised by the fluid upon the heart, the great vessels, and the air passages causes increasing dyspnœa of a suffocative character, pallor and lividity of the countenance, swollen cervical veins, a weak, rapid, and irregular pulse. Dysphagia is sometimes observed in consequence of compression of the œsophagus.

PARACENTESIS OF THE PERICARDIUM.—This procedure may be carried out for exploratory purposes in order to ascertain the nature of the pericardial fluid. It is indicated also in cases of extensive serous or sero-fibrinous effusion in which the heart suffers injurious compression. In cases of intrapericardial hæmorrhage the immediately pressing symptoms may be relieved by a timely paracentesis.

Were it possible to determine beforehand whether the effusion within the pericardium were serous or purulent, the point selected for puncture would in many cases be a matter of indifference, that is, provided the fluid were serous and non-infective, it would not make any appreciable difference whether the needle in entering traversed the pleural cavity or not. However, as one must often remain in doubt as to the nature of the fluid in acute cases, it is safer, as a rule, to introduce the exploring needle at a point where it is unlikely that either pleural sac will be wounded—in other words, the puncture should be *extrapleural*, not *transpleural*.

It would appear that the risk of wounding the pleura will be least if the needle be introduced through the anterior extremity of the fifth or sixth space, which is at this level reduced to a linear slit and may be partially bridged across by cartilage.

The sixth space is an excellent site for puncture, as it directly overlies the large subcardiac recess within which the bulk of the fluid is contained, and there is very little risk of wounding the heart at this level. This accident would be most likely

to happen if the needle were thrust in very deeply. It will rarely be necessary to penetrate deeper than an inch, as the distended pericardium lies in close apposition to the chest wall. Some confusion may arise in performing paracentesis owing to the increased thickness and toughness acquired by the pericardium in some cases, especially those of a purulent nature.

In cases of extensive serous effusion Curschmann recommends that the puncture should be made in the fifth or sixth space in the mammary line with a view to tap the distended lateral recess. The introduction of the needle here is calculated no doubt to avoid injury to the heart, but it necessitates the penetration of the pleural cavity.

The Technique of Paracentesis. The skin over the lower part of the sternum and the adjoining part of the chest is carefully disinfected and the patient placed in the partially sitting-up position, as it affords the greatest ease and it has the effect of causing the fluid contents of the pericardium to gravitate into the large subcardiac recess.

The site for the puncture is selected, *i.e.* either the fifth or sixth space close to the sternum, and the superficial tissues are anæsthetised here by means of a subcutaneous injection of novocain and adrenalin.

The skin is incised for about $\frac{1}{2}$ inch. The needle passes easily through the deeper tissues, but it may require some force to push it through the skin. The direction given to the exploring needle is backwards and slightly inwards behind the left sternal margin. It is usually easy to tell when the needle has entered the sac, as all sense of resistance to its passage will have disappeared. It should be passed slowly and steadily, the hand of the surgeon being applied to the chest of the patient somewhat in the same way as when holding the knife in tracheotomy when the incision is being made into the trachea.

By withdrawing the piston the fluid will flow into the barrel of the exploring syringe and its general character will be noted.

In performing paracentesis we prefer a trocar and cannula to an aspirator of the Dieulafoy pattern as it enables the fluid to drain away slowly; and this is a matter of importance, as it is advisable that the pressure upon the heart should not be removed quickly; sufficient time should be permitted to enable it to recover itself when the pressure conditions are being restored to their normal state.

A tube is connected with the cannula and the fluid is allowed to flow away into a vessel beside the bed. It is better not to aim at the complete removal of the fluid, as the attempt may result in wound of the heart by the end of the cannula, which projects within the pericardial sac. Such an accident is still more likely to occur if an aspirator be employed, such as that of Dieulafoy or Potain.

The cannula having been withdrawn, the site of puncture is covered by a small sterile pad which is retained *in situ* by some strips of adhesive plaster.

PERICARDOTOMY. This procedure is usually undertaken in cases of purulent effusion within the pericardium; the serous sac is opened and drained in accordance with the principles which regulate the treatment of purulent collections in other parts of the body.

The operation may be conducted under local anæsthesia.

The Procedure of Delorme and Mignon. Assuming that the usual details relative to the cleansing and disinfection of the skin have been carried out and the patient placed in the partially sitting-up position, the superficial tissues in the lines of the cutaneous incisions are rendered anæsthetic by means of novocain and adrenalin. A

vertical incision is made close to the left margin of the sternum from the upper border of the fourth to the seventh costal cartilage, and from its upper and lower extremities short incisions are carried outwards for about 2 inches. The rectangular flap so defined is reflected outwards, all the tissues being detached from the subjacent cartilages. At the inner margin of the wound the tissues are dissected up and drawn inwards so as to expose the side of the sternum. The next step consists in dividing the fifth

FIG. 98. The procedure of Delorme and Mignon for effecting drainage of the pericardium. Portions of the fifth and sixth costal cartilages have been excised and the internal mammary artery has been exposed as it rests upon the triangularis sterni muscle. The inset figure represents the opened pericardium. The internal mammary vessels and the left pleural sac have been preserved from injury by careful retraction.

costal cartilage close to the sternum with a blunt-pointed tenotome or cutting gouge, after which it is raised and the tissues detached from its deep surface and a piece excised, care being taken in doing so to avoid the internal mammary artery. A piece of the sixth costal cartilage having been removed in a similar manner, a vertical incision is carried through the triangularis sterni muscle from below upwards close beside the sternum. Inflammatory condensation of the tissues at this level may cause some confusion. The tip of the index finger in the wound is insinuated beneath the sternal margin and recognises the tense pericardium; at the same time the left

pleura and the internal mammary artery are pushed outwards. The pericardium is seized with a sharp hook or hæmostatic forceps and opened vertically for ¾ inch. Should more room be required a piece of the left margin of the sternum may be resected with rongeur forceps.

In cases where the effusion is extensive it will be advisable to introduce two tubes. One is passed across to the right pericardial recess between the lower aspect of the heart and the diaphragm; the other passes directly backwards into the large recess on the left side.

Rehn's Procedure. The cutaneous incision has a curved direction, and extends along the lower border of the seventh left costal cartilage for a distance of 3 inches and transversely across the base of the ensiform cartilage. The tissues are progressively divided and the seventh costal cartilage is detached from the sternum. The tissues related to the deep aspect of the cartilage and the adjoining sternal margin are detached by a process of blunt dissection, and the retrosternal space is opened above the sternal attachments of the diaphragm. Portions of the costal cartilage and left sternal margin are resected with cutting forceps, and if extra room is required a portion of the sixth costal cartilage may be resected also. By drawing aside the wound margins and working deeply with a blunt dissector through some fatty tissue the pericardium is exposed, the pleural sac being at the same time displaced outwards. Distension of the pericardium facilitates its exposure, but in the course of the procedure careful precaution should be taken to avoid a wound of the peritoneum.

The pericardium is opened and drained as in the last operation.

It may be necessary to wash out the pericardium if it contains decomposing blood clots or masses of coagulated exudate. The best fluid to use for this purpose is warm sterile salt solution.

SECTION IV

THE ABDOMEN

ABDOMINAL HERNIAS

INGUINAL HERNIOTOMY.

General Consideration. Those cases of inguinal hernia which come under the notice of the surgeon with a view to treatment of an operative nature may be divided into two main groups, according as they are met with in childhood or in adult life.

Inguinal Hernias in Infants and Young Children. The majority of these are due to defects in the natural processes of development, the more common being complete patency or only partial obliteration of the funicular process of the peritoneum. These hernias are classified according to their relationship with the funicular process as (*a*) complete congenital inguinal hernia, (*b*) hernia into the funicular process, and (*c*) encysted congenital hernia.

Such hernias may be treated by palliative measures, *i.e.* by trusses, or by one of the recognised operative procedures which aim at effecting a permanent cure.

The wearing of a truss no doubt may lead to complete cure. To ensure success, however, the instrument must be worn day and night, and a special truss covered with rubber must be worn by the child when having a bath. This form of treatment for obvious reasons is unsuited for the children of the poorer classes. Furthermore, even if persisted in, cure of the defect is by no means certain. After discarding a truss the hernia may subsequently appear.

Herniotomy in young children is a simple procedure, it is attended by very slight risk in competent hands, and it affords an excellent prospect of permanent cure. As a rule the child may be regarded as cured after two weeks from the date of the operation, and no further measures are required. Young children from one year upwards otherwise in good health bear herniotomy well.

The prospect of a lasting cure after herniotomy during childhood is very great as the tissues of the abdominal parietes are growing and strengthening. If the serous tube and its contents are removed completely from the canal this latter quickly narrows in and assumes its normal valvular condition.

Inguinal Hernias in Adults. A hernia in the adult may be of the congenital or acquired type.

According to R. H. Russell, of Melbourne, R. W. Murray, of Liverpool and others, a large percentage of these hernias must be regarded as the result of congenital defects, the view held being that the sacs are preformed owing to the persistence of portions of the funicular process of the peritoneum within the inguinal canal.

Cases of inguinal hernia in the adult which are submitted for treatment may be of

fairly recent duration or may have been in existence for several years. In the early cases the inguinal canal and its apertures have altered but little from the normal and consequently the anatomical conditions are favourable for successful treatment by operative measures. In an old-standing case, however, the inguinal canal is greatly

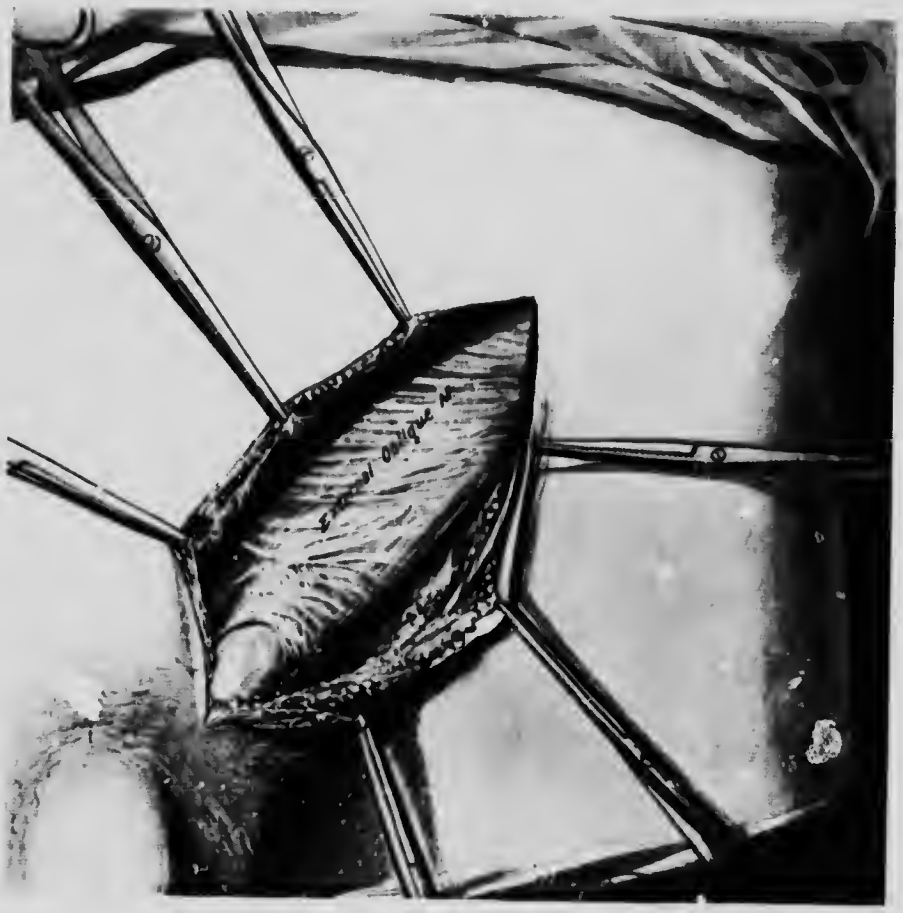

FIG. 103. Bassini's Inguinal Herniotomy. The superficial tissues have been divided, and the aponeurosis of the external oblique muscle exposed. The spermatic cord is seen at its exit from the external abdominal ring. Note the strongly developed arcuate fibres which cross the parallel bundles of the external oblique tendon.

altered, its obliquity is greatly diminished, or the passage is replaced by a large patulous aperture. The muscular tissue surrounding it has undergone atrophy and its vascularity is by no means great. The general tonicity of the abdominal muscles is apt to be very feeble in such individuals and they are often troubled with difficulty in micturition or a chronic, bronchitic cough. The anatomical and constitutional

conditions in such cases are not such as to inspire great hopes of the permanent success of operative measures.

The hernial protrusion in the last type of case may be very large and the greater part of the intestine and omentum may occupy the hernial sac.

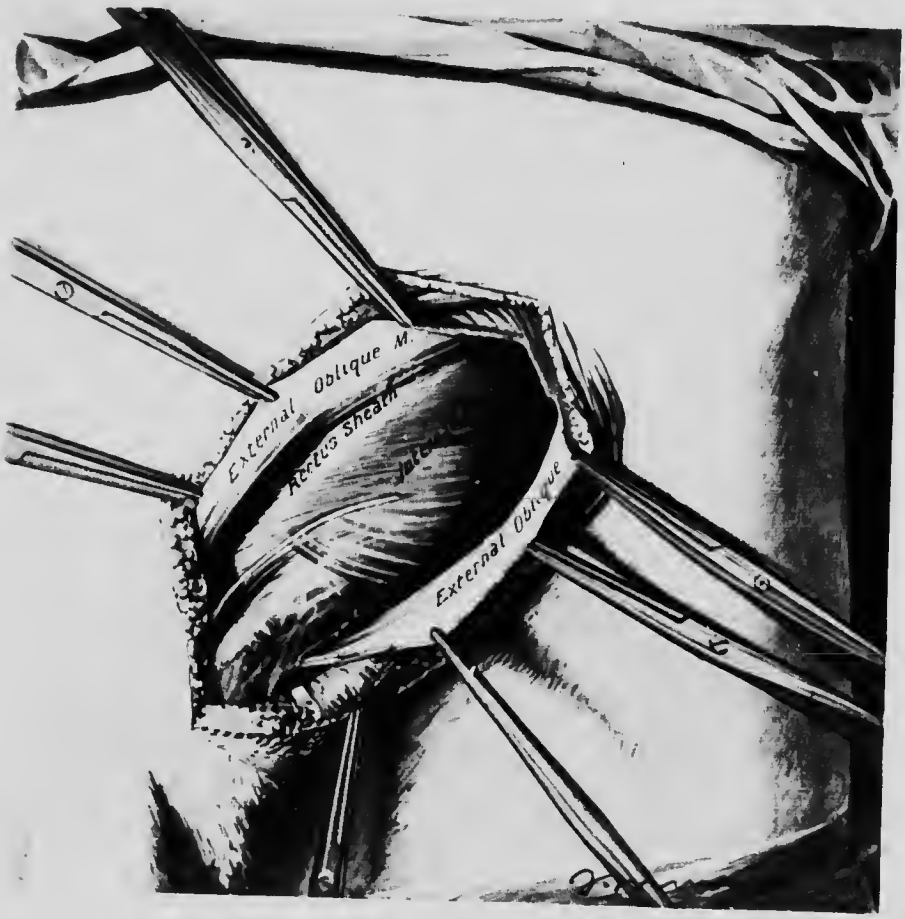

FIG. 100.—Bassini's Inguinal Herniotomy. The external oblique muscle has been split in the fibrous axis of the inguinal canal and its margins have been drawn apart. The internal oblique muscle gives place to a tendon as it approaches the middle line. At its lower border this tendon fuses with that of the transversalis forming the conjoint tendon which lies behind the spermatic cord just before it emerges from the external abdominal ring. The ilio hypogastric nerve will be observed in relation to the superficial aspect of the internal oblique muscle.

Strangulated Inguinal Hernia. Strangulation may occur at any age or at any period in the development of the hernia. The amount of bowel affected may vary from a mere nipping of a portion only of the intestinal cylinder (partial enterocele) up to the strangulation of one or more coils of intestine. Strangulation may supervene promptly with the appearance of the hernial protrusion or after the hernia has been in existence for a considerable time.

The usual site of strangulation is the neck of the sac. The tissues here are tough and condensed, forming an unyielding cicatricial ring. Less frequently strangulation may be caused by the transversalis fascia or the external abdominal ring. For further remarks see under heading of "Operation for Strangulated Inguinal Hernia."

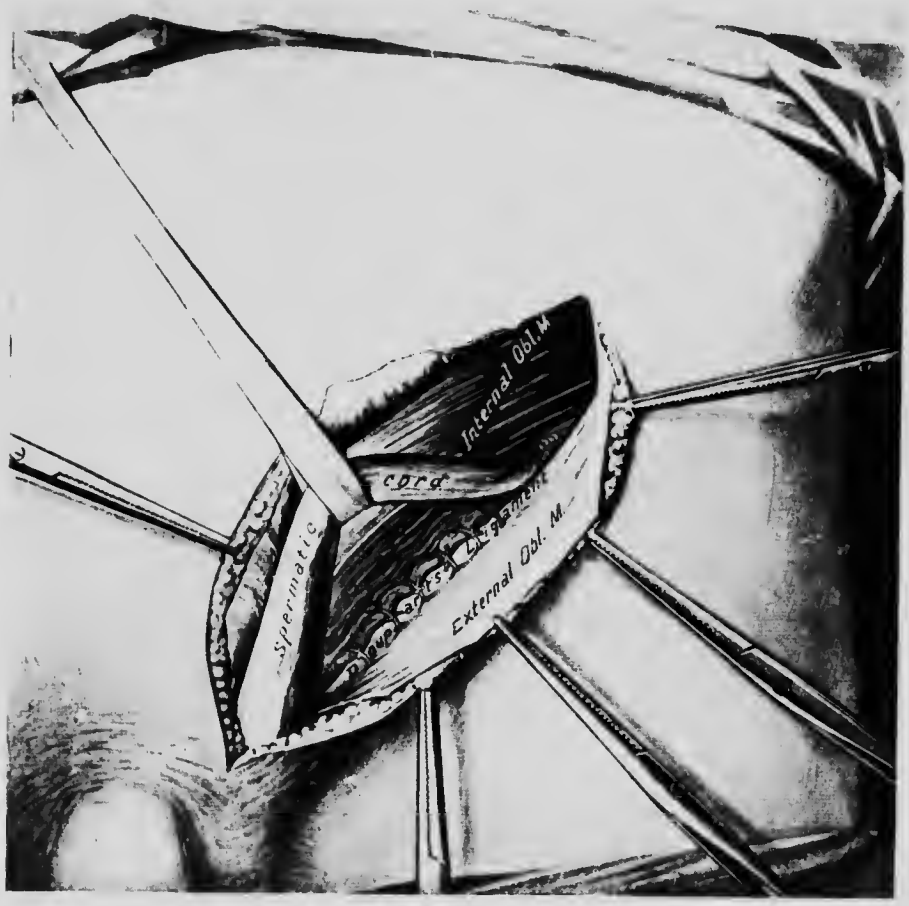

FIG. 9.—Bassini's Inguinal Herniotomy. The sac of the hernia has been separated from the spermatic cord, ligatured at its neck and the fundus removed. The lower margins of the internal oblique and transversalis muscles have been connected by sutures with the deep aspect of Poupart's ligament. While this is being done the cord is held aside by a strip of muslin passed around it in the form of a loop.

Indications for Herniotomy. The following are the chief conditions for which the operation of the inguinal herniotomy is indicated: (1) Inguinal hernias in infants after the first year and in young children, especially those of the poorer classes, in whom treatment by a truss is difficult if not impossible. (2) Difficulty in carrying on their ordinary avocations by individuals with existing inguinal hernias.

(3) Strangulation or symptoms indicative of such, even though reduction has been successfully effected. (4) To meet the requirements of the public services. (5) Irreducible hernias which incommode the individual and threaten strangulation. (6) Hernias associated with ectopia testis.

BASSINI'S OPERATION. Preliminary Measures. The usual course of preparatory treatment is carried out, and special attention is directed towards the cleansing and disinfection of the skin (see p. 18). The iodine method is to be recommended, but except in cases of urgency its employment should be preceded by a thorough mechanical cleansing of the skin and shaving of the pubic region in adults.

Anæsthesia.—We prefer general anæsthesia, as a rule, in herniotomy operations, and usually employ nitrous oxide gas followed by ether for adults. In the case of strong adult males, and more especially those addicted to alcohol, the administration of omnopon beforehand is useful in promoting quiet anæsthesia with good relaxation.

In a few cases it may be deemed prudent to employ local anæsthesia if it appears likely that a general anæsthesia will not be well tolerated, or if its employment is attended by danger, as may happen with patients suffering from bronchitis. Novocain with adrenalin suits admirably for this purpose, and we have not observed any unpleasant consequences from its use.

Spinal anæsthesia has been advocated by some surgeons, but we have not employed it extensively in cases of herniotomy.

In infants and young children chloroform is very suitable.

In the following operation it is assumed that the hernia is reducible and that the contents of the sac have been returned within the abdomen.

The Skin Incision in the adult is about 4 inches in length; it commences over the site of the emergence of the cord from the inguinal canal and extends outwards to a point beyond the level of the internal abdominal ring (Fig. 99). The superficial tissues are divided. The superficial external pudic and superficial epigastric vessels are usually divided, but are secured if possible before division with hæmostatic forceps. They are twisted or ligatured with fine catgut (No. 00).

Division of the External Oblique.—Commencing at the summit of the external abdominal ring, the aponeurosis of the external oblique muscle is slit up in a direction parallel to its tendinous bundles for about 3 inches; its cut margins are seized at their extreme edges and retracted (Fig. 100).

The lower margins of the conjoined tendon and of the internal oblique muscle are now defined, and by drawing them upwards and outwards by means of a retractor the inguinal canal is exposed in its entire extent.

Isolation of the Hernial Sac. The tissues investing the spermatic cord, viz., the cremaster muscle and the transversalis fascia, are picked up and divided between forceps. The spermatic vessels are seen and the sac of the hernia identified. This latter is incised for about $\frac{1}{2}$ inch; its interior is examined and its contents, if any, are reduced within the abdomen.

The left index finger, protected by a glove, is now introduced into the hernial sac, and a dry swab held in the right hand is employed to wipe away the tissues of the cord from the sac. This is done with gentleness, and care is taken to prevent unnecessary tearing of small blood vessels. The sac is isolated up to its junction with the parietal peritoneum, transfixed at this level, ligatured, and the fundus cut away. The ligatured stump retracts towards the abdominal cavity; it must on no account remain in relationship with the inguinal canal.

Suture of the Internal Oblique Muscle to Poupart's Ligament.—The cord is raised and held aside, and a series of sutures is introduced so as to approximate the conjoined tendon and internal oblique muscle with the deep aspect of Poupart's ligament (Fig. 101). One of these sutures is situated at the outer side of the internal abdominal ring where the cord emerges; the remainder lie at the inner side of the internal ring. The cord is now released and made to rest upon the superficial aspect of the internal oblique and the conjoined tendon.

Suture of the External Oblique and Closure of the Wound. The margins of the tendon of the external oblique muscle are brought together by a continuous suture or by a series of interrupted sutures. The external abdominal ring is narrowed as far as possible consistent with the safety of the cord (Fig. 102).

The superficial wound is closed, but before doing so any vessel likely to bleed is secured. As some oozing of blood is usual, it is a wise precaution to introduce a

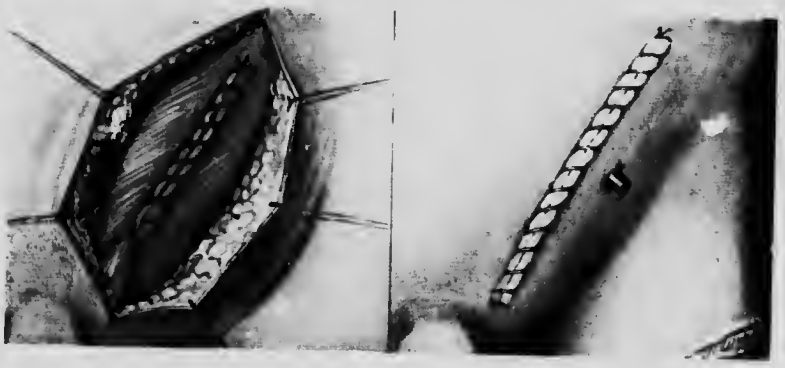

Fig. 102. Bassini's Inguinal Herniotomy. The margins of the external oblique tendon have been brought together by a continuous suture which also narrows the external abdominal ring, enough room being left to permit of the passage of the cord.

Fig. 103. Bassini's Herniotomy. The superficial wound has been closed by a continuous suture of fine silk and a drainage tube has been introduced through a small puncture below the main wound.

perforated glass drainage tube through a small puncture below the centre of the inguinal wound (Fig. 103).

A method which we have found useful in closing these wounds is to pass three or four deep sutures of silkworm gut the free ends of which emerge from the skin respectively about $\frac{3}{4}$ inch from the wound margins. These latter are approximated entirely by a continuous subcuticular suture or by interrupted sutures of silkworm gut. A gauze swab rolled up in the form of a cylinder is placed over the wound and the deep sutures are tied over it. This method has the advantage of preventing the deep sutures from cutting into the skin and arresting oozing from the superficial vessels after the closure of the wound; it therefore tends to prevent the development of a hæmatoma in the wound and does away with the necessity for drainage.

The Dressing. The sutured wound is wiped dry and painted over with tincture of iodine. A muslin swab is then applied and over it a layer of absorbent wool or gamgee tissue. The dressing is retained by some strips of adhesive strapping or by means of a soft flannellette bandage. In infants and young children we usually close the wound without drainage and apply Kocher's paste (p. 7). This latter is put on in a thick layer, and acts as an excellent protective medium.

COMMENTS.

The Aims of the Operation. Bassini's operation has two objects in view, viz., the complete obliteration of the hernial sac and the reconstitution of the normal obliquity and valvular character of the inguinal canal. It has received a very wide

FIG. 104.—Bassini's Inguinal Herniotomy. This figure represents a method of securing the ligatured neck of the sac. The two ends of the ligature which have been left long are drawn up behind the muscles and the stump of the sac is drawn away at the same time from the immediate vicinity of the external abdominal ring.

acceptance, and is extensively performed at the present day either in its original form or with some slight modification.

Asepsis.—The success of this and other forms of herniotomy depends mainly upon the degree of asepsis maintained throughout the operation. Suppuration and the subsequent development of cicatricial tissue predispose more than anything else to a recurrence of the hernia.

Hæmorrhage. The arrest of bleeding should be attended to carefully. The superficial vessels are the main offenders. If one of the veins of the cord should be torn it must be identified and ligatured with fine thread or catgut. As some oozing of blood often occurs between the superficial tissues and the external oblique aponeurosis,

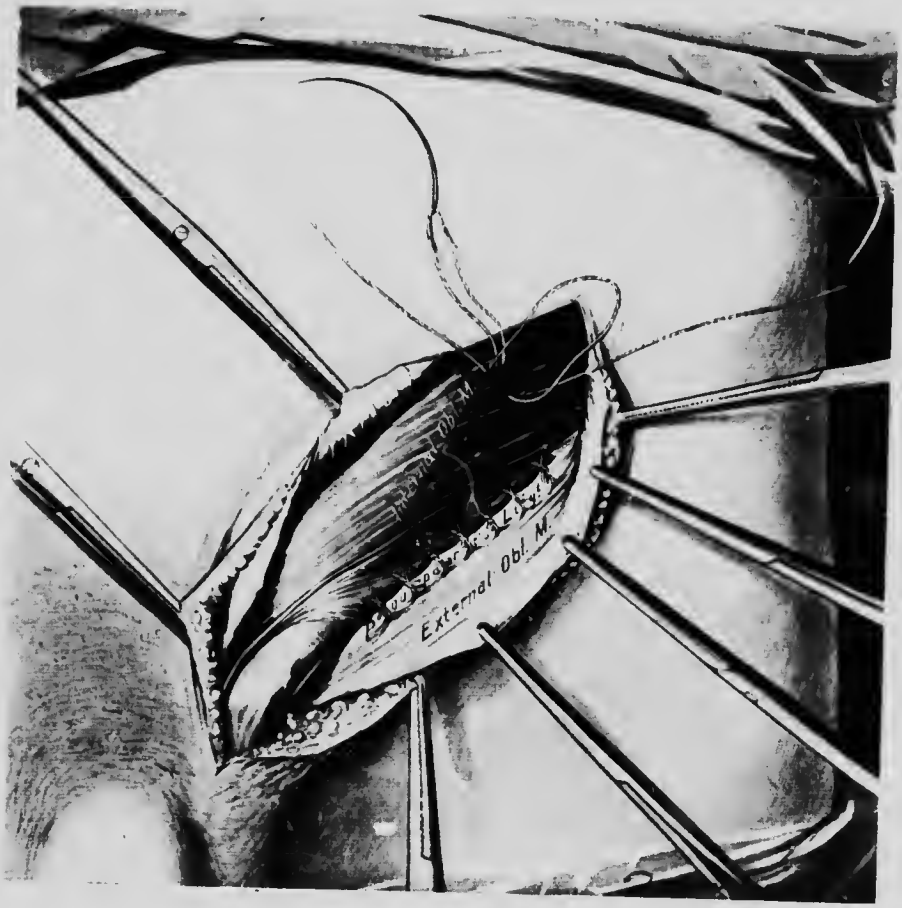

FIG. 105.—Bassini's Inguinal Herniotomy. The method of introducing the deep suture as represented in this figure differs from that of Bassini. The cord has been displaced backwards and the lower margins of the internal oblique and transversalis muscles have been connected by interrupted sutures with the deep aspect of Poupart's ligament. The suture traversing the internal oblique muscle higher up represents the way in which the stump of the sac (see Fig. 104) is anchored in relation to the deep aspect of the abdominal parietes.

we are in favour of introducing a small glass drainage tube through a stab wound just above Poupart's ligament and leaving it *in situ* for twenty-four hours.

Ligatures and Sutures. We usually employ fine linen thread or fine silk for the buried sutures in herniotomy. The objection to non-absorbable sutures is that they

may give trouble sooner or later after their introduction by occasioning suppuration and discharging sinuses. However, with careful attention to aseptic details, the minimum of handling and damage to tissues, and careful hæmostasis, the risk of septic mischief from the employment of such suture materials is very slight. Those who employ catgut claim for it the following advantages :—its absorbability, as the result of which it soon disappears completely, its efficiency in so far that it holds the tissues until they have securely grown together, and the fact that sterilisation can be assured.

We generally employ catgut in young children in whom there may be difficulty in maintaining complete asepsis, and also in cases of strangulation where the condition of the parts renders it obvious that organisms from within the strangulated bowel have made their way to its free surface and to the interior of the sac. The skin wound may be closed in various ways. The principal are—(*a*) a continuous suture of fine silk or linen thread ; (*b*) interrupted sutures of silkworm gut ; (*c*) a continuous subcuticular suture ; or (*d*) Michel's metallic clips. We frequently employ silkworm gut for the deep supporting sutures and Michel's clips for securing accurate adjustment of the wound margins.

The Hernial Sac.—In Bassini's operation the sac is cut away and the neck, having been securely ligatured, is allowed to recede away from the inguinal canal. Occasionally we displace the stump of the sac in the manner represented in Fig. 104. The internal oblique and transversalis muscles are transfixed by a pair of sinus forceps or by some form of suture carrier, and a finger passed up beneath these muscles guides the point of the instrument into the wound. The long ends of the ligature are drawn out through the muscles ; one of the threads takes up a stitch beside the aperture and is then knotted with its fellow.

If adhesions exist within the sac they must be fully exposed and dealt with. Omental tissue is ligatured and divided ; redundant masses of omentum may be removed.

If the sac is very capacious at its neck it will be easier to close it by a continuous suture than by transfixion and ligature.

It is advisable always to open the sac before commencing its isolation. This precaution obviates the possibility of other tissues being allowed to adhere to the sac during the isolation process ; the proper limits of the sac are instantly defined and thereby less risk is incurred of damaging blood vessels when the surrounding tissues are being wiped away.

Before transfixing the sac at its neck its interior should be inspected so as to avoid damaging intestine or possibly the bladder.

The Spermatic Cord. In Bassini's operation the cord reposes on the superficial aspect of the internal oblique muscle and its conjoined tendon. As an alternative it may be placed behind these parts, ultimately emerging from beneath them, just before it issues from the external abdominal ring (Fig. 105).

The bulk of the cord is sometimes considerable, and this is a serious disadvantage considering how its presence in the inguinal canal predisposes so strongly to hernial development. The volume of the cord may be increased by numerous large spermatic veins, and not infrequently by collections of extraperitoneal fat. Double ligature and excision of these superfluous veins as performed for varicocele and removal of redundant fatty tissue may be carried out with advantage. In dealing with such collections of fat care should be taken to ascertain that they do not exist in association with protrusions of the bladder. Some forms of bladder hernia are preceded by masses of fatty tissue, which may conceal the viscus entirely.

Injury of Nerves. Pain after inguinal herniotomy may be greatly minimised by avoiding the inclusion of nerves in the grasp of the deep sutures. This applies mainly to the ilio-hypogastric and ilio-inguinal nerves (Fig. 100). The ilio-hypogastric nerve should be pushed aside and not included with the sutured tissues. We are convinced that severe pain after herniotomy is often due to neglect of this simple precaution.

Dressings, Removal of Drainage Tube, etc. —Tincture of iodine is applied to the wound area, and this is protected by a dry gauze dressing which is changed next day, by which time the drainage tube, having fulfilled its purpose, may be dispensed with. The sutures and clips are removed after five or six days as the wound margins will have united. A collodion dressing may then be applied as a protection for some days longer, or the wound may be dusted over with an antiseptic powder.

Rest and Precautions after Operation. —As a rule hospital patients are allowed up after the end of the second week, usually about the tenth day. Those who can afford to rest for a longer period should certainly do so. As little strain as possible for at least three months should be put upon the sutured parts. This applies most urgently to cases in which the hernias have been long in existence, the inguinal canal large and patulous and the abdominal muscles atonic.

There is usually no necessity for a truss to be worn after the operation either in the child or adult with the exception of those aggravated cases just indicated. Should suppuration have taken place in the wound there will be still greater need for care and avoidance of all hurtful strain for several months after healing has taken place.

Modifications of Bassini's Operation. —While Bassini's operation is admirably adapted for a large percentage of the cases of inguinal hernia which come under the notice of the surgeon, there are some in which it may with advantage be replaced by other methods which have the same principle in view and in fact resemble it in their more essential details.

In the hernias of infants and children, and in the recent hernias of adults when there is already but slight alteration of the relationships of the parts in the inguinal canal, it is possible to remove the hernial sac and effect a very efficient degree of repair with a less extensive division of the aponeurosis of the external oblique muscle than is performed in Bassini's operation.

Again, in those old-standing, aggravated cases already alluded to there seems to be a need for some measure which will provide greater facilities for repair and restoration of the inguinal canal.

HERNIOTOMY FOR THE RECENT HERNIAS OF ADULTS AND FOR THE MAJORITY OF INGUINAL HERNIAS IN CHILDREN.

The following operation is that which we usually employ in these cases.

The skin incision is parallel to Poupart's ligament and extends from the level of the external to a point just beyond that of the internal abdominal ring. The superficial tissues are divided and bleeding vessels dealt with as already described. The aponeurosis of the external oblique muscle is exposed. With the handle of the scalpel

the superficial tissues are pushed aside so as to define Poupart's ligament below and the external abdominal ring at the inner angle of the wound (Fig. 106).

A short incision is made in the tendon of the external oblique parallel to its tendinous bundles about 1 inch above the centre of Poupart's ligament. The cut margins of the tendon are neatly seized with hæmostatic forceps and retracted. The handle of the scalpel serves to undermine the tendon for some distance all round the button-hole aperture. The deep aspect of Poupart's ligament is clearly recognised below.

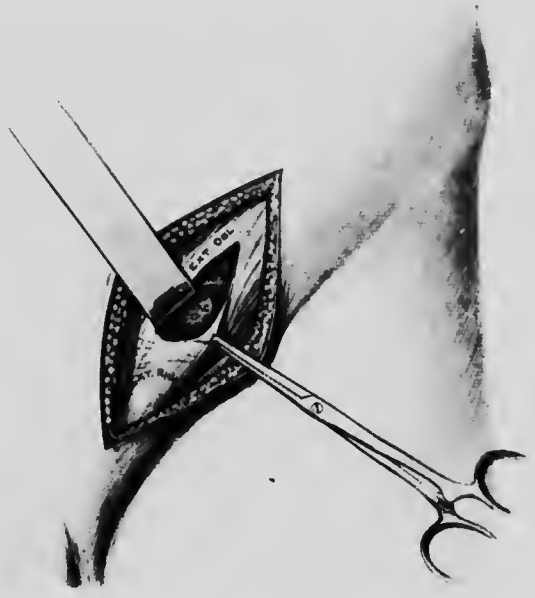

Fig. 106. The Author's modification of Bassini's Herniotomy. The superficial tissues have been divided in the usual manner and by a little dissection the aponeurosis of the external oblique muscle, Poupart's ligament and the external abdominal ring have been defined. A small aperture has been made by cutting between the parallel bundles of the external oblique tendon opposite the level of the internal abdominal ring. By drawing apart the margins of the aperture the lower border of the internal oblique muscle has been identified and drawn upwards. The sac of the hernia invested by the transversalis fascia appears in the depth of the wound.

With the handle of the scalpel or a suitable blunt dissector the lower border of the internal oblique muscle is defined and pushed upwards and held aside in this position by a retractor. The sac of the hernia invested by the transversalis fascia lies at the bottom of the wound at its point of emergence from the abdomen. Its identity is established by drawing upon the tissues of the cord, the traction being so exerted as to displace these from the external towards the internal abdominal ring. In endeavouring to expose the sac the tissues are divided between forceps, due care being taken of the structures of the cord (Fig. 106).

The sac is cleared as before and isolated up to its junction with the peritoneum.

It is then transfixed and ligatured with the precautions already given. The ligatured stump, relieved from traction, recedes from the canal and assumes a new position above and to the outer side of the internal ring (Fig. 107).

The lower margins of the internal oblique and transversalis muscles are connected by two or three sutures with the deep aspect of Poupart's ligament. Each suture takes a good hold of the muscles avoiding the ilio-hypogastric nerve, and its two

Fig. 107. The Author's procedure in Inguinal Herniotomy. The sac of the hernia has been isolated and rendered quite free of all its surroundings up to the level of the internal abdominal ring. It has been transfixed here by a needle carrying a ligature of fine linen thread (or chromicised catgut). After ligature the fundus of the sac is cut away and the stump allowed to recede as much as possible from the vicinity of the internal ring.

extremities pass from the deep to the superficial aspect of Poupart's ligament close together and are knotted with moderate tension (Fig. 108).

The external abdominal ring, which is usually capacious, is narrowed and the aperture in the oblique tendon is closed by a few interrupted sutures (Fig. 109).

The superficial wound is closed. In adults drainage with a small glass tube is usually carried out for twenty-four hours. In children no drainage is attempted.

COMMENTS.

Limited Division of the External Oblique. The main feature of this operation is the limited division of the tendon of the external oblique muscle which it entails. That part of the tendon above and to the outer side of the external ring is preserved

intact. This is certainly an advantage, as it diminishes the likelihood of subsequent yielding of the cicatrix. Just above the external ring the tendon is reinforced by the arcuate fibres, which bind together its flat tendinous bundles more efficiently than any form of suture which could be employed.

Technique. The operation just described is simple and easy of execution. With the exception of the manipulations incidental to the isolation of the sac, the fingers of the operator whether protected or not by gloves need never touch the tissues. Long dissecting forceps or those of the type devised by Leedham Green should replace

Fig. 108.—The Author's procedure in Inguinal Herniotomy. Following the ligature of the sac the lower margins of the internal oblique and transversalis muscles are connected in the manner represented in the figure with the deep aspect of the external oblique tendon at or close to Poupart's ligament. In the figure four sutures appear, but frequently one or two suffice. Two interrupted sutures have been passed through the margins of the external abdominal ring, which is usually large and patulous in these cases.

Fig. 109.—The Author's procedure in Inguinal Herniotomy. This figure represents the deep sutures knotted. The lower sutures are those which emerge superficially at the level of Poupart's ligament. The aperture in the external oblique tendon has been closed and the external abdominal ring reduced to smaller dimensions. Note that the arcuate fibres which cross the external oblique tendon have not been divided.

the fingers. Handling of the tissues should be avoided in all wounds as much as possible.

Reparative Measures.—In the hernias of young children the necessity for reparative measures directed towards the inguinal canal is not as a rule imperative. In such cases the mere obliteration of the hernial sac and narrowing the external abdominal ring suffice amply to ensure permanence of cure. The sac may be exposed and dealt with either at the external ring or through a small button-hole aperture in the external oblique tendon opposite the internal ring as above described.

Treatment of the Sac in Congenital Hernias. The main difficulty attending inguinal

herniotomy in children is to be found in connection with the isolation and obliteration of the sac when the hernia is of the ordinary congenital type. In these cases the testis and the hernia have the same sac in common, viz. the tunica vaginalis. The method of dealing with this patent serous tube consists in dividing it circularly in the vicinity of the testis and then stripping it off the cord up to the internal ring, at which level it is ligatured and the isolated part cut away. The lower segment of the sac recedes within the scrotum; there is no necessity to close it by sutures, it

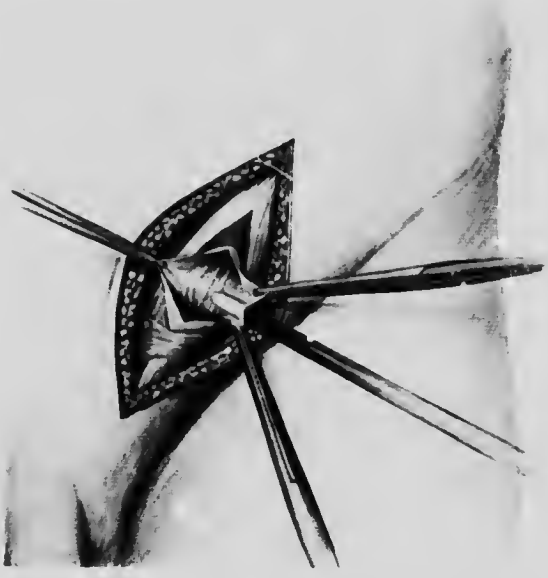

FIG. 110.—The Author's Procedure in Inguinal Herniotomy. This figure represents a safe method of dealing with the sac in cases of congenital hernia. The posterior wall of the sac with which the structures of the spermatic cord are closely related is being undermined preparatory to its division. A blunt dissector is employed for this purpose; it is gently insinuated beneath the serous membrane and at the same time the vas deferens and the vessels of the cord are safely pushed aside and protected from injury.

will take care of itself. The vas deferens is the structure especially to be avoided in dividing and stripping up the membrane. The method recommended for dealing with the sac in these cases is represented in Fig. 110.

KOCHER'S OPERATION.—The usual superficial incision is made in the inguinal region and, the hernial sac having been exposed at the external abdominal ring, is freed as far as possible up into the canal.

The sac, unopened, is seized at its fundus and invaginated along the canal into the abdominal cavity. The retaining forceps are made to press against the parietes at a point somewhat to the outer side of the internal abdominal ring.

The operator makes a small incision through the tissues overlying the forceps,

and these are made to project, pushing before them the parietal peritoneum and the invaginated sac.

The parietal peritoneum is incised, its margins secured by hæmostatic forceps. The sac is now pushed out and drawn forwards with some slight force, the forceps which retained it being at the same time withdrawn.

The sac is crushed beyond its point of exit, transfixed with a fine silk ligature which also engages the margins of the everted parietal peritoneum. The fundus of the sac is excised and the stump allowed to recede slightly; it is still held by the two ends of the occluding ligature, which traverse respectively the two margins of the external oblique tendon and are knotted together.

FIG. 110.—Large Scrotal Hernia. This figure has been prepared from a composite photograph of a series of dissections from a formalin hardened subject. The sac of the hernia contained a bulky mass of omentum, the outline of which is represented in the figure, and the greater part of the pelvic or sigmoid colon. The inguinal canal has been transformed into a large patulous ring.

A series of interrupted sutures is introduced after the manner of Lembert's sutures for the intestine for the purpose of narrowing and strengthening the inguinal canal. Each suture takes up a portion of the external oblique tendon and some of the fleshy fibres of the internal oblique. The external ring is narrowed and the operation completed by the closure of the superficial wound. This method of strengthening the inguinal canal is applicable especially to cases in which the muscles are lax and atonic.

COMMENTS.

Advantages claimed. - Professor Kocher claims for this operation that it inflicts very little damage upon the tissues and that it is more effective in reducing the hernial protrusion than any other because the peritoneum is drawn away from the internal ring and maintained stretched in an outward direction opposite to the normal course of the spermatic cord.

Objections. The method employed for narrowing the canal does not appear quite satisfactory. In passing the deep sutures the vessels of the cord may be wounded. The obliquity and valvular character of the canal is not restored with the same efficiency as in Bassini's operation or in other procedures based upon it.

Kocher's method of dealing with the hernial sac is not always easy. In children a satisfactory isolation of the sac may be extremely difficult or impossible as the membrane is so thin and delicate. It is out of the question in many congenital hernias.

In some hernias in adults the sac may be thick and very adherent rendering its isolation and invagination impossible or at least very dangerous.

Irreducible hernias with adherent contents are unsuited for Kocher's procedure.

HERNIOTOMY FOR LARGE INGUINAL HERNIAS OF LONG STANDING. The treatment of these hernias is sometimes attended by considerable difficulty, and the results have not been quite satisfactory following the usual operative procedures employed for the purpose of effecting a radical cure. With a large, bulky inguinal hernia it is not unusual to find adhesions within the sac and bulky masses of omentum. The inguinal canal will have undergone marked alteration; its normal obliquity is lost, and its direction has gradually altered until in a well-marked case it presents the form of a large patulous aperture directed from before backwards at the level of the external abdominal ring. When the sac has been emptied of its contents the size and extent of the ring can be accurately gauged by invaginating the scrotum with the index finger and pressing backwards above the pubic crest. To the inner side of the ring will be felt the rigid border of the rectus muscle in its sheath. Below the finger rests against the crest of the pubis and the inner extremity of Poupart's ligament. Above and to the outer side the ring is bounded by the conjoined tendon and the fibres of the internal oblique and transversalis muscles.

FIG. 112.—The Author's Method of Herniotomy for Large Scrotal Hernia. The superficial tissues have been divided and drawn aside in order to expose the external oblique tendon, the external abdominal ring, and the inner half of Poupart's ligament.

The chief operative difficulty attending the performance of a satisfactory operation in these cases is the closure of this patulous ring in such a way as to prevent a recurrence of the hernial protrusion. The following procedure is that which we usually employ in attempting to effect a radical cure of this type of hernia; the chief details are represented in the figures numbered 112—116.

Stages of the Operation. *The Superficial Incision and Exposure of the Sac of the Hernia.*—Assuming that the usual preparatory details have been carefully carried out, an incision is made from a point opposite the external abdominal ring upwards and outwards parallel to Poupart's ligament for a distance of 4 or 5 inches. Bleeding vessels are secured with forceps, and those which are of considerable size are either twisted or ligatured with fine catgut. Both here and throughout the succeeding stages of the operation hæmostasis should be as complete as possible. By a little careful dissection the aponeurosis of the external oblique muscle will be exposed and the margin of the inguinal aperture defined. The superficial tissues overlying the inner part of Poupart's ligament are pushed aside with a dry swab and this structure is well defined.

Division of the Aponeurosis of the External Oblique Muscle followed by Clearance and Ligature of the Sac.– Commencing at the highest part of the inguinal aperture the oblique aponeurosis is slit for a couple of inches, preferably in one of the thinned intervals which separate its tendinous bundles. The margins are seized with forceps and drawn aside, and at the same time the internal oblique muscle and the conjoined tendon are brought into view (Fig. 113). The sac is opened and its contents, if not already reduced,

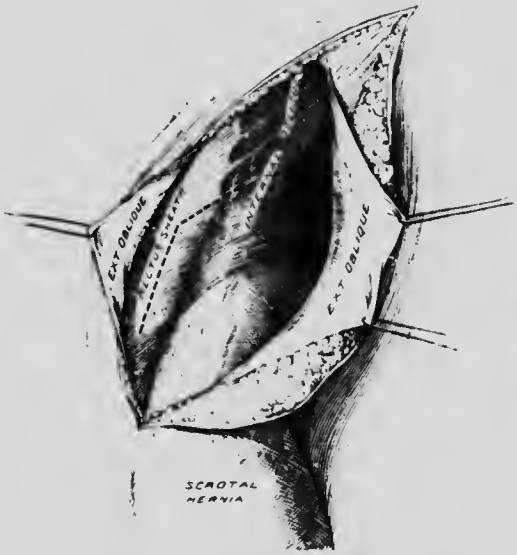

FIG. 113.—Herniotomy for Large Scrotal Hernia (Author's Operation). The tendon of the external oblique muscle has been split as in Bassini's procedure. The conjoined tendon and the lower border of the internal oblique muscle present a curved outline in relation to the inner and upper aspects of the sac, which presents a considerable bulk. The lines of incision in the rectus sheath and the internal oblique muscle are represented by a dark interrupted line. These incisions are intended to permit of relaxation of the inner and upper boundaries of the hernial aperture.

FIG. 114.—Herniotomy for Large Scrotal Hernia (Author's Operation). The large hernial aperture has been closed as fully as possible without interference with the spermatic cord. This latter has been displaced backwards and the internal oblique and transversalis muscles have been sutured to Poupart's ligament in front of it. This stage has been rendered possible by the relaxation afforded by the incision in the rectus sheath and the splitting of the internal oblique and transversalis muscles higher up. The outer margin of the wound thus created is connected by a few interrupted sutures with the rectus abdominis muscle in the manner represented in the figure.

are replaced within the abdomen. Any adhesions within the sac will require to be dealt with at this stage in the manner described above; masses of omentum, too, may have to be excised. The margins of the aperture in the sac are accurately defined, and the investing tissues, including the vessels of the cord, are separated from it by a process of dry sponging, no undue force being exerted lest vessels should be torn and give rise to troublesome bleeding. Even with care a certain amount of hæmorrhage usually takes place, and as this may subsequently occasion a hæmatoma appropriate measures should be taken to arrest it. When the sac has been cleared well up to the

ring and separated all round from its margins it is ligatured at its neck and the fundus cut away; the stump is then pushed back from the inguinal ring.

Closure of the Hernial Aperture.—The boundaries of this aperture have been noted above. The rectus muscle with its sheath on the inside and Poupart's ligament below are both rigid and unyielding and tend to prevent the satisfactory approximation of the margins of the ring. To overcome this difficulty two short incisions are made as represented in Fig. 113. One incision traverses the rectus sheath longitudinally

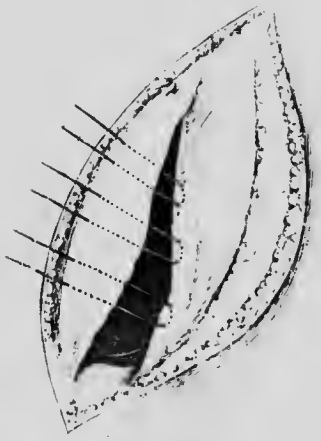

Fig. 115.—Herniotomy for Large Scrotal Hernia (Author's Operation). The margins of the external oblique tendon which are usually lax from overstretching are approximated in such a way as to cause them to overlap. The method by which this is accomplished is represented in the figure.

Fig. 116.—Herniotomy for Large Scrotal Hernia (Author's Operation). Overlapping and suture of the divided tendon of the external oblique muscle. The upper lamina of the tendon overlaps the lower. The upper or inner series of sutures are represented in the preceding figure. The external abdominal ring has been reduced in size as far as possible without causing an undesirable amount of pressure upon the cord.

a little to the inner side of the ring and the other extends from the upper extremity of the first incision in an outward direction parallel to the fibres of the internal oblique and transversalis muscles. These two incisions suffice to mobilise the ring margins above and along its inner side without in any way diminishing the strength of the abdominal wall. Interrupted sutures of chromicised catgut No. 2 are passed with a fully curved needle through the upper and lower margins of the ring and at the same time the vessels of the spermatic cord are pushed back, but just enough space is left at the side of the rectus muscle to allow them to pass without constriction (Fig. 114).

Suture of the Aponeurosis of the External Oblique Muscle.—In consequence of the stretching to which this tendon had been previously subjected it is possible not merely

to bring its margins into contact but to overlap them as is represented in Fig. 115. This overlapping is an important feature of the operation, as it helps to brace up the tissues and strengthen the abdominal wall in the inguinal region. Chromicised catgut is again employed, and the individual sutures, which are of the matrass pattern, are passed in the manner indicated in the figure. If it has been necessary to make a considerable gap in the rectus sheath in the displacement of tissues necessary to close the inguinal aperture, the outer border of the muscle may be drawn outwards and retained by sutures in such a way as to strengthen the abdominal wall at the lower part of the semilunar line (Fig. 114).

The capacity of the external abdominal ring is reduced as far as possible without constricting the vessels of the cord.

Closure of the Wound: Drainage.—As a precautionary measure we usually introduce a small perforated glass drainage tube through a puncture beneath the centre of the lower margin of the wound. It is removed after twenty-four hours. The wound margins are approximated by two or three deep sutures of silkworm gut passed at regular intervals, their points of entrance and exit corresponding to superficial scratches made with a sharp-pointed needle before incising the skin. The intervals between these sutures are closed with Michel's metallic clips or with a few additional silkworm gut sutures. The wound is finally wiped with tincture of iodine and a light dressing applied.

COMMENTS.

Post-operative Details.—It is advisable to recommend rest for a few weeks after this operation, as the sutured parts should not be subjected to strain until sufficient time has elapsed to enable them to unite and grow together.

In aggravated cases it may be a wise precaution to recommend the application of a truss with a light spring for a few months.

Complications.—The principal accidents or complications likely to occur are hæmorrhage and sepsis. The chief measures to be adopted towards the prevention of hæmorrhage have been alluded to in describing the stages of the operation; nevertheless some oozing is likely to take place, and to prevent any bad effects from this source we are in the habit of employing a drainage tube for the first twenty-four hours. Should it have been necessary to remove a large and very adherent sac from the scrotum it may be necessary to introduce the tube lower down than the point already indicated, viz., through a puncture in the scrotum.

Sepsis is a rare complication of herniotomy apart from that undertaken for strangulation. Its occurrence will be rendered manifest by the usual local and constitutional symptoms. The best course to adopt under such circumstances is to remove the sutures sufficiently to provide free exit for the discharges and to dress the wound with hot boracic compresses at regular intervals until the process of healing is well advanced. The risk of recurrence of the hernia is greatly increased by suppuration occurring in the wound.

STRANGULATED INGUINAL HERNIA.—Strangulation of a hernia implies that the passage of the intestinal contents is definitely impeded through the herniated part and that the circulation of blood in the constricted bowel is arrested either immediately on the supervention of strangulation or soon afterwards.

With persistence of the strangulation the bowel inevitably becomes gangrenous, and in the great majority of cases a fatal result will follow unless relief be afforded by surgical measures.

Without gangrene necessarily occurring the tissues of the strangulated intestine become swollen and œdematous, the infiltrated segment of the bowel is paralysed and the intestinal wall affords increasing facilities for the passage of micro-organisms and their toxins from the mucous towards the peritoneal aspect. Toxæmia, therefore, is a marked feature in the clinical picture of strangulated hernia, and even after relief of the strangulation and replacement of the bowel within the abdominal cavity symptoms of intestinal obstruction may persist owing to intestinal paresis.

The herniated bowel when exposed in the course of herniotomy may apparently still retain its vitality. Subsequent to reduction, however, thrombosis may take place in the greatly congested vessels with partial or complete loss of vitality of the herniated segment. It follows from those facts that no case of strangulation should be allowed to remain untreated, *i.e.* to persist without definite relief, a moment longer than can be avoided. This is particularly essential in aged and weakly individuals whose vital forces are exhausted and may become still further depressed with great rapidity by the toxæmia resulting from strangulation.

Taxis.—In performing taxis for strangulated inguinal hernia the pelvis is raised and the thighs are slightly flexed and separated from each other. The thumb and fingers of one hand grasp the hernia at its emergence from the inguinal canal and exert slight lateral compression. The other hand grasps the hernial protrusion, the fingers being well spread out.

The principle to follow in employing taxis for herniated bowel is to endeavour to empty the bowel of its contents in the first place, and secondly to replace it within the abdominal cavity.

The pressure exerted upon the hernia should be moderate and uniform, not forcible or abrupt. The fundus of the sac should not be pressed up towards the hernial aperture, but the entire effort should be directed towards that part of the gut in the vicinity of the ring. A slight emptying of the bowel will probably be followed by its reduction. On no account should taxis be continued if failure to relieve the strangulation follows after a reasonable attempt. Prolonged and repeated attempts at taxis do harm by damaging the herniated part and wasting valuable time.

In the event of taxis failing everything should be ready for prompt herniotomy. With the patient anæsthetised another attempt at taxis may be made if the strangulation is recent and the local conditions are deemed favourable.

HERNIOTOMY.—The skin over the area of operation and for a considerable distance all round is thoroughly cleansed, the pubis is shaved and tincture of iodine is applied over a wide area of integument. The penis is surrounded by a sterilised swab which is held in place by towel forceps.

A general anæsthetic is not always desirable. With a patient showing marked depression, weak heart action and bronchitic trouble, the operation had better be conducted under local anæsthesia. We have found a solution of novocain and adrenalin very suitable for this purpose. Spinal anæsthesia is favoured by some surgeons.

The skin incision is free and in a case of scrotal hernia it extends from a point

well to the outer side of the internal abdominal ring to the upper part of the scrotum. Hæmorrhage is arrested.

Exposure of the Sac and Examination of its Contents. The aponeurosis of the external oblique muscle is split freely as in Bassini's operation. A safe way of doing so is to make a small aperture in it over the neck of the hernia and pass a blunt dissector through this aperture and out at the external abdominal ring. The tendon is then split over the dissector.

The sac of the hernia is opened, and in doing so it is necessary to proceed with caution, as the contained intestine may be adherent and very tense. Small portions

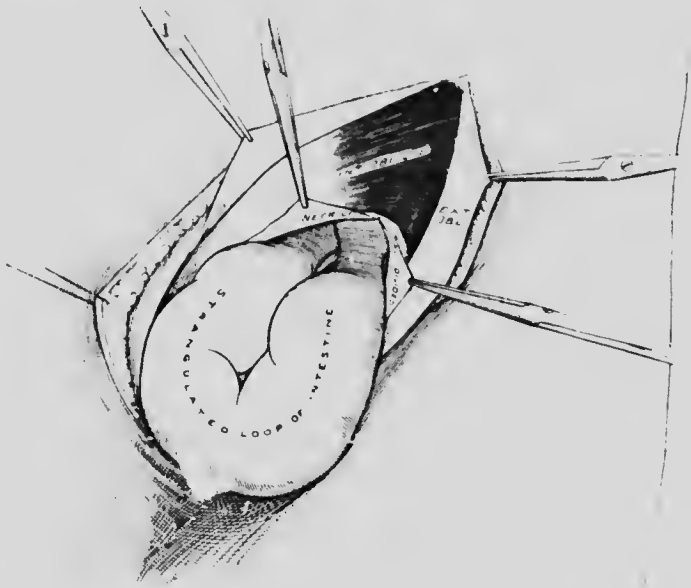

FIG. 117. Strangulated Inguinal Hernia. The seat of constriction, viz., the neck of the sac has been divided and the margins of the serous membrane held apart. The compressing effects of the ring margins upon the intestine are represented at the level of the internal abdominal ring.

of overlying tissue are seized and divided between forceps until the cavity of the sac is opened. This is usually recognised by the escaping fluid contents and its smooth lining.

The herniated parts are inspected and these, together with the entire cavity of the sac, are flushed with hot sterilised saline solution.

Relief of the Strangulation.—As the site of strangulation is usually in the neck of the sac this should be exposed by retracting the overlying oblique and transversalis muscles. When recognised the constricting ring of tissue may be divided from without inwards, the operator having a full and clear view of everything divided until the strangulation is relieved. An alternative is to divide the constriction from within outwards. This is done as follows:—The tip of the index finger as a guide is

introduced between the bowel and the margin of the constriction. Along the finger a blunt-pointed tenotome or Cooper's hernia knife is passed on the flat, and when in position its cutting edge is turned towards the constricting band and made to incise or nick it to a slight extent in an upward and inward direction. A blunt hernia director may be substituted for the finger as a guide and very gently insinuated beneath the constriction.

The margins of the divided sac are seized with clip forceps and drawn apart. The herniated bowel and the omentum, if present, are gently drawn down and exposed fully to view (Fig. 117).

Management of Strangulated Intestine.—The colour of the intestine is noted and particular attention is bestowed upon the sulcus which marks the site of constriction; its severity will be indicated by its depth and sharpness. An excessive degree of damage here might determine a subsequent perforation. Tearing of the intestine or its mesentery may have resulted from repeated and too vigorous taxis. Injured areas of the bowel had better be inverted by sutures of fine catgut so as to avoid subsequent adhesions.

Even though the colour of the bowel be very dark, douching for a few seconds with hot saline solution may result in definite circulatory improvement as shown by the returning red colour and distinct pulsation of the vessels at the mesenteric junction.

In replacing the gut within the abdominal cavity great gentleness must be employed. If much difficulty is encountered it would be better to enlarge the aperture more fully than subject the bowel to injurious compression by jamming it against the margins of the aperture.

Gangrene of the bowel, either obvious or impending, necessitates resection of the involved segment. This is dealt with below.

Management of Strangulated Omentum.—If the herniated omentum is small in amount and its condition very slightly altered, it may, after thorough washing with hot saline solution, be replaced within the abdomen.

If the omentum has undergone hypertrophy so as to be large and voluminous, and if it has acquired adhesions to the sac, its herniated part had better be removed. If the mass to be ligatured is not very big it is transfixed by a double thread of strong silk. The loop of the ligature is divided, its two ends are crossed, and the omental pedicle is ligatured in two sections. If the omentum is broad at the level selected for its division a long silk ligature is taken in a suture-carrier and passed through the omentum at intervals so as to leave a series of free loops. Each of these is cut, and before knotting the individual ligatures are crossed so that there is an interlocking of the entire chain. The omentum is divided about ½ inch beyond the ligatured part. The vessels in the omentum are large, and consequently haemorrhage of a very serious nature would probably take place in the event of one of the ligatures becoming released or slipping off. Great care is necessary, therefore, in resecting large masses of omentum. The ligatures are always applied on the proximal aspect of the constricted part. Gentleness is necessary in reducing the omentum after resection.

The Sac.—If possible the sac should be isolated and removed after having been transfixed and securely ligatured at its neck.

If the serous aperture is large it will be better to close it by a continuous suture. In some cases the closure may be effected very satisfactorily by running a purse-

string suture through the margins of the sac and drawing them together as the knot is tightened.

If the hernia is of the congenital variety the same precautions will be necessary in dealing with the sac as have been already described (see p. 209 and Fig. 110).

Radical Cure. It is desirable in all cases where the local conditions are favourable and the general state of the patient permits of it to perform a radical cure after strangulation has been relieved. The method of doing this has been fully described in Bassini's operation.

Adherent Omentum.—The omentum in strangulated inguinal hernia is often spread over the intestine and adherent to the sac. If the adhesions are recent they may be overcome by detaching the omentum from the sac by means of a dry muslin swab. Old fibrous adhesions are divided between clip forceps and the tissues ligatured subsequently. All adhesions should be divided quite up to the internal abdominal ring and the finger made to sweep all round inside the ring to make certain that everything is free in this locality.

Adherent Intestine.—The adhesions between the herniated intestine and the sac may be soft and fibrinous. If so they are readily overcome, and this is best accomplished by means of a swab which is made to rub the intestine off the sac. No traction whatever should be made upon the intestine, as it is in a friable condition and likely to tear.

Old fibrous adhesions are divided with scissors. If the intestine is closely applied to the sac the adhesions are divided at the expense of the sac, *i.e.*, portions of the sac may be left adhering to the intestine. If adhesions bind the limbs of a coil of intestine together so as to distort it they will need to be divided so as to allow the bowel to straighten out. Oozing of blood may be troublesome where adhesions have been divided, but firm gauze pressure for some moments usually suffices to arrest it. Any obvious spouting vessels are clipped or ligatured. If direct ligature is difficult a suture may be so applied as to invert a bleeding point. The actual cautery may occasionally prove of service.

As far as is possible, protruded intestine should be protected by swabs wrung out of hot saline solution.

Gliding Hernias.—Difficulty in reducing intestine in some cases is due to the fact that the herniated segment is not completely surrounded by peritoneum. This may occur in the case of the caecum on the right side, the iliac colon on the left side. The bowel glides from above into the sac, part of its periphery being clothed by serous membrane,—intrasaccular, part being devoid of serous covering,—extrasaccular.

In opening the sac of a strangulated hernia such a contingency should be borne in mind and the aperture made at a point where the sac moves over its contents and can be raised in the form of a fold.

The sac in such cases is divided below the adherent bowel, the cord being carefully avoided. The upper segment of the sac is then raised and, together with the bowel, gently detached from its surroundings up to the internal ring, a form of reduction *en masse*. Following reduction the sac is closed and the closure of the canal effected as before. The vessels which supply the bowel in such cases reach it on its deep or extraperitoneal aspect, and consequently they should be avoided in the mobilising process.

The Trendelenburg position may considerably assist the operative manipulations attending the reduction of these hernias.

In a very difficult case, and the patient's condition not good, one might have to remain contented with relief of the strangulation and not attempt reduction.

Treatment of Gangrenous Intestine—Evidences of Gangrene. In coming to a conclusion one judges the state of the bowel by its appearance, its feel, and its odour. In favour of gangrene would be loss of lustre, colour very dark or very green, the bowel no longer well filled out and resilient, but rather flaccid. On seizing it between the finger and thumb it feels sodden and boggy and its surface sticky. With gangrene there is always an offensive odour from the bowel contents and the products of putrefaction.

The following signs would be regarded in favour of the vitality of the bowel—surface shining, colour deep red or dark, lumen well filled out, pulsation in the vessels at the mesenteric junction, resiliency of the walls of the gut when grasped by the thumb and finger.

Improvement in the colour of the gut after relief of the strangulation on flushing it with hot sterile saline solution would be a favourable sign.

The great difficulty in deciding upon the vitality of strangulated intestine is met with in cases just on the borderland. Bowel apparently in a vital state may perforate after reduction, or may give rise to peritonitis in consequence of allowing micro-organisms and their toxins to pass through into the peritoneal cavity.

Paralysis of the strangulated segment after reduction may be followed by great abdominal distension from meteorism in the bowel above. The contents of this bowel, too, are highly toxic and its mucous membrane in a state of septic inflammation, which may lead to perforation.

Limited Gangrene.—The gangrene may be of limited extent in the form of one or more patches which involve part of the periphery of the gut or there may be a limited area of gangrene at the seat of constriction. It is often difficult to say if such patches are really necrotic or are capable of recovery.

Areas of small extent may be invaginated by introducing a few Lembert sutures and taking care in so doing not to narrow the lumen of the bowel to an excessive degree.

Excision is a preferable procedure in cases where the bowel wall is thick and rigid and the tissues very friable. The involved part is excised by a lozenge-shaped incision and the aperture closed in such a way as not to lead to a serious degree of constriction. During the procedure the gut previously emptied is retained in clamp forceps. The incision should always lie in healthy tissue.

Total Gangrene. The entire portion of the intestine in the sac may be in a state of gangrene.

In dealing with such cases there are many points which require careful consideration, such as (*a*) the age and general condition of the patient; (*b*) the duration of the strangulation; (*c*) the degree of toxæmia present, the state of the pulse being a good index; (*d*) the possibility of carrying out the necessary operative details efficiently and quickly; (*e*) the possibility of a long and tedious operation involving the resection of a large segment of intestine and mesentery or omentum, the division of adhesions, etc.; (*f*) coexisting lung troubles.

The following are the procedures applicable to such cases:—

Resection. The conditions for resection of the gangrenous intestine being deemed favourable, the loop is drawn down and isolated from its surroundings by means of a series of pads rinsed out of hot saline solution. The bowel is doubly clamped on each side of the gangrenous area in healthy tissue and the line of division of the mesentery is determined. The section has a wedge-shaped outline, but as a rule the apex of the wedge should not extend very deeply into the mesentery or involve the larger arterial arcades. The site of the apex of the mesenteric section having been determined, a loop of ligature is passed through surrounding any obvious vessel at

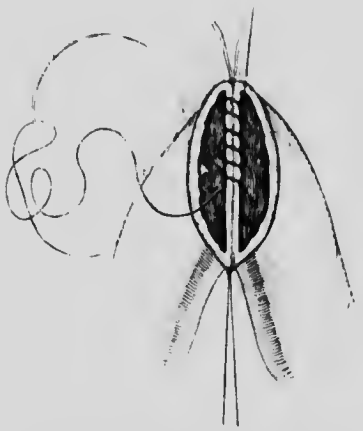

FIG. 118. End-to-end union of two segments of intestine after resection for strangulation. The two cylinders have been connected at their points of mesenteric attachment and at their convex margins. The first line of suture is being introduced. It penetrates all the coats of the bowel, and is represented as extending from the mesenteric attachments towards the convex margins of the two cylinders.

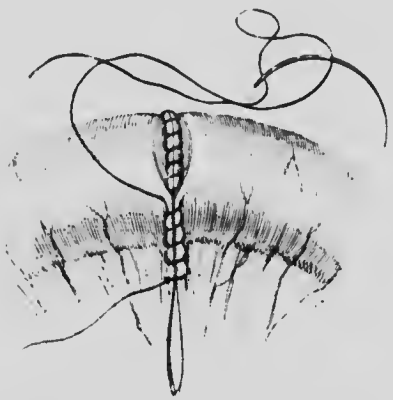

FIG. 119. End-to-end union of two segments of intestine. The inner or penetrating suture has been completed and the outer or sero-muscular suture has been commenced. It is represented in the figure as extending from the serous layer of the mesentery close to the attachment of the bowel. It invaginates the first or penetrating line of suture and brings serous surfaces everywhere into apposition.

this point and tied. The mesentery is then cut on the distal side of the ligature, and proceeding from this aperture the mesentery in each side of the V-shaped section is ligatured in segments until the bowel is reached.

The bowel is divided on the proximal and distal sides of the gangrenous segment and the line of section is slightly oblique, so that of the bowel left behind more is removed from its convex than from its mesenteric border.

The condition of the bowel on the proximal side of the obstruction has an important bearing on the extent of the resection as well as on the subsequent events. This part of the bowel will probably be found distended to a varying extent, its contents are of a liquid character, and owing to retention they will have undergone fermentative changes, with the result that they are very irritating, highly toxic, and the contained organisms very virulent. The mucous membrane becomes inflamed and may present areas of ulceration; the other coats of the bowel, too, may appear swollen and

oedematous. Taking these facts into account it will be seen that the tissues of such a swollen and distended segment of intestine are badly adapted to the exigencies of a resection and the immediate re-establishment of the continuity of the intestinal passage. The tissues are friable and are difficult to suture properly; the sutures, too, are liable to cut their way out, with resulting extravasation of the bowel contents. The surgeon must therefore plan the resection so as to remove a liberal area of this proximal bowel segment. Unless this is done the result will probably be disastrous, owing to failure in the healing process, leakage at the suture line, and fatal peritonitis.

End-to-end Junction. The two bowel segments are placed side by side, and a suture is passed so as to approximate their points of mesenteric attachment. Another suture connects the two ends at points most remote from the mesenteric attachment (Fig. 118). The first line of suture is a penetrating one. The cut margins of the opposing sides of the two intestinal cylinders are made to lie in close contact by exerting traction upon the two sutures already introduced, and a continuous suture is passed commencing at the mesenteric attachment and proceeding to the convex borders, and from this point back again to where the suture commenced. This suture brings the cut intestinal margins into contact and establishes the continuity of the intestinal tube. The individual stitches are close together and are drawn with a degree of tension.

A second seromuscular-serous line of suture is placed outside this. The bowel loop is raised and the first stitch is taken in the mesentery on its deep aspect, close to its point of attachment to the gut (Fig. 119). The succeeding sutures do not penetrate deeper than the submucous coat, they invert the first line of penetrating sutures, and having reached the convex border they are continued back to the mesentery where the two ends of the suture are knotted. If any part of the suture line appears insecure one or more complementary sutures may be introduced for reinforcing purposes.

Excessive inversion along the line of suture is to be avoided so as not to occasion a dangerous degree of stenosis of the passage.

As failure of union is most likely to occur at the site of attachment of the mesentery to the two segments of the divided bowel, it is usually advisable to introduce an additional inverting suture here.

The parts are well flushed with hot sterilised saline solution and replaced within the abdomen, no attempt at force being employed in doing so.

Lateral Implantation. When there is a striking disproportion between the two bowel segments, the upper being largely dilated, the lower powerfully contracted, end-to-end junction may be impossible or attended by great difficulty. Under such circumstances the end of the lower segment is implanted into the upper a short distance above the site of occlusion.

Steps of the Procedure.—The cut margin of the upper cylinder is traversed by a purse-string suture as represented in Fig. 188. The two ends of this ligature are knotted, and the ligatured part is then well invaginated by means of a second purse-string suture which does not penetrate the lumen of the gut (sero-muscular). Lembert sutures or matrass sutures answer equally well for the purpose of invagination.

The implantation is effected by bringing the lower segment into contact with the side of the upper about 2 inches from its blind extremity. Both pieces of intestine are held by forceps (Fig. 198). The first row of sutures is of the sero-serous type,

and is passed between the lower cylinder near its cut margins and the side of the upper cylinder near its convex border. When this suture has been carried from one lateral margin of the cut bowel to the other it is laid aside and the second line of suture is commenced. It is also a continuous suture, but penetrates all the tissues of each segment. Before introducing it the upper bowel segment is incised to an extent equal to that of the open end of the lower segment and about $\frac{1}{8}$ inch in front of the first or sero-serous suture line.

The penetrating suture is carried completely round, uniting the cut margins of the intestines and establishing the continuity of the tube. This suture is relied upon also to control hæmorrhage from the cut intestinal margins. The individual stitches therefore are placed close together and are drawn fairly tight.

The outer or sero-serous suture is again taken up and as it proceeds back to its starting point it invaginates the line of the penetrating suture.

A few complementary sutures may be introduced here and there if deemed necessary for the purpose of securing more accurate sero-serous junction. The two segments of the mesentery should be brought together as far as possible.

Artificial Anus. Resection of the gangrenous part may not be practicable owing to the serious condition of the patient which renders it impossible for any prolonged operative intervention to be undertaken, or there may not be facilities at hand for a resection operation. The nature of the procedure will depend upon the extent of the gangrenous area.

Small Segment of Bowel Gangrenous.—The gangrenous gut is incised *in situ*, and having done so the surgeon should see that the exit for the bowel contents from the upper segment is sufficiently free to permit of the contents escaping easily.

Gentle dilatation of the aperture with the finger may suffice, or it may be necessary to relieve the constriction to some extent without encroaching upon the peritoneal cavity and exposing it to the risk of infection.

A rubber tube introduced into the upper bowel segment and retained by a suture will facilitate drainage.

Following such an opening into the obstructed bowel there is usually a sudden rush of fæcal matter. Gas only may escape at first, as the muscular coat of the intestine requires some little time to regain its contractile power. The paresis may be persistent, and even though the strangulation be relieved and drainage established the distended bowel may fail to empty itself.

Extensive Segment of Intestine Gangrenous. The removal of the gangrenous tissues and general trimming of the parts is carried out without interfering with the seat of constriction. The presence of a large amount of putrefying tissue would be attended by serious septic complications if the wound were opened up too freely, and might lead to peritonitis. The opposing surfaces of the two intestinal segments are approximated by sutures and the bowel is connected by a few sutures with the skin.

As before, it should be ascertained that the means of exit for the intestinal contents are free. For this purpose relief of the constriction may be necessary, using the same precautions as indicated above.

Cases of this kind are grave in the extreme and recovery is rare. Even should the patient survive it would be necessary for a second operation to be undertaken for the restoration of the continuity of the intestine.

Local or spinal anæsthesia too should be preferred to general anæsthesia for patients in such a desperate condition.

Stercoral Phlegmon. In these cases gangrene of the herniated bowel is succeeded by cellulitis and suppuration in the surrounding tissues. The skin presents a dusky red colour and the subcutaneous tissues are greatly swollen and perhaps emphysematous.

The hernial sac is fully opened and the parts irrigated with warm antiseptic solution, such as tincture of iodine one drachm to the pint of hot water; cyllin 1 in 50; corrosive sublimate 1 in 4,000.

Sloughs are removed but vascular tissues are not incised. The entire wound is left open and treated with moist antiseptic compresses. An attempt may be made to introduce a rubber tube into the distended bowel.

Cases of this kind are extremely rare nowadays, as the facilities for early operation are present everywhere and the same reliance is not placed upon taxis as formerly.

FEMORAL HERNIOTOMY

The various operations in vogue for the radical cure of femoral hernia aim at obliteration of the sac and closure or narrowing of the femoral ring. The procedure which we usually employ in simple uncomplicated cases is carried out as follows:

Steps of the Operation. *Exposure and Ligature of the Sac.*—The skin incision is directed either vertically with its centre over the femoral ring or obliquely, below and parallel to Poupart's ligament. Superficial vessels are seized with clip forceps and all bleeding arrested.

The sac of the hernia is exposed. If its interior is occupied by intestine or omentum, but more especially if it is tense and distended, as happens when strangulation exists, it is often easy on exposing its exterior to enucleate it from its surroundings as if it were a solid tumour. The sac is opened and its contents are replaced within the abdominal cavity.

The sac having been thoroughly isolated is carefully detached at its neck from the margins of the ring, transfixed as high as possible, and ligatured. The fundus is then cut away and the ligatured stump pushed back from the femoral ring. A small aperture is made in the aponeurosis of the external oblique muscle about 1 inch above and to the outer side of the femoral ring; a blunt-pointed suture-carrier is passed through the puncture and made to emerge through the femoral ring, where it engages the two ends of the ligature and then draws them through (Fig. 120). The ligatured neck of the sac is thus drawn upwards and outwards and anchored securely against the abdominal parietes. The ends of the ligature are knotted over the aponeurosis of the external oblique, one end having first been passed through the margins of the aperture of exit (Fig. 121).

Closure of the Femoral Ring.—The femoral ring is closed by two or three sutures which pass through Poupart's ligament in front and the ligament of Cooper and the fascia over the pectineus muscle behind. The falciform edge of the saphenous opening is sutured to the fascia over the pectineus muscle. The superficial wound is closed (Fig. 121).

KOCHER'S OPERATION. The skin incision is parallel to the inner half of Poupart's ligament. The superficial tissues are divided and the sac exposed. The

sac is isolated and set free from its surroundings as high as possible, *i.e.*, within and above the femoral ring. The neck is transfixed, doubly ligatured, and the fundus cut away.

If it is not possible to effect a high ligature of the sac on account of its fixity in the region of the femoral ring Kocher invaginates it as in his operation for inguinal hernia and brings it through the abdominal parietes at the outer side of the external

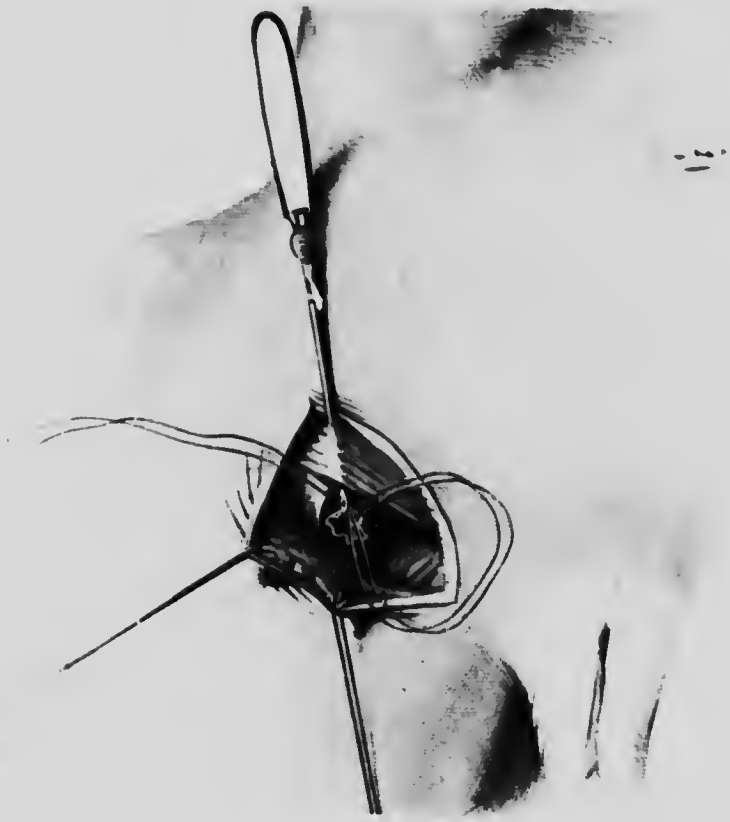

FIG. 120.—Femoral Herniotomy. The sac of the hernia has been ligatured and its fundus removed. The ligatured stump is about to be displaced upwards and outwards away from the vicinity of the femoral ring by means of a suture carrier which traverses the flat muscles as represented in the figure.

abdominal ring. It is drawn forwards with some force and sutured to the oblique muscle by a couple of penetrating sutures. The fundus is then cut away. The femoral ring is closed by one or two sutures passing through the pectineus fascia and Cooper's ligament behind and Poupart's ligament in front. The femoral vein must not be compressed by these deep sutures.

LOTHIESSEN'S OPERATION. The skin incision lies above and parallel to the inner half of Poupart's ligament, or it may be given a vertical direction, especially if

the operation is undertaken for the relief of strangulation. The superficial tissues are divided and the tendon of the external oblique muscle is split from one angle of the wound to the other.

The conjoined tendon of the internal oblique and transversalis muscles is drawn upwards and the sac of the hernia identified as it passes from above into the femoral canal. It is seized with forceps, drawn up into the wound and isolated. If large

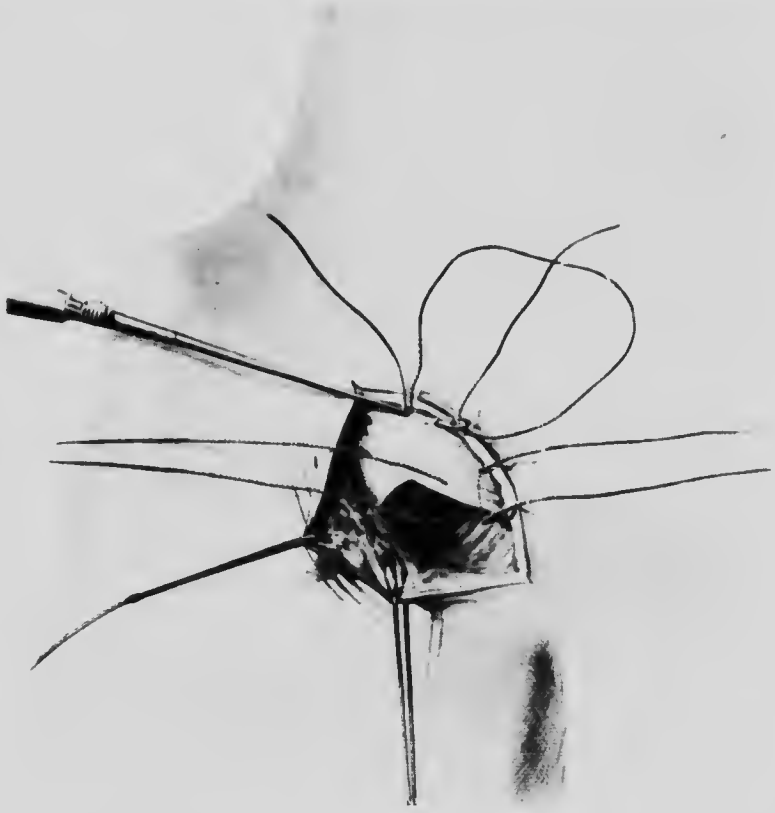

Fig. 121. Femoral Herniotomy. The free ends of the ligature which occludes the neck of the sac have been drawn through from the deep to the superficial aspect of the abdominal muscles. The mode of tying the stump here will be understood from the figure. Two sutures have been introduced into the tissues which bound the femoral ring and are represented *in situ* before being knotted.

and adherent it will be necessary to retract the lower margin of the wound and isolate the sac from below where it comes through the saphenous opening. It is then drawn up through the femoral ring and into the abdominal wound. A ligature is applied to the neck and the sac excised. Sutures of chromicised catgut are passed from before backwards with short fully curved needles through the conjoined tendon and Cooper's ligament; the first suture is close to Gimbernat's ligament, the next comes close to the femoral vein. Three or four sutures may be required.

The wound in the external oblique tendon is closed by a continuous catgut suture.

The saphenous opening may be narrowed by a few catgut sutures connecting its free margin with the pectineus fascia. A procedure very similar to this has been described and practised by Mr. T. E. Gordon, of Dublin.

BASSINI'S OPERATION.—This operation closely resembles that of Kocher, in which the isolation and high ligature of the sac are easily effected. Bassini having isolated the sac ligatures it at its neck and cuts away the fundus. The ligatured stump is pushed back. Two sets of deep sutures are now introduced. The first set, two or three in number, connects Poupart's ligament with the pectineus fascia and Cooper's ligament as in Kocher's operation. The second set, on a more superficial plane, connects the falciform edge of the saphenous opening with the pectineus fascia.

COMMENTS.

The Hernial Sac.—Separation of the sac from its connections with the tissues which constitute the boundaries of the femoral ring is very desirable so as to render the closure of this aperture efficient and easy of execution. Kocher's method of drawing the invaginated sac through the abdominal parietes and the method of drawing up the ligatured stump of the sac by sutures passed from above Poupart's ligament provide an additional precaution against recurrence, but the most important safeguard against recurrence of these hernias is the complete detachment of the sac at the femoral ring and displacement of the ligatured stump from the immediate vicinity of this aperture.

Irreducibility of the hernial contents and firm adhesion of the sac to its surroundings are a source of difficulty in Lothiessen's operation and those which approach the femoral ring from above. Under such circumstances the best course to adopt is to extend the superficial incision over the saphenous opening and open the sac from below, reduce its contents, and isolate it from its surroundings. It can then be drawn up into the abdominal wound.

The Femoral Ring.—In the ordinary method of closing the femoral ring the parts concerned in the suturing process should be clearly identified, viz., the pectineus muscle and the pubic bone behind, the lower border and deep aspect of Poupart's ligament in front. The most important of these sutures is that which passes near the crescentic edge of Gimbernat's ligament.

Operations which aim at closing the femoral ring from above have much to be said in their favour, as the closure which can be effected in this way is very secure and no depression is left on the abdominal aspect of the hernial aperture.

Ligatures and Sutures.—We usually employ linen thread for the buried sutures, as it possesses great strength and its sterilisation can be rendered quite certain. The method of preparation of this and other non-absorbable sutures has been described in the section dealing with "Surgical Technique."

Some surgeons prefer chromicised catgut to silk or linen thread in all cases. We prefer to reserve its use for cases operated on for strangulation owing to the uncertainty of being able to carry out the procedure under aseptic conditions. When the strangulation has been in existence for some hours it is probable that the colon bacillus and other organisms have made their way from within the bowel to the interior of the sac.

After Treatment. The importance of rest after femoral herniotomy should be emphasised as much as possible. No strain should be thrown upon the part

concerned in the operation for at least two or three months, and all exertion should be avoided for six months, if not more, in cases where the hernia has been large and of long standing with great relaxation of the tissues bounding the femoral canal.

HERNIOTOMY FOR STRANGULATED FEMORAL HERNIA. *Exposure of the Sac and Examination of its Contents.*- The skin incision is free and follows the long axis of the tumour, *i.e.*, oblique from without inwards and downwards. Some of the superficial branches of the femoral artery are divided in the subcutaneous tissue and are either twisted or ligatured with very fine catgut.

The sac is reached and isolated from its surroundings before being opened. This step is usually easy when the tumour is of moderate dimensions and can be effected with the finger supplemented by a blunt dissector. The tissues forming the sac are most readily defined by first exposing the inner part of Poupart's ligament and tracing the sac downwards from behind this.

The sac is opened, and while its margins are held aside by clip forceps its contents are washed with hot saline solution and thoroughly examined. A small segment of darkly injected intestine may be seen, or a knuckle of intestine may be hooded over and concealed by a mass of omentum.

Relief of the Strangulation.—In all cases the strangulating medium is sought at the inner side of the sac. The parts are fully retracted so as to expose the pubic spine and the inner extremity of Poupart's ligament and bring the seat of constriction as fully into view as possible. In some cases the tip of the index finger can be passed up between the sac and the free margin of Gimbernat's ligament. The hernia knife is introduced flat against the finger and when its blunt extremity has passed beyond the constriction it is turned so that its cutting edge is directed inwards and the sharp margin of the ligament divided to the necessary extent. More frequently the guiding index finger is passed up within the sac and gently insinuated between it and the bowel. The knife is then introduced and the constriction relieved from within the sac. The best way to divide Gimbernat's ligament is to turn the cutting edge of the hernia knife against the pubic bone and aim rather at nicking the ligament and scraping it off the bone than incising it upwards and inwards, as is generally recommended.

The parts are now drawn down and examined more fully, particular attention being directed to the groove in the bowel caused by the constriction. If the condition of the gut is satisfactory it is finally washed with saline solution and returned. The omentum if small in amount and little altered from the normal is returned also, but if large and bulky it is ligatured and excised with the precautions given under the heading of " Inguinal Herniotomy."

The sac is ligatured at its neck and the fundus cut away. The femoral ring is then closed and the operation completed as when a radical cure is being performed. Full details of this procedure have been already given.

COMMENTS.

The Coverings of the Sac of a femoral hernia vary very much in thickness in different cases. They may be stretched and thinned to a marked degree, or they may possess a considerable thickness owing to the local accumulation of fatty tissue. Spaces containing clear or bloodstained fluid are sometimes encountered in the tissues overlying the sac, and are apt to be confounded with the interior of the latter. A free superficial incision, followed by exposure of the aponeurotic tendon of the external oblique and

progressive division of the tissues below this between clip forceps, will usually render this stage of the operation devoid of great difficulty.

Division of the Constriction.—It matters not whether the constricting force is exerted by the margin of the saphenous opening, Gimbernat's ligament, or the neck of the sac, its division for anatomical reasons should be effected from the inner side.

If the ring is very narrow it may not be possible to insinuate the tip of the index finger as a guide when introducing the hernia knife. A grooved hernia director with a rounded blunt point is gently introduced beneath the constricting margin, every precaution being taken in so doing to avoid injury of the intestine within and above the ring.

An alternative method for relieving the constriction when good access is required consists in performing a hernia laparotomy. The aponeurosis of the external oblique muscle is incised parallel to Poupart's ligament, the internal oblique and transversalis muscles are retracted upwards, and Poupart's ligament cut through from before backwards by successive snips of scissors. The femoral ring is thus widely opened and abundance of room is provided for inspecting the hernial contents and returning them into the abdominal cavity. Should resection of a piece of the gut be necessary the room so provided will greatly facilitate the procedure and the subsequent replacement of the sutured parts. The divided portions of Poupart's ligament are subsequently sutured separately to the pectineus fascia and Cooper's ligament. The internal oblique (conjoined tendon) may also be sutured to the parts as in the operation of Lotheissen and Gordon.

If this procedure should be required in the male the spermatic cord must be exposed after division of the external oblique and gently retracted upwards and inwa

The Bladder may come into close relationship with or actually enter the femoral canal. When this occurs it is the extraperitoneal part of the viscus which usually enters the ring first. It is preceded by a mass of fatty tissue, and may escape recognition unless its existence is suspected.

The Obturator Artery, when following an abnormal course, may have its origin in the deep epigastric artery and proceed to the obturator canal downwards along the outer side of the femoral ring or inwards over the neck of the hernial sac and then downwards along its inner aspect. In the first case the artery will not give rise to any trouble, but in the latter it may be wounded in relieving the strangulation. Such an accident is best avoided by exposing the seat of constriction as fully as possible and treating it in the manner above described.

Division of the artery would necessitate a free opening of the ring and ligature of both ends of the divided vessel.

The Hernial Contents.—What has been stated above with reference to the method of dealing with intestine and omentum in strangulated inguinal hernia is equally applicable here; no further comments are necessary (see pp. 217 *et seq.*).

UMBILICAL HERNIOTOMY

General Considerations.—Umbilical hernias may require surgical treatment during infancy or after the individual has reached adult age.

The *congenital* and *infantile* varieties of rupture seldom demand operative measures if the intestine can be replaced within the abdomen and retained there by a suitably

adjusted pad or truss. If operative intervention should be deemed necessary it consists in opening the hernial sac, freshening the margins of the umbilical ring, and closing the aperture by a few deep sutures.

The *acquired* variety of umbilical hernia is most common in women at or near middle age with flabby and pendulous abdominal walls loaded with fat. Such individuals have usually borne children, and very often suffer from bronchitic trouble, which aggravates these hernias and influences unfavourably the prospect of cure by operative measures.

The contents of such acquired umbilical hernias, which may assume large proportions, usually consist of omentum and large intestine, the transverse colon being the part most frequently implicated. They may contain coils of small intestine and other abdominal viscera. The hernial sac is usually loculated, and the masses of omentum which fill the loculi are invariably fixed by adhesions. For this reason

FIG. 122.—W. J. Mayo's Operation for Umbilical Hernia. An elliptical incision has been made surrounding the sac of the hernia and isolating it on all sides up to the margins of the umbilical ring. The sac has been partially opened in front of the ring and the mass of omentum in its interior exposed.

the liberation of the omentum by opening the sac and evacuating each of these pockets is a tedious process and attended by difficulty. These acquired umbilical hernias in women are a great source of danger owing to the readiness with which they may become incarcerated, inflamed, or strangulated. Treatment by operative measures is therefore strongly indicated at an early period of their development before any of these conditions, but especially strangulation, has supervened, otherwise operation may have to be undertaken under very unfavourable circumstances and with an unpromising outlook, not alone with regard to the cure of the hernia but to the life of the patient.

The difficulty in effecting a radical cure in cases of old-standing umbilical hernia is always considerable and may be insuperable; it depends to a large extent upon the quality of the tissues surrounding the hernial aperture. These are fibrous and inelastic, and they do not possess an abundant blood supply. The margins of the widely separated recti muscles are very thin and atrophic.

Hitherto the method of performing a radical cure consisted in making a median vertical incision, closing the sac by a single ligature if small, by a continuous suture

if of a larger size, and bringing the tissues of the parietes together by deep sutures arranged in strata. This form of operation was not very successful, being frequently followed by recurrence. The best operative procedure undoubtedly is that devised by Dr. William J. Mayo, of Rochester, Minnesota, U.S.A., in which the hernia is reached by a transverse incision and the aperture closed by means of two flaps so arranged that one overlaps the other.

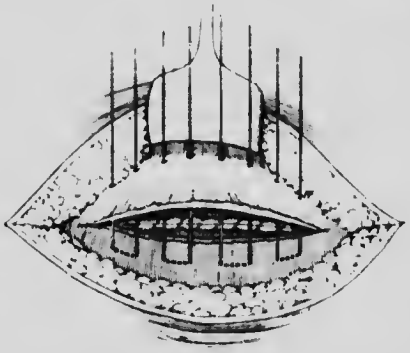

Fig. 123. W. J. Mayo's Procedure for closing the Umbilical Ring. The serous margins of the neck of the sac have been connected by suture. The four mattress sutures represented in the figure have been introduced in such a way as to enable the lower tendinous lamina bounding the ring to be drawn up behind the upper

MAYO'S HERNIOTOMY. The disinfection of the patient's skin demands great care. In the case of large umbilical hernias it is often moist and red owing to the development of intertrigo between the lower part of the hernial protrusion and the abdominal parietes. Bronchitic trouble should be assuaged as much as possible and chloroform substituted for ether as a general anæsthetic.

The skin incisions circumscribe an elliptical area of integument over the most prominent part of the hernia; they are made in the transverse direction and exceed the peripheral limit of the protrusion on each side.

The superficial tissues are divided down to the level of the hernial aperture, and the rectus sheath is exposed for a couple of inches on each side of this.

The hernial tumour thus isolated circumferentially is drawn forwards, an incision is made into the sac transversely just in front of the ring, and the serous margins are secured by clip forceps (Fig. 122).

The sac is freely opened and its contents reduced. If the omentum is voluminous and adherent it had better be ligatured in sections in the manner already described and the redundant part removed *en masse* with the sac and the elliptical area of skin.

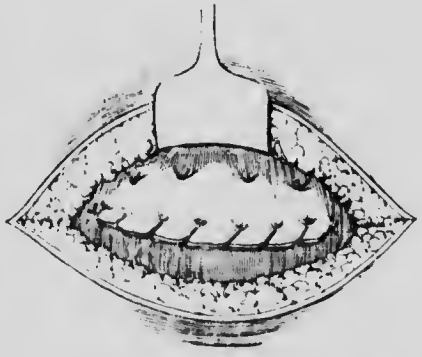

Fig. 124. W. J. Mayo's Procedure for closing the Umbilical Ring completed. The four interrupted mattress sutures represented in the preceding figure have been knotted and the upper lamina of the tendinous ring has been connected with the superficial aspect of the lower by a continuous line of suture

An incision is made transversely on each side from the margin of the ring through the aponeurotic tissues including the peritoneum, but not through the recti muscles, for a couple of inches. This deep aponeurotic wound is now closed in such a way that its margins overlap. The peritoneal margins are first approximated if possible by a continuous suture of chromicised catgut. If they do not come easily together their approximation will be facilitated by drawing upon the aponeurotic sutures. These are of the mattress type. Each suture pierces the upper flap from

its superficial to its deep aspect about 2 inches above its free margin, it then traverses the lower flap close to its free margin from its superficial to its deep aspect, returns to the surface and finally traverses the upper flap again, emerging on its superficial aspect near the point of entrance (Fig. 123). The remaining aponeurotic sutures are passed in a similar manner. When these are drawn tight and knotted the lower flap is drawn up into the recess between the upper flap and the parietal peritoneum.

The free margin of the upper or overlapping flap is attached to the aponeurotic sheaths of the recti muscles by a continuous catgut suture as represented in Fig. 124. The superficial wound is closed without drainage.

COMMENTS.

Overlapping of Aponeurotic Flaps. This may be done from side to side instead of from above downwards, depending upon which method appears the easier.

Silver Filigree.—With a view to strengthen the cicatrix in the umbilical region it has been proposed by some surgeons, notably Bartlett in America and McGavin in Great Britain, to introduce a framework of fine silver wire between the peritoneum and the recti muscles with their aponeurotic investments. Under aseptic conditions silver wire is devoid of irritating properties and the wound heals readily. Granulation tissue grows between the meshes of the filigree and the subsequent fibrous tissue formation tends to consolidate the parts. While we consider the introduction of silver filigree advantageous in certain cases of umbilical hernia we have seldom found its employment necessary. Our experience of it has been for the most part in connection with post-incisional ventral hernias.

Strangulation. The necessity for early intervention here cannot be insisted upon too strongly. Owing to the fact that this condition is attended by a high mortality; consequently, if success is to be achieved, herniotomy must be undertaken before the local effects of strangulation are pronounced, and before the general effects as indicated by the intensity of the toxæmia have lowered the resisting forces of the patient.

In all cases the hernial ring is first exposed by a gradual dissection through the superficial tissues. The tendinous tissue bounding the ring is divided either in the middle line or at one side. This may be done by opening the sac, introducing the finger and cutting either upwards or downwards from within, or by dividing the tissues progressively from the exterior to the seat of constriction; the latter is usually the better way. The constriction will be found either in the ring itself or in the neck of the sac.

The arrangement of parts within the sac in large umbilical hernias is often embarrassing. A small loop of deeply congested intestine may be found enveloped by a voluminous and adherent mass of omentum. Instead of wasting time in separating extensive adhesions the omentum should be exposed at its point of entrance into the sac, ligatured and divided. The adherent part is removed with the sac, the contained intestine having first been liberated and replaced within the abdomen.

For further observations concerning the methods of dealing with gangrenous intestine, adhesions of intestine, etc., the reader is referred to p. 217 *et seq.*

GASTRO-INTESTINAL OPERATIONS

PRELIMINARY CONSIDERATIONS.

Preparation of the Patient. It is eminently desirable that a patient about to undergo an abdominal operation should receive careful preparatory treatment for a period of some days; especially is this so when the mouth is in a dirty condition

FIG. 125.—Method of Suturing the Abdominal Wound. The parietal peritoneum and the posterior layer of the rectus sheath are being brought together by a continuous suture of chromicised catgut which commences at the upper angle of the wound. The surgeon, holding the thread with his left hand, draws it taut, and by so doing the peritoneal margins are raised and approximated, thereby facilitating the passage of the needle.

and the teeth carious. The latter should be attended to by a dentist, and a mouth wash of sanitas or peroxide of hydrogen used many times a day.

If there be evidence of gastric stasis the stomach should be washed out thoroughly twice a day for several days with large quantities of fluid, of which the amount

is more important than its chemical constitution; sterilised saline solution answers well for the purpose. This measure greatly enhances the prospects of success in cases where the discharge from an ulcer or malignant growth has rendered the gastric contents foul and infective.

Fig. 126. Method of Suturing the Abdominal Wound. This figure represents a later stage of the suturing process. The continuous suture connecting the serous and aponeurotic layers behind the split rectus muscle having reached the lower angle of the wound is knotted, and the needle is then passed through the rectus and the anterior layer of its sheath. Three interrupted sutures of silkworm gut are next passed at equal distances apart through the superficial tissues and the rectus muscle on each side, but not through the peritoneum. These sutures, having been passed, are held by hæmostatic forceps and the surgeon resuming with the needle at the lower angle of the wound, proceeds to connect the margins of the anterior layer of the rectus sheath from below upwards, and having reached the upper angle of the wound the suture is knotted with the free end left there for the purpose.

Lavage of the stomach immediately before the administration of the anæsthetic is an essential procedure when the operation is for the relief of intestinal obstruction.

In routine cases the patient is confined to bed for at least twenty-four hours before operation. A suitable purgative is given two nights before and is followed by

a saline aperient on the following morning. Finally, either the night before or the morning of the operation, a large soap-and-water enema is administered.

The method which we usually employ for the cleansing and disinfection of the skin of the operation area has been fully described in the introductory section (see "Surgical Technique," p. 18). Two hours before the scheduled time the sterilised dressing is removed from the abdomen and a wide cutaneous area is painted over with tincture of iodine, special attention being paid to the umbilicus. Another dry sterilised dressing is then applied. When the patient arrives in the theatre a second application of iodine renders the skin surgically clean. Harrington's solution may be used with advantage as the final antiseptic if the patient's skin is rough or harsh and not unduly sensitive (p. 5).

Attitude during Intra-abdominal Procedures. In operations on the gastro-intestinal system the ordinary dorsal attitude is the one usually adopted. But if exposure of pelvic organs is necessary the Trendelenburg or head-down position offers many advantages. The intestines recede from the pelvis towards the diaphragm leaving a clear field for inspection and manipulation. Symptoms of dyspnœa should be regarded as a contraindication to this position owing to the engorgement of the head and neck and the impediment to diaphragmatic respiration that this attitude entails.

Strict observation should be exercised while the patient is being slowly restored to the horizontal position, seeing that in individuals with weak circulation there is some risk of syncope following the change in position, especially if it be carried out too rapidly.

Abdominal Incisions. A well-planned abdominal incision must fulfil two conditions. In the first place it must not injure the nerves of the abdominal wall, as these are largely motor in function and their division tends to produce muscular atrophy and consequent post-operative hernia. Secondly, it must divide muscles and aponeuroses in the direction of and not at right angles to their constituent bundles. In some cases of emergency these principles are necessarily neglected, more particularly when it is all-important that free access should be obtained, so that the intra-abdominal procedures may be carried out quickly and effectively.

A median incision gives good access to the abdominal cavity. When the linea alba is divided above the umbilicus the fascia transversalis presents, and it is so intimately associated with the peritoneum that both membranes are divided together. A small fold of the presenting tissue is picked up and divided between two forceps, the incision being just large enough to admit the forefinger of the left hand. Then with a pair of blunt-pointed scissors the peritoneum is cut to the required extent, the finger inside protecting the viscera. If it be necessary to enlarge the incision beyond the umbilicus the line of section is carried around the latter, not through it.

Below the umbilicus the linea alba is reduced to an intermuscular septum so that a median incision exposes the edge of one or other muscle.

A paramedian incision is made at one side of the median line down to and through the anterior layer of the rectus sheath. The muscle is then split with the handle of the knife and, the posterior layer of the sheath being exposed, the incision is continued through it and the peritoneum opened as before.

It is advisable to split the rectus near the median line rather than further outward so that a smaller proportion of its fibres may be deprived of their nerve supply.

In Lennander's modification of this incision the anterior layer of the sheath is divided as before, but the muscle instead of being split is displaced bodily outwards so as to expose the posterior layer of the sheath.

An incision in the semilunar line divides the aponeuroses of the flat muscles of the abdomen at right angles to their fibres and also necessarily severs the nerves supplying a corresponding portion of the rectus. On this account it is contraindicated when a less destructive incision can be employed.

An oblique incision is especially serviceable in the lower part of the abdomen. The skin is divided in the direction of the fibres of the external oblique. The incision is carried through the latter, and the internal oblique and transversalis are split by blunt dissection in the direction of their fibres. Finally the section is carried through the transversalis fascia and the peritoneum. This incision is frequently employed in operations upon the vermiform appendix and will be described more fully in the section dealing with these. Other forms of abdominal incision are described in subsequent sections and need not be further alluded to here.

Closure of Abdominal Wound. Careful suturing of the layers of the abdominal wall is the surest guarantee against post-operative hernia. The wound is closed as follows:—The peritoneal margins are approximated by means of a continuous suture of medium catgut, which includes the posterior wall of the rectus sheath if the incision has been made through the latter (Fig. 125). This suture is securely tied and the needle end left long. Three or four silkworm gut sutures, according to the length of the wound, are now placed at equal distances apart, their exact sites being usually indicated by faint scratches in the skin made before it is divided (Fig. 126). Each suture includes the skin and rectus muscle, entering and issuing from the skin about $\frac{3}{4}$ inch from the respective edges of the wound. The loose ends are retained on each side by clip forceps. The peritoneal catgut suture is next continued in the reverse direction back to its starting point through the anterior layer of the rectus sheath, whereupon its two ends are knotted and cut. The silkworm gut sutures are tied; they bring the edges of the skin into apposition and act as retention sutures. Accurate closure of the wound is completed by interrupted silkworm gut sutures or by Michel's clips.

When Lennander's modification of the usual incision through the rectus muscle has been adopted it is unnecessary to include any of the muscular fibres in the suture of its sheath. The muscle is simply allowed to fall naturally into position and a separate suture is used to close the aperture in the sheath in front.

A fully curved needle, with sharp edges close to its point only, is the easiest one to use in introducing the continuous sutures. The needle should be held with the thumb in its concavity, as the surgeon can thus maintain more control over it and exert the necessary force (Fig. 125).

Intra-abdominal Technique.—In the majority of cases the operator has a fairly good idea when he opens the abdomen of what viscus is involved and what type of lesion he will discover. It is of the utmost importance, therefore, to be instinctively familiar with the situation and mutual relationships of the intra-abdominal organs as well as with the easiest and most rapid method of reaching them. Any unnecessary handling of the intestines adds considerable risk to the operation.

In many instances, owing either to faulty anæsthesia or to distension of the intestine, coils of the latter tend to escape from the abdominal cavity. If the patient strains

the edges of the wound should be pressed together or a large swab held firmly against the opening until the muscles become relaxed.

In some obstructive conditions it may be impossible to proceed with the necessary manipulations without emptying the prolapsed gut of its gaseous or fluid contents. Having localised the diseased organ, it should be carefully isolated from the rest of the abdominal contents either by withdrawing it from the cavity of the abdomen or by surrounding it by carefully placed swabs so that there may be no risk of the parts in its immediate vicinity becoming infected.

In any case in which pus is present or when it is necessary to open the cavity of the stomach or the lumen of the intestine it is wise to have the abdominal wound protected from infection by folded layers of gauze or sheets of 'tetra' tissue. These

FIG. 127. Lembert's Peritoneal Suture. The wound in the intestine having been closed by a continuous suture traversing all the tissues of the bowel, the adjoining serous surfaces are approximated by a series of interrupted sutures. Each suture picks up a fold of the serous and muscular tissues of the bowel, but does not enter the lumen. The first suture line is thus invaginated.

FIG. 128. Dupuytren's Continuous Peritoneal Suture. The principle adopted in passing this suture resembles that of Lembert, the only difference being that the sutures connecting the peritoneal surfaces run continuously.

are applied to the margins of the wound and are retained in position by suitable forceps; those employed by Moynihan are very suitable for this purpose.

A piece of gauze wrapped round the fingers prevents the intestinal coils from slipping from the grasp and often facilitates the work of the surgeon and his assistant.

A pair of ordinary tongue forceps with the blades protected with rubber serves to hold a loop of gut in position if necessary.

No swabs should be introduced into the abdominal cavity without having an attached tape hanging outside the wound and retained there by forceps, for it is extremely easy to leave an unguarded swab behind when closing the abdomen. For this reason all instruments and wipes should be counted beforehand and the number checked before the abdominal wound is closed.

Peritoneal Cleansing. This subject will be discussed more fully in connection with peritonitis. It is only necessary here to state that the less mechanical cleansing performed the better.

Gentle sponging up of any infective matter is usually all that is indicated. Rubbing with gauze injures the peritoneum and renders it unable to cope with infection. An intact peritoneum is the strongest barrier against bacteria and the products of their activity.

Intraperitoneal lavage is sometimes useful, and gentle flushing with normal saline solution is indicated in perforations of the stomach and duodenum, the contents of which, on entering the peritoneal cavity, set up a chemical irritation. When, however, definite pus is present or when the highly septic contents of the ileum or colon have escaped, lavage tends to disseminate the noxious fluids and aggravate the mischief.

Drainage of the Peritoneal Cavity. In routine cases without peritonitis of a diffuse or localised type drainage is unnecessary and may be actually harmful, inasmuch as it prevents the speedy healing of the abdominal wound, which is our surest guarantee against post-operative hernia. Moreover, if pus be not present when the drain is inserted it is likely to be there in a short time, the supposed precaution determining its advent. The surgeon who drains after an intestinal anastomosis, for instance, tacitly acknowledges a lack of faith in his own technique.

Even when a small amount of pus has been found localised in the peritoneal cavity

Fig. 129. Halsted's Mattress Suture of the Peritoneum. This suture may be described as a double Lembert suture. A loop is left on one side of the wound and the two free ends of the suture lie on the other; these latter are drawn tight and knotted, as represented in the figure.

Fig. 130. Cushing's Peritoneal Suture. This suture is passed continuously from one extremity of the wound to the other, and it differs from that of Lembert in the fact that the needle takes up a fold on each side parallel to the long axis of the wound and not at right angles to this.

it is often perfectly safe to close the wound completely, having of course satisfied one's self that the focus of infection has been adequately dealt with and the infective material present carefully swabbed away. The peritoneum is much more resistent than was believed a few years ago. However, when pus is present in large quantities and cannot be removed adequately, or when the primary focus of infection has not been satisfactorily dealt with, drainage becomes essential.

Of the various types of drains devised a large bore rubber tube is the most satisfactory and is everywhere obtainable. This is split longitudinally and a thin wick of gauze laid inside and allowed to project from each end. It is important not to plug the tube tightly with gauze and so defeat the object for which it is intended. When the wick becomes sodden its function ceases and it should then be replaced. Gauze in contact with the tissues rapidly becomes adherent and difficult to withdraw, hence the value of the protecting tube.

The placing of this drainage tube varies with the lesion and is not the least important part of the operation. The right iliac fossa, the kidney pouch on each side and the pelvis are the parts from which it is most often necessary to provide free drainage. Incisions above the iliac crests are necessary when the renal pouches contain pus and above the symphysis pubis when the pelvis requires drainage. Stiff rubber tubes

have occasionally led to serious complications by pressing injuriously upon and eroding important vessels; they may in like manner injure the intestine and lead to a fæcal fistula.

Intestinal Sutures. The principles regulating the establishment of intestinal anastomoses and the closure of wounds in the gut are easily grasped and are of great importance. In the first place the cut edges must be inverted so that the serous surface of one side comes into intimate contact with that of the other, and secondly no suture at the completion of the operation should at the same time communicate with the lumen of the gut and the patient's serous surface. If this latter principle be neglected there is danger of infection along the suture lines from the lumen into the peritoneal cavity.

A simple method embodying these principles is Lembert's or the modifications thereof introduced by Dupuytren, Halsted and Cushing.

Lembert's Suture.—This suture is carried as follows: With a dissecting forceps a fold of the intestinal wall is raised and the needle is passed about ¼ inch from the edge of the wound in the gut. The needle is then carried in a direction at right angles to the long axis of the wound, picking up all the coats except the mucosa and emerging just clear of the cut edge. It is then brought across the wound, where it again traverses the tissues of the bowel in exactly similar fashion but in the reverse direction, entering a short distance from the edge of the wound and emerging about ¼ inch from it. The tying of this suture inverts the edges of the wound and brings broad surfaces of the peritoneum on each side into contact. Similar sutures are placed about ⅛ inch from each other until the wound is securely closed (Fig. 127). It is simply a matter of practice to take up sufficient of the wall of the gut in each stitch. It is important to include the submucosa in the suture, since by doing so the thread is much less likely to cut out (Halsted).

Dupuytren's Suture.—This is simply a continuous Lembert's suture. A single Lembert's suture is introduced and tied and the end on which the needle is threaded left long and the suturing process continued until the whole wound is closed. This continuous Lembert's suture is the one adopted for all intestinal anastomoses. The special methods of applying it are described in detail under "Gastro-enterostomy and Enterectomy." It is represented in Fig. 128.

Halsted's Suture is in reality a Lembert's suture introduced in the mattress fashion (Fig. 129).

Cushing's Method consists in passing the needle through the intestinal tissues parallel to and not in a direction at right angles to the wound (Fig. 130).

In closing wounds in the gut the interrupted suture of Lembert or the continuous suture of Dupuytren is usually sufficient. When, however, any anastomosis between distinct intestinal segments is necessary, for additional security the free ends of the intestine are first joined by a continuous suture passing through all the coats of both segments, this line of juncture being protected by a continuous non-penetrating suture on the principle of Lembert.

The most satisfactory material for effecting anastomoses in the gastro-intestinal tract is Pagenstecher's celluloid thread or linen thread. The suture is introduced with a round-bodied needle, which may be either straight or curved. An ordinary sewing needle is excellent. Needles with cutting edges are contraindicated in intestinal work.

OPERATIONS UPON THE STOMACH

GASTROTOMY.

This procedure affords access to the interior of the stomach and is mainly indicated for the removal of a foreign body from the stomach itself or from the lower portion of the œsophagus, for the dilatation of a low œsophageal stricture or one at the region of the pylorus, and for the treatment of intragastric hæmorrhage the result of ulceration or some other condition.

If the condition demanding operation permit, thorough gastric lavage should be carried out for some days previously, the last washing being performed immediately before the administration of the anæsthetic, for the reasons stated in the introductory paragraphs.

The Abdominal Incision, which measures at least 3 inches in length, is made between the ensiform cartilage and the umbilicus and slightly to the left of the middle line. The sheath of the rectus muscle is incised and the inner border of the muscle is defined and displaced outwards. The posterior layer of the rectus sheath is then divided and the peritoneal cavity opened in the usual manner.

Examination and Opening of the Stomach. When the stomach is exposed its outer surface must be carefully examined for any external evidences of disease. Some localised thickening or slight variation in the overlying serous coat may indicate the position of an ulcer.

The stomach is usually opened by a vertical incision through its anterior wall midway between the curvatures, but when the operation is exploratory in purpose a transverse incision affords better exposure of the mucous membrane. The site of the opening is first of all carefully surrounded by swabs wrung out of hot sterilised saline solution to prevent soiling of the peritoneum.

Intragastric Procedures. 1. *Digital Exploration*. When the finger is introduced into the gastric cavity it is usually easy to explore the whole interior of the stomach from cardia to pylorus or to extract any foreign body that may be present. It is important in the latter case to have the opening in the stomach wall of adequate size: if it be too small delay and injury result. After a digital exploration the glove protecting the examining hand should be removed and a fresh one put on so as to prevent the possible contamination of the peritoneum.

2. *Visual Exploration* is specially serviceable when searching for the source of bleeding. An ordinary rectal speculum of small size may be introduced through the opening and inspection of the mucous membrane proceeded with, provided, of course, that there is a good light. An electric head lamp may be of great service.

A more effective method of investigation may be carried out in the following manner. A hole is made in the gastro-colic omentum just below the greater curvature of the stomach of sufficient extent to admit at least two fingers into the lesser sac of the peritoneum. The posterior wall of the stomach is now invaginated through the anterior gastric aperture. By this means and by successive invaginations practically the whole of its mucous surface can be carefully inspected.

3. *The Arrest of Gastric Hæmorrhage.*—If the bleeding be found to proceed from an ulcer a gastro-jejunostomy immediately performed without interfering with the ulcer itself will in the majority of cases cure the hæmatemesis by emptying the stomach and allowing it to contract. In other cases, however, it is wise to enfold the site of the ulcer by means of a few Lembert's sutures introduced in the usual manner through the healthy and unindurated serous and muscular coats of the stomach.

As a rule it is only when a clear history of gastric ulcer can be obtained that the operation should be undertaken for hæmatemesis. In some cases no ulcer can be demonstrated and when the mucous membrane is inspected by the invagination method a small erosion from which blood oozes is alone found. This should be surrounded by a suture of fine chromic catgut inserted from the mucous aspect with a curved needle. A few Lembert's sutures introduced at a corresponding site on the peritoneal aspect give additional security.

In other cases a definite vessel can be discovered and secured by a ligature introduced beneath the bleeding point. If this fail to arrest the hæmorrhage direct ligature of the particular gastric vessel which seems to be implicated has been carried out: thus the coronary artery may be secured close to its origin through an aperture in the lesser omentum; the gastro-epiploic vessels are easily found and tied beneath the greater curvature of the stomach; the pyloric and gastro-duodenal arteries are found by opening through the lesser omentum to the left of the pylorus, but in the presence of adhesions and extensive gastric induration the search for these vessels may be attended by great difficulty.

4. *The Removal of a Foreign Body.*—An adequate opening into the stomach and the careful withdrawal of the contained body by blunt-pointed forceps are the essential points in this procedure. Especially are these important when there are any sharp angles or hooks attached to the body to be removed—a swallowed tooth-plate, for example.

If the foreign substance lie in the lower end of the œsophagus the gastric incision should be made as high up as possible. Two fingers are passed towards the cardia the lesser curvature being stretched meanwhile by downward traction so as to obliterate the folds of mucous membrane around the orifice. With the fingers as a guide a long curved forceps with blades protected by rubber tubing is passed through the œsophageal aperture. By gradually separating the blades the aperture may be sufficiently stretched to permit of the passage of the foreign body or to enable the latter to be grasped with the forceps and safely extracted.

5. *Dilatation of a Stricture at the Cardia or low down in the Œsophagus.* The method just described for dilating the cardiac orifice can be applied in exactly the same fashion if there be cardiospasm or an organic stricture in this region (Mikulicz).

In cases of cardiospasm the blades of the forceps have been separated as much as 6 centimetres without untoward result. Gastrotomy, however, is seldom indicated in such cases.

Closure of the Stomach Aperture and Suture of the Abdominal Wound.—When the intragastric procedures have been carried out it remains to close the stomach wound. The edges are wiped dry and the aperture is closed by a continuous penetrating suture of catgut embracing all the coats of the stomach. This suture is supplemented by an outer sero-muscular suture of silk or linen thread passed continuously in the manner represented in Fig. 128.

The abdominal wound is closed, but it is unnecessary to give details of the procedure here as it has been fully described in the introductory section (p. 235).

GASTROSTOMY.

In this procedure a gastric fistula is established for the purpose of administering nourishment when the passage of food along the œsophagus in sufficient quantity to sustain life is no longer possible.

The chief cause of such a condition is an annular cancer of the œsophagus or a cancer of the stomach at the cardia, but it may also be due to stenosis of the œsophagus resulting from simple or cicatricial stricture.

Gastrostomy has been regarded too long as a last resort, to be postponed until the patient is about to die. In such cases its performance simply brings death a few hours earlier, for a patient brought to an extreme stage of inanition by starvation has no resources with which to withstand even the most trivial operative procedure.

It is not sufficiently recognised that in stenosis of a non-malignant nature gastrostomy *per se* may be if not definitely curative at least productive of great amelioration of the trouble by affording absolute rest to the œsophagus. Even in malignant stricture the removal of the irritation necessarily caused by bougies and attempts to swallow will retard the growth and prolong life. Moreover, not all strictures diagnosed malignant have the diagnosis confirmed on the *post-mortem* table. As soon therefore as the amount of nourishment that can be introduced through normal channels proves insufficient to maintain the patient's full weight gastrostomy should be performed. This point of view, however, is not universally accepted, so the surgeon must be prepared to operate on greatly emaciated and enfeebled patients, and consequently he must take suitable precautions to minimise the depressing effects of the operation.

Local instead of general anæsthesia may be necessary. A cold theatre may be fatal and a prolonged operation disastrous. At the end of the procedure the introduction of some form of liquid nourishment into the stomach may tide the patient over the stage of post-operative shock.

In the early days of surgery one of the chief objections to gastrostomy resulted from the fact that some regurgitation of the gastric contents was liable to take place through the fistulous opening. These being acid and highly irritating caused excoriation of the skin of a very painful character. To overcome this objection surgeons have devised with perfect success certain ingenious operations which aim at substituting a valvular opening for one leading directly from the stomach to the surface of the abdomen. Of these the simplest and the most generally applicable is Senn's operation.

SENN'S OPERATION. *The Abdominal Incision* is made through the left rectus muscle midway between its inner and outer margins, and extends vertically downwards from the costal margin for about 4 inches. The muscle fibres are separated and the posterior layer of the sheath and the peritoneum are divided in the usual manner.

The Gastric Stoma. When œsophageal stenosis has existed for some time the stomach may have undergone marked contraction resembling in its general contour a cylindrical segment of intestine rather than the normal viscus. When this condition obtains the stomach is most readily recognised by retracting the upper angle of the wound and raising the left lobe of the liver. If, as often happens, the colon presents in the wound it should be displaced downwards so as to facilitate the exposure of the stomach. The latter is now drawn into the wound and the site of the stoma determined. This latter should lie well towards the cardiac extremity of the viscus

and midway between the two curvatures. The protruding stomach is surrounded by warm and moist sterilised swabs. A fold of the gastric wall is raised between two clip forceps at the selected point and incised. The opening is just sufficient to admit a piece of rubber tubing with a lumen of from $\frac{1}{4}$ to $\frac{3}{8}$ inch.

Method of securing the Tube in the Stomach.—The tube is passed into the gastric

FIG. 140.—Senn's Gastrostomy.—The stomach has been brought out through a vertical mid-rectus incision below the left costal arch. A piece of rubber tubing has been introduced into its interior and fixed *in situ* by a suture of fine catgut. A purse-string suture has been passed circularly about $\frac{1}{2}$ inch away from the tube preliminary to the invagination of the latter.

cavity and towards the right side for a distance of 2 or 3 inches; it is then attached to the margin of the aperture by a suture of fine catgut which passes through all the coats of the stomach and takes up a substantial portion of the tube as well (Fig. 139). A purse-string suture, picking up the sero-muscular strata of the gastric wall at five or six points, is now passed circularly about $\frac{1}{2}$ inch away from the tube. As this suture is being tightened the tube is depressed towards the cavity of the stomach inverting

the margins of the aperture. This invagination may be facilitated by leaving a loop of the purse-string suture long at a point opposite that at which the needle is first entered, so that when the introduction of the suture is completed the surgeon, by holding the loop in one hand and the ends of the thread in the other, can keep the stomach

FIG. 142.—Senn's Gastrostomy. The tube has been fixed in the stomach and the latter connected with the parietal peritoneum and the posterior layer of the rectus sheath by two supporting sutures, one above and one below the site of emergence of the tube. The abdominal wound is closed in the usual way.

wall steady as the tube is depressed by the assistant. In tightening the suture the ends of the thread should be crossed, otherwise there is some danger of tearing the wall. The ends are now knotted and the serous covering of the stomach is thus drawn in against the tube. Another purse-string suture is passed in a similar way through the stomach wall about ½ inch from the tube. The latter is again

depressed, causing a further inversion of the stomach, whereupon the ends of the suture are drawn tight and knotted. This is followed by a third and possibly by a fourth purse-string suture, each causing further invagination of the gastric wall. Viewed from within the stomach the wall of the latter presents the form of a cone with the rubber tube emerging from its apex.

Fixation of the Stomach to the Abdominal Parietes. The stomach is anchored to the abdominal parietes by two sutures of medium catgut, one above and one below the point of emergence of the tube. Each of these sutures traverses the serous and

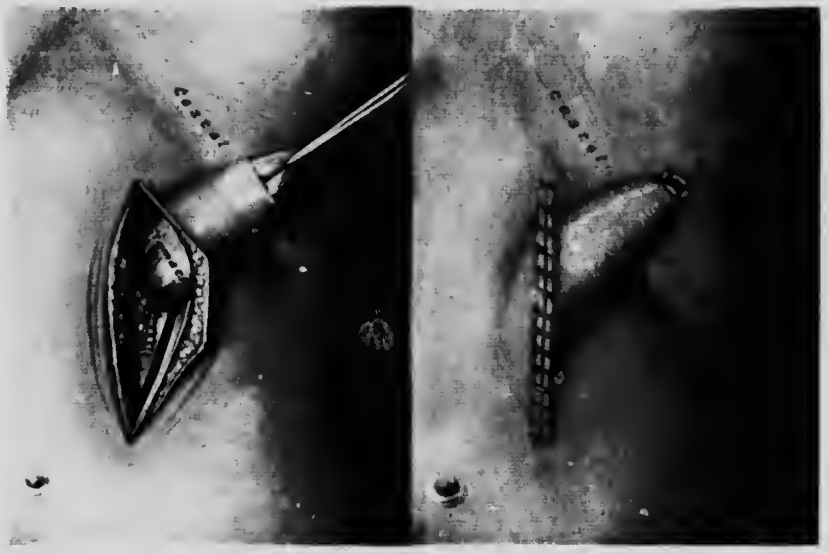

FIG. 133. FIG. 134

FIG. 133.—Frank's Gastrostomy. The stomach in the form of a cone has been drawn out through a mid-rectus incision on the left side. The parietal peritoneum has been connected with the stomach all around the base of the cone, and the apex of the latter has been drawn out through a small aperture over the costal arch, the skin and subcutaneous tissues having been previously undermined in order to provide a passage for the stomach.

FIG. 134.—Frank's Gastrostomy. The apex of the gastric cone has been opened and its margins have been connected with those of the skin aperture. The abdominal wound has been closed with the exception of the part through which the stomach emerges.

muscular coats of the stomach and the peritoneum of the abdominal wall, including the posterior layer of the rectus sheath (Fig. 132).

Closure of the Abdominal Wound. This is effected in the manner already described in the introductory section. The rubber tube emerges from between the margins of the wound near its mid-point.

The Administration of Food. About half a pint of warm peptonised milk is introduced immediately through the tube. The extra-abdominal portion of the latter is compressed by a suitable clip in order to prevent the escape of the gastric contents.

FRANK'S OPERATION. This operation is a good one in the rare cases in which the stomach is not small and contracted and where one can afford to sacrifice a considerable area of its internal secreting surface. In the usual condition of affairs

however, it is a more difficult procedure than that of Senn and in result not more satisfactory.

Method of Fixation of the Stomach. The abdomen having been opened as in the

FIG. 145.—Witzel's Gastrostomy.—A rubber tube has been placed in contact with the stomach and two folds of the latter have been raised and brought together over it by means of a continuous sero-muscular suture. The tube has then been bent upon itself and its distal extremity inserted into the stomach through a small punctured wound. The continuous sero-muscular suture is about to be resumed and completed.

operation just described, the stomach is found, drawn forwards, and the site of the stoma determined as before. The part so selected is grasped with forceps and a portion of the stomach is drawn through the abdominal wound in the form of a cone.

Commencing at the lower angle of the abdominal wound the peritoneum and the posterior layer of the rectus sheath are brought together by means of a continuous suture up to the point where the stomach cone protrudes (Fig. 133). The latter also is secured all round its base to the parietal peritoneum by a continuous suture, care being taken in doing so not to pierce one of the large vessels which enter or emerge from the stomach opposite the curvatures. A second skin incision, about 1 inch in length, is now made above and to the outer side of the first. It is parallel to and at a higher level than the left costal margin. The subcutaneous tissue between the two apertures is undermined with the scalpel so as to detach it from the rectus sheath and the external oblique muscle. In this way a passage is made from one incision to the other. The blades of a pair of forceps introduced through the smaller aperture are made to grasp the apex of the protruding cone of the stomach and draw it upwards and outwards through the space just made for it. The apex of the cone protrudes just beyond the margin of the smaller opening and is fixed to it by a few sutures.

Closure of the Abdominal Incision.—This is effected in the usual manner except at the point where the stomach emerges. Here the separated fibres of the rectus muscle exert a sphincteric action on the base of the gastric cone. In the remainder of its extent the latter is subcutaneous.

The Gastric Stoma.—The protruding apex of the stomach is incised and a piece of rubber tubing of the size of a large catheter is introduced. Through this nourishment may be administered immediately as in the last operation.

WITZEL'S OPERATION.—The abdomen is opened and the stomach is identified and examined as before.

Fixation of the Stomach.—The stomach is drawn forwards, and a large catheter, the eye of which is directed upwards and to the left so as to diminish the risk of regurgitation, is lodged in a canal in its anterior wall made by raising up two folds about 3 inches in length midway between the curvatures and connecting these by a continuous sero-muscular suture over the tube, as is represented in Fig. 135. This suture first approximates the folds at their pyloric extremity and is then continued to the level of the end of the tube, where it is knotted and the needle end left long. The stomach is now steadied by a properly applied suture (Fig. 135) or by grasping the extreme cardiac end of each sero-muscular fold with a pair of tenaculum forceps. A knife is thrust sharply through the stomach wall between the forceps and the end of the catheter introduced through the opening so made for about 2 inches. The suture is now continued towards the cardia to a sufficient extent to approximate the folds of the stomach wall securely over the point of entrance of the tube. To prevent leakage a clamp should be put on the outer end of the latter.

Fixation of the Stomach to the Abdominal Parietes is effected by one or two interrupted sutures of catgut at the lower angle of the abdominal incision, which traverse its deeper strata and engage the sero-muscular layers of the stomach near the point of emergence of the tube. If silkworm gut sutures are used for this purpose they should traverse the entire thickness of the abdominal wall so as to be easily accessible for removal after the stomach has become adherent.

The abdominal wound is closed in the usual way.

Post-operative Measures.—The following are the more important points to be attended to:—(1) Feeding immediately after the termination of the operation (2) The administration of normal saline per rectum if necessary. (3) After the first day the patient may receive by the tube two eggs beaten up and half a pint of milk.

These are given through a funnel connected with the tube in the stomach or through a large syringe. If the patient be troubled by hiccough washing out the stomach will usually afford relief. Solid food well broken up, such as minced meat, or food chewed by the patient may be introduced into the stomach after a few days. (4) The skin around the opening is protected by frequent applications of vaseline or by dusting with zinc oxide or magnesium carbonate. Painting the skin with a solution of pure rubber in benzene or cementing a large sheet of dental rubber dam with rubber dissolved in xylol to the area surrounding the opening will serve to mitigate the annoyance caused by escaping acrid fluids. (5) Some liquids may still be given by the mouth, and it is sometimes noted that the difficulty in swallowing diminishes somewhat after a while, evidently in consequence of the rest given to the œsophagus by the presence of the gastric stoma. (6) The tube in the stomach remains *in situ* for about eight days; after this it need only be introduced for the administration of food.

GASTRO-ENTEROSTOMY.

This is a short circuiting operation between the stomach and the duodenum or the jejunum near its commencement. A gastro-duodenal anastomosis is but rarely performed; the jejunum is more accessible and more easily manipulated than the duodenum, consequently gastro-jejunostomy is the operation employed almost exclusively at the present day.

Under normal conditions the gastric contents are impelled towards and through the pylorus by the peristaltic contraction of the stomach walls, and so long as the pyloric outlet is free the gastric contents continue to pass in this direction even though an artificial aperture may have been established between the stomach and the jejunum (Cannon and Blake). This is explained by the fact that during the contraction of the stomach the margins of the new aperture are stretched and approximated and the passage of the gastric contents by this route is to a large extent prevented.

If obstruction exist at the pylorus or within the duodenum the food is still propelled towards the seat of obstruction, but, finding its progress barred, it is driven by a reverse current towards and through the anastomotic aperture by the contracting muscular effort of the stomach and the resulting increased intragastric tension.

The passage of the gastric contents through the anastomotic aperture then is not a mere question of drainage in which fluids gravitate from the cavity of the stomach to that of the intestine. For its performance it requires a definite obstruction in the course of the normal gastro-duodenal passage and an adequate degree of contraction in the gastric wall.

It is extremely questionable whether gastro-enterostomy should be performed if no definite pathological condition exist obstructing the normal gastric outflow.

When an ulcer is not situated near enough to the pylorus to obstruct the latter many surgeons advocate the closure of the pyloric canal by enfolding it with a few Lembert's sutures.

After the operation some of the alkaline duodenal contents usually find their way into the stomach, but without any bad effects; they may even act advantageously by diminishing the acidity of the gastric secretion.

As a result of gastro-enterostomy the intragastric pressure is greatly diminished, and the gastric movements consequently are less forcible. Should an ulcer exist within the stomach these altered conditions will place it at a greater advantage for healing, and such serious complications as perforation and excessive hæmorrhage may be prevented.

Indications. This operation is most distinctly indicated in cases where the normal passage of food through the pylorus is barred by definite pathological conditions.

1. In certain cases of active ulceration of the stomach or duodenum: (*a*) in all cases of chronic ulcer at or near the pylorus which have resisted medical treatment; (*b*) in certain cases of perforated ulcer of the stomach or duodenum; (*c*) for recurrent hæmorrhage from a gastric or duodenal ulcer.

2. For certain conditions resulting from simple gastric ulcer: (*a*) fibrous stricture

FIG. 130.—The Transverse Colon with its mesentery and the intramesocolic subdivision of the Abdominal Cavity. The commencement of the jejunum will be observed at the left of the vertebral column. The transverse meso-colon and the main branches of the middle colic artery are deserving of note.

at or near the pylorus; (*b*) perigastric adhesions which seriously interfere with the mobility of the stomach; (*c*) cases of hour-glass contraction of the stomach in which the constriction separates a large cardiac from a small pyloric pouch.

3. For congenital hypertrophic stenosis of the pylorus.

4. As a palliative measure in inoperable cancer of the stomach.

5. As a step in the operation of gastrectomy or as a preliminary measure when this procedure is carried out in two stages.

GASTRO-JEJUNOSTOMY. In effecting a gastro-jejunal anastomosis the intestine may be connected with the anterior or posterior wall of the stomach.

In order to connect the jejunum with the anterior aspect of the stomach this segment of the bowel must be brought from the lower or inframesocolic compartment of the abdomen in front of the great omentum and transverse colon so as to reach the gastric wall; this procedure is termed *anterior* or *precolic* gastro-jejunostomy. An alternative method consists in bringing the selected jejunal loop first through an

FIG. 137. Posterior Gastro-Jejunostomy. The posterior wall of the stomach has been made to bulge through an aperture in the transverse meso-colon between the limbs of one of the larger arterial arches. A loop of the jejunum close to the duodeno-jejunal flexure has been drawn out through the abdominal wound. The lines of incision in the stomach and jejunum are indicated by black lines; that in the stomach is sometimes made more nearly vertical.

aperture in the transverse mesocolon and then forwards through another aperture made in the gastro-colic or great omentum.

The jejunum may be brought into contact with the posterior aspect of the stomach through an aperture in the transverse mesocolon; this procedure is known as *posterior* or *transmesocolic* gastro-jejunostomy. It is the operation usually performed and will be described first.

POSTERIOR GASTRO-JEJUNOSTOMY. *The Abdominal Incision.* A vertical incision about 4 inches in length, its lower extremity reaching to the level of the umbilicus, is made slightly to the right of the middle line.

Examination of the Stomach and Duodenum. The stomach is drawn into the wound and carefully examined from the cardia to the pylorus so as to exclude hour-glass

contraction, a condition easily overlooked if not definitely remembered. Perigastric adhesions should be sought for their cause determined and their effects noted. Gentle palpation of the gastric walls may demonstrate the presence of indurated areas suggestive of underlying chronic ulcers. Any opacity of the serous covering must be investigated.

A definite vein passing transversely to the long axis of the pyloric canal marks the site of the pylorus and the beginning of the duodenum. The latter must now be

FIG. 148.—Posterior Gastro-Jejunostomy.—The stomach and jejunum have been grasped by clamp forceps, the blades of which are sheathed in rubber. The transverse colon and the great omentum appear above, and pieces of sterilised muslin have been arranged around the parts concerned in the operation. The latter only remain outside while the anastomosis is being established, the other parts are returned within the abdomen.

examined. Gentle traction on the stomach will draw the first stage of the duodenum forwards and to the left so that clear observation and palpation may reveal the presence of ulceration or of its effects. Dr. W. J. Mayo has described an anæmic spot on the first stage of the duodenum, produced by traction on the stomach and liable to be mistaken on superficial examination for a pathological lesion.

So many abdominal organs when diseased may give rise to gastric symptoms the discrimination of which may not be clear before operation, that it is well as a routine measure to make a rapid examination of neighbouring parts, especially the gall-bladder and the appendix, before proceeding with the gastro-jejunostomy.

The Site and Direction of the Gastric Incision. The most dependent part of the stomach is identified. It usually corresponds to that part of the greater curvature opposite to which the left or vertical segment of the lesser curvature passes into the horizontal segment.

The colon and the great omentum are turned up and the transverse mesocolon exposed from below. A non-vascular area between the limbs of one of the larger arterial arches is selected, the peritoneum at its centre is raised in the form of a fold, divided with scissors and afterwards stretched with two forceps or with the fingers,

FIG. 136.—Posterior Gastro-Jejunostomy. This figure represents the stomach and the jejunum securely held by clamps and packed all around with swabs of sterilised mush. The inner or penetrating suture has been commenced and is being carried from left to right; it traverses all the layers of the stomach and intestine.

thereby opening into the lesser peritoneal sac and exposing the posterior wall of the stomach.

The stomach is drawn through the mesocolic aperture and its most dependent part again noted. The line of the gastric incision is now determined; it has an almost vertical direction, or it may be slightly oblique from above and on the left, downwards and to the right (Fig. 137).

A fold of the gastric wall, the summit of which corresponds to the line of incision, is raised and grasped with a suitable clamp. The blades of the latter point to the patient's right shoulder and grasp the greater curvature of the stomach near their distal extremities.

The Jejunum. The beginning of the jejunum is identified by following the transverse mesocolon back to the spine, hooking up the bowel immediately to the left side

of the latter and tracing it to the duodeno-jejunal flexure, where the fixed and movable segments of the small intestine meet. The jejunum is drawn forwards directly from its commencement and placed alongside that portion of the stomach which is grasped by the clamp. A second clamp is now made to grasp the segment of the jejunum thus selected for the anastomosis. The blades of the clamp point towards the patient's right side; they grasp the gut at two points about 4 inches apart and compress the mesentery close to its line of intestinal attachment. It will be seen that the extremity of the gastric fold next the cardia and that of the segment of jejunum next the duodeno-jejunal flexure lie towards the handles of the respective clamps on the patient's left side.

FIG. 430.—Posterior Gastro-Jejunostomy. The inner or penetrating suture has been made to connect the posterior margins of the anastomotic opening and, having reached the right extremity of the latter, it is continued back from right to left and connects the anterior margins of the aperture.

Instead of the two separate clamps, the application of which has just been described Moynihan's modification of Roosevelt's clamps may be used or any of the twin pattern forceps. These instruments keep the stomach and jejunum steadily in the correct position during the process of suturing.

The Anastomosis.—All abdominal contents with the exception of the portions of the stomach and intestine which are held by the clamps are replaced within the abdomen. The two clamps are placed alongside each other, a small swab rinsed out of hot saline solution intervening. Additional swabs are placed all round so as to protect the wound and abdominal contents.

The Posterior Line of Sero-muscular Suture.—This line of non-penetrating suture runs continuously from left to right for a distance of 3 inches or more and lies about

½ inch away from the site of the anastomotic opening. The needle takes up the sero-muscular coats on each side. Having reached a point at or close to the greater curvature of the stomach, the needle is laid aside and covered with a sterilised swab (Fig. 138).

Opening into the Stomach and Intestine. The opening into the stomach is made ½ inch from and parallel to the line of sero-muscular suture, and is so placed that the length of the latter exceeds the length of the incision by ½ inch at each extremity. The incision is made by successive strokes of the scalpel until the mucous membrane

FIG. 140.—Posterior Gastro-Jejunostomy. The inner or penetrating suture has been completed and its two ends knotted at the left extremity of the suture line. The next stage in the suturing process consists in resuming the sero-muscular suture at the right side (see Fig. 139) and carrying it back to its starting point on the left side (see Fig. 142).

is reached. This bulges prominently forwards into the gastric wound owing to the lax character of the submucous tissue. The redundant mucous membrane is seized with forceps, incised, and an elliptical area removed. Escaping fluids are instantly mopped up and the parts wiped dry.

The gastric aperture is at least 2 inches in length; as a rule it is somewhat longer, but it is doubtful if there is any advantage in allowing it to exceed 3 inches.

If desirable any large vessels seen crossing the line of incision may be underrun and ligatured before the mucous membrane is divided. This is a useful precaution against post-operative intragastric hæmorrhage.

The jejunal incision is made in the same way and, as before, some of the redundant

mucous membrane may be excised. Immediate swabbing away of escaping bowel contents is again essential.

Suture of the Margins of the Gastric and Intestinal Apertures. This is accomplished by one continuous suture which penetrates all the tunics of the stomach and intestine. It commences on the left side and proceeds continuously towards the right, uniting the contiguous margins of the gastric and jejunal apertures. The individual stitches are inserted close together, and after each passage of the needle the thread is drawn

FIG. 142.—Posterior Gastro-Jejunostomy. The clamps have been removed and the anastomosis between the stomach and the jejunum is being completed by carrying the outer or seromuscular suture from right to left. Note the peritoneal forceps at the left extremity of the suture line—it grasps the stomach and the jejunum and helps to raise up two folds which facilitate the suturing process.

taut and held steadily until another stitch has been taken up. As a precaution it is well to reinforce this line of suture here and there by knotting the thread (Fig. 139).

Having reached the right extremity of the anastomotic aperture the suture is continued back from right to left, connecting the anterior margins of the aperture (Fig. 140). In turning the corner at the right side the needle, having entered the stomach, is made to traverse the gastric wall again from its mucous to its serous aspect and then across to the jejunum, the wall of which it traverses from its serous to its mucous aspect. When the starting point has been reached the two ends of this suture are securely knotted (Fig. 141).

The clamps are now released and a careful inspection made to see if any bleeding of consequence takes place along the suture line. If such should occur an additional underrunning suture will suffice to occlude the bleeding vessel.

The parts are wiped with a swab moistened with hot saline solution. Soiled wipes and instruments are replaced by a fresh set, and the operator rinses his hands first in biniodide and then in sterile salt solution.

The Anterior Line of Sero-muscular Suture. The sero-muscular suture is now resumed and carried from right to left back to its starting point (Fig. 142). It inverts

FIG. 143.—Posterior Gastro-Jejunostomy. The anastomosis having been completed the margins of the aperture in the transverse mesocolon are connected by some interrupted sutures with the jejunum close to the anastomotic suture line.

the inner penetrating line of suture. When passing the needle through the stomach in completing this suture some large branches of the epiploic vessels are liable to be wounded. Care should be taken to prevent such an accident, as the needle puncture would be followed by a hæmatoma. The line of sero-muscular suture is carefully inspected and reinforced by additional single sutures if necessary.

It is a wise precaution to fix the left extremity of the jejunal loop to the stomach by one or two additional sero-muscular sutures above and to the left of the anastomotic aperture.

The Mesocolic Aperture. A few sutures are introduced to connect the margin of

the aperture in the mesocolon to the jejunum close to its junction with the stomach (Fig. 143). These sutures prevent the opening in the mesocolon from constricting the jejunal loop, and they remove the possibility of a hernia of some portion of the intestine taking place into the lesser sac of the peritoneum.

The Sutured Parts returned and the Abdominal Wound closed. All swabs are withdrawn, the sutured parts are gently sponged with wipes moistened by warm saline solution and replaced within the abdomen. The abdominal wound is closed in the usual way (p. 235).

COMMENTS.

Examination of the Stomach and Duodenum. This investigation should never be omitted. Neglect to perform a careful examination has resulted in the jejunum being connected with the distal segment of a stomach presenting an hour-glass constriction. Should an ulcer be found in the stomach or duodenum it is advisable to infold the involved area by a few Lembert's sutures. Having regard to the frequency with which carcinoma develops in a chronic ulcer clean excision of the latter with suture would appear to be a more rational measure, and it is one which we have carried out very satisfactorily in a considerable number of cases.

The Anastomotic Aperture. The chief points to bear in mind in connection with the new gastric outlet are that in direction it should either be oblique from above and on the left downwards and to the right or practically vertical; it should correspond with the most dependent part of the stomach and measure at least 2 inches in its long axis.

Operative Technique. *The Anastomosis.* In adjusting the jejunum to the stomach before commencing the anastomosis it should be seen that the bowel is directed from left to right so that the direction of the peristaltic current in it may correspond with that in the stomach (iso-peristalsis). Mayo advocates performing the anastomosis with the jejunum directed towards the left on the supposition that this is its normal course from the duodeno-jejunal flexure and that it prevents kinking of the gut at that point. In correspondence with this direction of the jejunal loop he makes the gastric aperture run from above downwards and to the left, not to the right as above described. There is no special advantage in this modification.

It is sometimes found that the first few inches of the jejunum are attached to the transverse mesocolon either by adventitious adhesions or by a definite mesentery (Mayo). These connecting bands should be separated so that the anastomotic aperture may be made as close to the duodeno-jejunal junction as possible.

2. *Suture Material.* The suture material which appears most suitable is either fine linen or Pagenstecher thread. Catgut is preferred by some for the inner or penetrating suture owing to its absorbability. Non-absorbable sutures work their way out and ultimately become free, but in doing so they may occasion an ulcerative process involving the margins of the aperture, and it has been suggested that the coincident formation of granulation tissue may result in narrowing or stenosis. This has also been a determining factor in the development of a jejunal ulcer (Wilkie).

3. *Intragastric Hæmorrhage.* One of the risks of the operation is hæmorrhage from one of the divided gastric vessels. The bleeding may take place into the stomach and lead to a fatal termination. The only method of preventing such a complication is to exercise scrupulous care in introducing the penetrating suture, *i.e.*, to

place the stitches close together and draw the thread tight after each transit of the needle. When the penetrating suture has been completed the clamps are relaxed and a careful inspection made of the approximated gastric and intestinal margins.

4. *Artificial Appliances.*—Murphy's button, bone bobbins, and the elastic ligature are unnecessary, and cannot be compared with ordinary suture as a means of effecting an anastomosis at once safe, simple and efficient.

A Long or Short Jejunal Loop.—In the earlier operations a loop of jejunum several inches in length was allowed to intervene between the termination of the duodenum and the site of the anastomosis. Such an arrangement was found unsatisfactory. The loop frequently became distended with fluids—bile and pancreatic secretions, gastric contents escaping through the pylorus—and these, finding their way into the stomach, established the so-called "vicious circle" and were accountable for distressing and sometimes fatal post-operative vomiting.

This distended waterlogged loop exerted traction on the anastomosis, producing kinking at the site of the latter, and by its pressure prevented the free passage of gastric contents along the distal or efferent segment of the jejunal loop. Another risk attending the presence of a long loop on the proximal side of the anastomosis is internal hernia, several cases of which have been recorded.

The practically invariable custom nowadays is to avoid a pendulous jejunal loop, and since this rule of practice has been observed the number of cases of regurgitant vomiting has diminished almost to vanishing point.

The Mesocolic Aperture.—The margins of this aperture must be dealt with as described above, *i.e.*, fixed by sutures to the jejunum (Fig. 143). Failure to adopt this precaution has led to hernia and internal strangulation.

Post-operative Measures.—As soon as the patient has sufficiently recovered from the effects of the anæsthetic he is propped up in bed. Fluid may be given by the mouth when the patient desires it; a cup of tea is free from danger and has a good mental effect. No restriction of fluids should be prescribed. On the third day after operation he may be given some light pudding, and if he desires more solid food fish may be administered towards the end of a week. The patient's appetite is usually the best guide as to when solid food should be given.

Post-operative Hæmorrhage.—If hæmorrhage occur after operation the stomach must be given absolute rest and resort be had to rectal feeding and nutrient enemata.

Moynihan suggests the administration by the mouth of 30 minims of 1 in 1,000 solution of adrenalin in a dessert-spoonful of water every half-hour till six or eight doses have been given.

Vomiting.—Vomiting of the ordinary post-anæsthetic type is without significance, but if it be regurgitant in type it indicates some fault in the operative technique, either acute kinking of the jejunal loop or some obstruction at the duodeno-jejunal flexure or at the site of the anastomosis. Immediate gastric lavage will in many cases relieve this symptom and apparently remove the cause. The stomach should be washed out once or twice a day till all tendency to vomiting has disappeared. If, however, it persist the abdomen must be opened and the cause treated. A lateral anastomosis between the limbs of the jejunal loop with or without the division of the afferent limb should be performed according to the conditions obtaining.

ANTERIOR GASTRO-JEJUNOSTOMY. If on opening the abdomen the posterior wall of the stomach be found connected by dense adhesions to the pancreas, or if any such condition render the performance of a posterior gastro-jejunostomy a matter of great difficulty, the anterior method of anastomosis may be performed.

The abdominal incision is made and the stomach and duodenum are carefully examined in the manner described under "Posterior Gastro-jejunostomy."

Selection of the Jejunal Loop. The commencement of the jejunum is picked up immediately below the transverse mesocolon at the left of the spine. The loop so

FIG. 144.—Anterior Gastro-Jejunostomy. A long loop of the jejunum has been drawn upwards over the transverse colon and the great omentum. The stomach and the jejunal loop have been seized with forceps the blades of which are ensheathed in rubber. The incisions in the stomach and jejunum are represented by the dotted lines.

identified is now passed through the fingers till a point is reached 15 to 18 inches from the duodeno-jejunal flexure. This is the part selected for the site of the anastomosis. The jejunal loop is turned to the right so as to ensure iso-peristalsis and is brought in front of the great omentum and transverse colon into relationship with the anterior wall of the stomach (Fig. 144).

The Anastomosis. The most dependent portion of the stomach is identified and a clamp applied to its anterior wall as near as possible to this point. The clamps are applied to the stomach and jejunum and the anastomosis is carried out by simple suture in precisely the same manner as has been described in the posterior operation (Fig. 145).

COMMENTS.

The Jejunal Loop. The loop of jejunum between the duodeno-jejunal flexure and the stomach should be of considerable length, otherwise it has a tendency to compress the colon and may cause symptoms of obstruction.

Regurgitant Vomiting. After the anastomosis has been established the two limbs

FIG. 145.—Anterior Gastro-Jejunostomy. The anastomosis has been completed at the site of the gastro-jejunal aperture indicated by the loss of an elliptical area. It will be observed that the stomach and the jejunum have been connected by suture for a short distance to the left of the anastomosis with a view to prevent abrupt sagging of the two limbs of the loop.

of the jejunal loop may hang down and come to lie close together, with the result that a sharp angle or spur is formed between them. Such a condition of affairs would be very likely to lead to regurgitant vomiting. To prevent such a serious complication the junction of the jejunum with the stomach should extend over a wide area (Moynihan). Thus if the anastomotic opening measure 2 inches the jejunum should lie in contact with the stomach for at least another inch above and to the left of the aperture. As an additional safeguard against the results of this sagging of the jejunum an anastomosis may be established between the two limbs of the jejunal loop (entero-anastomosis).

ROUX'S OPERATION EN-Y. The abdominal incision is made as before and the stomach and duodenum are carefully examined.

The transverse mesocolon is raised and through a small aperture made in it a limited area of the posterior wall of the stomach is exposed.

The further steps of the operation can be readily understood by a reference to Figs. 146 and 147.

Division of the Jejunum. The jejunum is traced downwards from its commence-

FIG. 146.—Roux's Posterior Gastro-Jejunostomy *en Y*. The stomach has been exposed through a limited opening in the transverse mesocolon and the direction of the incision in its posterior wall indicated. The jejunum has been seized by two pairs of clamps with the blades sheathed in rubber, and the incision, which extends through the bowel and for some distance into the mesentery, is represented by a black dotted line.

ment and clamped in two places, 2 inches apart, about 6 and 8 inches respectively from the duodeno-jejunal flexure (Fig. 146). The bowel between the clamps is carefully isolated by swabs rinsed out of hot saline solution and is divided, the section being prolonged for a short distance into the mesentery. The open ends of the intestine are wiped dry and the divided extremity of the proximal segment wrapped in gauze and laid to one side.

A double anastomosis is now effected. The distal segment of the divided jejunum

is drawn up to meet the stomach. Both are securely held by clamps and the open end of the jejunum is implanted into the stomach close to its most dependent part, the method of suturing being exactly similar to that already described in the operation of posterior gastro-jejunostomy and represented in Fig. 147.

If the conditions present so indicate, the jejunum may be drawn forwards through

Fig. 147. Roux's Posterior Gastro-Jejunostomy en-Y. The distal extremity of the divided jejunal loop has been implanted into the stomach and the proximal extremity has been connected with the side of the distal segment of the loop about 3 inches away from the gastro-jejunal anastomosis. A few sutures serve to connect the margins of the aperture in the transverse mesocolon with the stomach close to the anastomotic site.

an aperture in the gastro-colic or great omentum and the anastomosis made with the stomach on its anterior aspect.

The Jejuno-jejunal Anastomosis. The proximal segment of the jejunum is now implanted into the right side of the distal segment about 3 inches beyond the site of the gastro-intestinal junction.

COMMENTS

This operation on *a priori* grounds seems to approach very near the ideal as the secretions of the liver and pancreas are led into the jejunum some 3 inches beyond

the new gastric outlet, and consequently the danger of vomiting caused by their entrance into the stomach must be reduced to a minimum.

The operation may be performed in certain cases where adhesions prevent free access to the posterior wall of the stomach and render the performance of the posterior no-loop operation difficult or impossible.

Roux's operation is more complicated and requires a longer time to perform than the posterior no-loop operation. Its results are no better than, probably not so good as those of the latter.

In performing Roux's operation, if the lumen of the jejunum be considered not

FIG. 148.—Lateral Gastro-Duodenostomy. In order to mobilise the second or descending stage of the duodenum the peritoneum investing the anterior aspect of the right kidney has been incised vertically for a couple of inches. Two fingers introduced through the peritoneal aperture have mobilised the duodenum and displaced it forwards to the left and brought it into closer relationship with the stomach.

of sufficient calibre for the free passage of gastric contents, the end of the distal segment may be cut obliquely from the mesenteric attachment to the periphery of the bowel so as to give a wider aperture.

GASTRO-DUODENOSTOMY. This procedure is also known as subpyloric or lateral gastro-duodenostomy (Villard and Kocher).

According to Kocher this operation is specially indicated when the free passage of gastric contents into the duodenum is interfered with or when the disease necessitating surgical interference is not situated in the region of the pylorus but in some other part of the stomach.

The abdomen is opened by a right paramedian incision and the condition of the stomach, duodenum, and bile passages is carefully examined.

Mobilisation of the Duodenum. An incision is made vertically through the peritoneum over the right kidney about an inch outside the second stage of the duodenum. The latter is then freed by the fingers and displaced inwards along with the head of the pancreas. The duodenum can now be brought forward into the wound, grasped

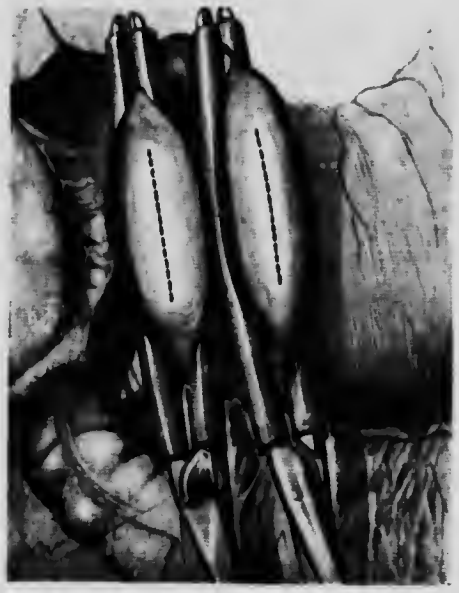

FIG. 139.—Lateral Gastro-Duodenostomy. The duodenum having been mobilised as represented in the preceding figure has been seized with clamp forceps and drawn over to meet the stomach, which has also been grasped by forceps in the vicinity of its greater curvature. The stages of the gastro-duodenostomy resemble those illustrated in connection with posterior gastro-jejunostomy.

by a curved clamp, and placed alongside the portion of the stomach selected for the anastomosis.

The Gastro-duodenal Anastomosis is carried out in the same manner as in the procedure of gastro-jejunostomy described above.

PYLOROPLASTY

Method of Heincke and Mikulicz. The abdomen is opened by a median or paramedian incision and the pylorus with its surroundings is examined.

The Pyloric Incision.—An incision is made in the long axis of the pyloric canal through the thickened ring of the pylorus and for a short distance into the duodenum. The entire incision will measure about 3 inches. If it be made too freely there may

be dangerous traction afterwards on the suture line. A large aperture is essential if the beneficial effects of the operation are to be permanent.

The Sutures. The margins of the incision are drawn apart vertically, so that the long axis of the gastro-duodenal aperture from being transverse is now directed from above downwards. Two rows of sutures are introduced. The first row connects

FIG. 150.—Finney's Pyloroplasty. A traction loop passed through the serous and muscular layers of the pylorus has enabled this latter to be drawn upwards in such a way that the first part of the duodenum comes to lie against the stomach opposite the right extremity of its greater curvature. The duodenum and the stomach have been connected for a distance of about 2 inches below the subpyloric angle. The incision which traverses the stomach and the duodenum extends through the pylorus and is represented in the figure.

the margins of the aperture; it is a continuous penetrating suture of silk or Pagenstecher thread extending from one angle of the wound to the other. The stitches are placed close together and the thread is drawn tight so as to ensure hæmostasis. The second row of sutures is non-penetrating; it traverses the sero-muscular layers and secures complete inversion of the first suture line.

GASTRO-PYLORO-DUODENOSTOMY (Finney's Operation).—This procedure is really a combination of the two operations just described, viz., gastro-duodenostomy and pyloroplasty.

The abdomen having been opened and the condition of the stomach and its surroundings carefully examined, the duodenum is mobilised in the manner already described and represented in Fig. 148. The pylorus must be thoroughly freed from adhesions.

Approximation of the Stomach and Duodenum. This may be accomplished by means of clamps suitably applied or by means of three traction threads, passed respectively through the upper border of the pylorus, the anterior duodenal wall and the anterior wall of the stomach near its greater curvature. The two latter threads are introduced about ¾ inches away from the pylorus on its distal and proximal sides

Fig. 151. Finney's Pyloroplasty. The gastro-duodenal incision having been made, the first or penetrating suture is commenced opposite the lower border of the pyloric aperture, and is carried downwards, traversing all the coats of the stomach and duodenum

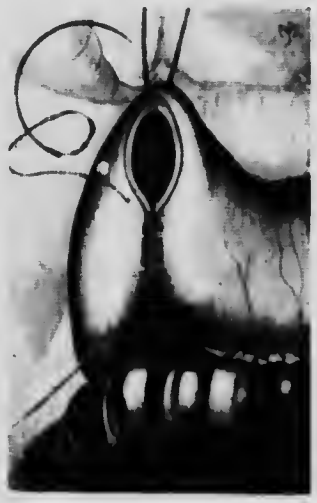

Fig. 152. Finney's Pyloroplasty. This figure represents the penetrating suture which connects the margins of the gastro-duodenal aperture approaching completion. It is seen at its commencement in Fig. 151. The free thread which is seen at the lower part of the suture line belongs to the outer or sero-muscular suture which is represented in Fig. 150

respectively. Traction on these threads brings the stomach and duodenum into close contact. Clamps are preferable to threads as they effectively prevent hæmorrhage and leakage.

The Posterior Sero-muscular Suture. This suture commences above in the angle between the stomach and duodenum and is carried continuously downwards for a distance of 2 inches or more as represented in Fig. 150.

The Gastro-duodenal Incision. The gastro-duodenal incision presents an outline of an inverted U. Its two limbs extend respectively into the stomach and duodenum and the summit of its convexity traverses the pylorus (Fig. 150). Redundant mucous membrane may be excised if it protrudes to such an extent as to cause difficulty in the suturing process.

The Penetrating Suture.—This is a continuous suture connecting the margins of the gastro-duodenal aperture. It commences just beneath the pylorus and proceeds downwards connecting the posterior margins of the aperture. Having reached the lower extremity of the opening, the corner is turned in the manner already described and depicted under "Gastro-jejunostomy" and the suture is then continued from below upwards so as to connect the gastro-duodenal margins in front (Fig. 152).

Fig. 153.—Finney's Pyloroplasty. This figure represents the process of suturing completed. The first or sero-muscular suture, which is seen in Fig. 150, has been continued from below upwards so as to invaginate the penetrating line of suture.

The Anterior Sero-muscular Suture.—The posterior sero-muscular suture which was temporarily laid aside is now resumed at the lower level of the gastro-duodenal line of contact; it is carried from below upwards inverting the penetrating line of sutures, and it terminates above at the pylorus.

The appearance presented at the completion of the suturing process is shown diagrammatically in Fig. 153. The capacity of the new aperture leading from the stomach into the duodenum will be appreciated by a reference to Fig. 154.

The sutured parts are wiped carefully with a moist saline swab and are returned within the abdomen. The abdominal wound is closed.

COMMENTS.

The Results of Finney's Operation.—The immediate results are often very satisfactory, but there would appear to be a tendency to recurrence of the symptoms owing to gradual narrowing of the aperture. The cases best suited for this procedure are those in which there is active ulceration some distance proximal to the pylorus accompanied by pyloric spasm.

In some cases in which extensive adhesions or other causes render gastro-enterostomy impossible to perform Finney's operation may be indicated.

It has a definite but restricted field of usefulness, and for this reason is not frequently performed.

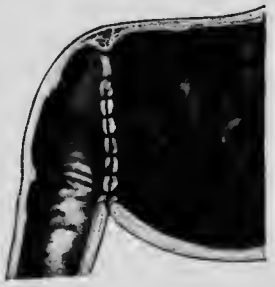

Fig. 154. Finney's Pyloroplasty. A sectional view of the stomach and duodenum after the completion of the operation. Note the greatly increased dimensions of the gastro-duodenal passage.

Difficulties of the Operation.—Thorough mobilisation of the pyloric canal and duodenum may be rendered exceedingly difficult by adhesions, but these can usually be separated with care.

Applicability of Finney's Operation to certain Cases of Hour-glass Constriction of the Stomach.—If it be desired to perform an anastomosis between the proximal and distal pouches in cases of hour-glass constriction of the stomach Finney's method may be used and is a very satisfactory means of performing this gastro-gastrostomy.

GASTRECTOMY

Indications. This operation is usually undertaken for malignant disease. Less frequently a partial resection may be required for simple ulceration or for extreme degrees of distortion, such as hour-glass deformity, which sometimes result from this.

Gastrectomy for Cancer: Pathological Anatomy.—Carcinoma of the stomach usually begins in the pyloric or prepyloric region, about 1 inch or 1½ inch from the gastro-duodenal junction. From this point of origin the growth tends to extend locally

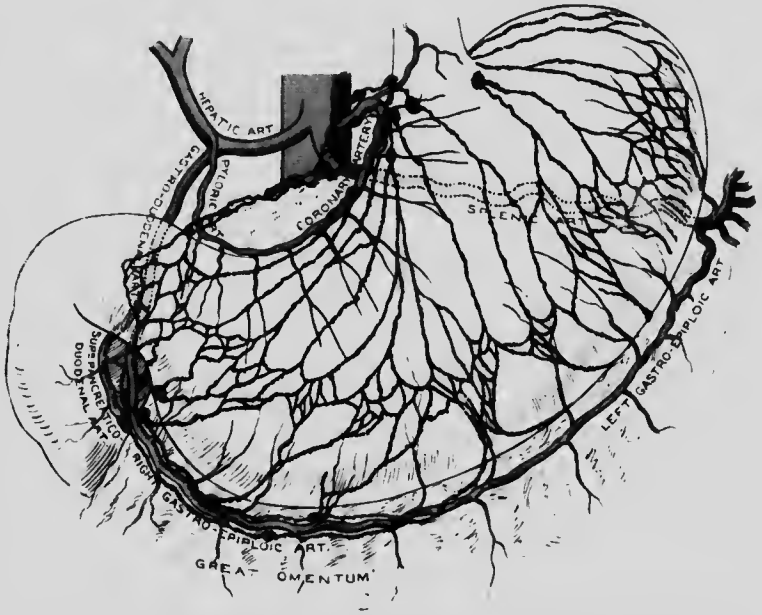

FIG. 155.—The Lymphatics of the Stomach. This figure has been prepared to illustrate the arrangement of the lymphatic vessels and glands related to the stomach in accordance with the researches of Professor Jamieson and Mr. Dobson, F.R.C.S., Leeds University.

towards the body of the stomach and shows a special tendency to implicate the curvatures, of which the lesser is usually the first affected. Extension by continuity of tissue to the duodenum is rarely demonstrable macroscopically, but microscopic preparations have shown that the first stage of the duodenum is more frequently involved than has been hitherto suspected. The growth in the stomach sooner or later becomes adherent to neighbouring viscera, especially the liver, pancreas and the transverse colon. The adhesions to these parts may be at first of a simple or inflammatory nature, but as the disease progresses they become permeated by carcinomatous cells, with resulting actual invasion of the surrounding parts by the growth.

Many ulcers of the simple type are surrounded by a dense wall of indurated tissue, and so are apt to be mistaken for carcinomatous growths. On the other hand, the

indurated mass felt on palpation in cases of cancer may be for the most part inflammatory, as for example when carcinoma develops in an existing chronic ulcer, the so-called *ulcus carcinomatosum*. The frequency with which cancer of the stomach appears to originate in simple ulceration has led to an increasing tendency on the part of many surgeons to excise all gastric ulcers as a supplemental measure to the procedure of gastro-jejunostomy when the condition of the patient permits of it being done.

FIG. 156.—The Lymphatics of the Stomach. This figure, like that on p. 267, has been prepared to illustrate the arrangement of the lymphatic vessels and glands related to the stomach in accordance with the researches of Messrs. Jamieson and Dobson. The gastro-colic omentum has been divided midway between the greater curvature of the stomach and the transverse colon; the stomach has been raised and the colon drawn down. This dissection provides a good view of the interior of the lesser sac of the peritoneum and the parts related to the posterior wall of the stomach, more especially the pancreas. At the right side note the faint ridge formed by the gastro-duodenal artery in the pancreatico-duodenal angle.

Lymphatic Extension.—This subject requires a brief survey of the anatomy of the gastric lymphatic vessels and the glands which are in connection with them. It has been very fully dealt with by Drs. Jamieson and Dobson, from whose paper the following *résumé* has been derived.

The glands which receive the lymphatic vessels coming from the stomach are as follows: (1) the coronary glands, (2) the paracardial glands, (3) the splenic glands,

(4) the right gastro-epiploic glands, (5) the subpyloric glands, (6) the suprapyloric glands, and (7) the suprapancreatic glands.

The coronary glands are subdivided into an upper and a lower group. The former are associated with the stem of the coronary artery as it lies in the falx coronaria and are continuous with the glands at the upper border of the pancreas surrounding the cœliac axis artery; the latter are found with the coronary artery between the layers of the gastro-hepatic omentum close to the lesser curvature and confined to the left half of the latter. Some of these glands may lie in direct contact with the musculature of the stomach beneath its serous covering. Both sets of glands are quite continuous.

The paracardial glands are grouped around the neck of the stomach and may be regarded as outlying members of the coronary series.

The suprapancreatic glands are arranged in three groups—a median group surrounding the cœliac axis artery and a lateral group on each side of that vessel. The left suprapancreatic glands are found with the main stem of the splenic artery at the upper border of the pancreas, while those on the right side lie with the trunk of the hepatic artery at the upper border of the pancreas; they are very constant and are usually of large size.

The splenic glands are contained between the layers of the gastro-splenic omentum close to its splenic attachment and in close relationship with the upper aspect of the tail of the pancreas. These glands are associated with the terminal branches of the splenic artery (Fig. 156).

The right gastro-epiploic glands, from four to seven in number, are arranged around the corresponding artery. They are usually situated below the artery and have a tendency to stray downwards between the layers of the omentum; on the left side they do not extend beyond the level of the middle of the greater curvature, while on the right they do not reach quite up to the pylorus.

Some of the efferents of these glands pass downwards in the great omentum and, looping backwards in front of the transverse colon, arrive by way of the transverse mesocolon at the suprapancreatic glands.

The subpyloric glands, numbering four to five, lie to the right of the pylorus in the angle between the first and second stages of the duodenum and in front of the head of the pancreas, in close relationship with the bifurcation of the gastro-duodenal artery. Some of the efferents of the right gastro-epiploic glands end in this group. They are primary glands for the pylorus and duodenum and secondary for the prepyloric region.

The suprapyloric glands are very inconstant and often absent, but a small gland is sometimes seen on the hepatic artery just above the duodenum and another in the lesser omentum a little above the pylorus. They receive some of the pyloric lymph vessels.

The biliary glands are arranged along the common bile duct. The highest of the series lies close to the neck of the gall bladder and is known as the *cystic gland*. The majority of these glands are found behind the second part of the duodenum where it comes into relationship with the pancreas.

The Lymphatic Currents in the Stomach Wall.—While it must be remembered that there is a free communication between the lymphatic vessels in the wall of the stomach and that it would be incorrect to regard certain areas as drained exclusively by vessels running to definite groups of glands, nevertheless the lymph currents stream in certain directions of a fairly well-defined nature. If a line be drawn from the summit of the fundus of the stomach to the pylorus along the junction of the lower with the middle third of the gastric wall it will mark the zone of demarcation between the lymph currents proceeding to the lesser and greater curvatures. A point at the centre of the greater curvature, *i.e.*, vertically below the œsophagus, may be regarded as indicating the point of divergence of the right and left gastro-epiploic currents.

Cancerous Invasion of the Lymphatic Glands.—Carcinoma of the stomach shows a marked tendency to invade the glands situated along the lesser curvature and to a somewhat lesser extent those of the gastro-epiploic and subpyloric groups. According to Lengemann, quoted by Jamieson and Dobson, the coronary glands are involved in 50 per cent. of cases, the glands along the greater curvature in 37 per cent., and the subpyloric glands in 60 per cent. Bearing these facts in mind, the aim of a radical gastrectomy must be to remove all the glands receiving vessels directly from the pyloric portion of the stomach. Such an operation, therefore, involves the excision of the whole of the lesser curvature with its related glands, half of the greater curvature and the omentum containing the right gastro-epiploic glands, and about an inch of the duodenum.

Not only is it necessary to remove the growth and the glands primarily involved, but, in the light of Sampson Handley's permeation theory, all the lymphatic vessels connected with these glands ought to be eradicated likewise. We have noticed the course of the lymphatic vessels from the greater curvature downwards into the great omentum and then upwards in the transverse mesocolon. Complete removal of this extensive lymph-bearing area would involve the resection of the great omentum and the stripping of the peritoneum from the front of the transverse mesocolon (Hey Groves).

When we consider that the first relay of diseased glands must be completely removed, and that these are the upper and lower coronary including those of the paracardial group to the right of the œsophagus, the right gastro-epiploic, the subpyloric, the right suprapancreatic and the biliary glands, some of which are so situated as to render their removal when diseased a matter of extreme difficulty, and when, moreover, all the lymphatic vessels lying in the path of "lymphatic permeation" must be extirpated, we realise that when once carcinomatous cells have reached the glands any radical operation becomes a formidable if not an impossible procedure.

Extension by the Blood Stream.—Extension of gastric cancer may also take place by the blood stream, the cancer cells being conveyed by the portal vein to the liver, where they give rise to multiple foci of disease. The presence of such secondary growths contraindicates any extensive resection of the primary growth.

The Scope of the Operation.—Assuming that the case is deemed suitable for removal of the growth, the operation, to be of a truly radical nature, will entail the removal of the following parts: a segment of the duodenum measuring from 1 to 2 inches to the right of the pylorus; a gastric segment, bounded on the left by an imaginary line extending from the right border of the œsophagus to the middle point of the greater curvature; portions of the greater and lesser omenta; and the following groups of

lymphatic glands: (*a*) upper and lower coronary, (*b*) right paracardial, (*c*) right gastro-epiploic, (*d*) subpyloric, and (*e*) right suprapancreatic.

Operation in Two Stages.—In many instances patients suffering from gastric carcinoma are in too debilitated a condition to undergo a lengthy surgical procedure. In such cases, which are usually characterised by anæmia, feeble pulse and other evidences of debility, it is wise to perform a gastro-enterostomy first and in the course of two or three weeks to undertake the radical operation for removal of the disease.

In those cases also where there is marked dilatation of the stomach with stasis

FIG. 157. Partial Gastrectomy for Carcinoma. This stage in the operation represents the completed division and ligature of the omenta in sections. The duodenum has been grasped by clamps preliminary to its division in the interval between these.

of its contents the risks of the operation are considerably diminished by performing it in two stages.

We have already seen that inflammatory changes contribute largely to the production of a tumour in gastric cancer: a preliminary gastro-enterostomy does much to allow any accompanying inflammation to subside and renders it easier for the surgeon to define more accurately the extent of the resection at the second operation. When a preliminary gastro-enterostomy is performed the anastomosis should be carefully made in relation to the left half of the greater curvature so as not to interfere with the subsequent resection.

Pre-operative Measures.—The nutrition of the patient is promoted as far as possible. Peptonised milk is the main article of food to be given by the mouth. Nutrient

enemata form a useful auxiliary when food is not well tolerated by the stomach. The condition of the mouth is thoroughly investigated. Bad teeth are attended to and all foci of oral sepsis are treated in the manner described in an earlier section (p. 18). Should the stomach be dilated owing to pyloric obstruction and its contents in a state of fermentation, lavage will be indicated for some days preceding the operation.

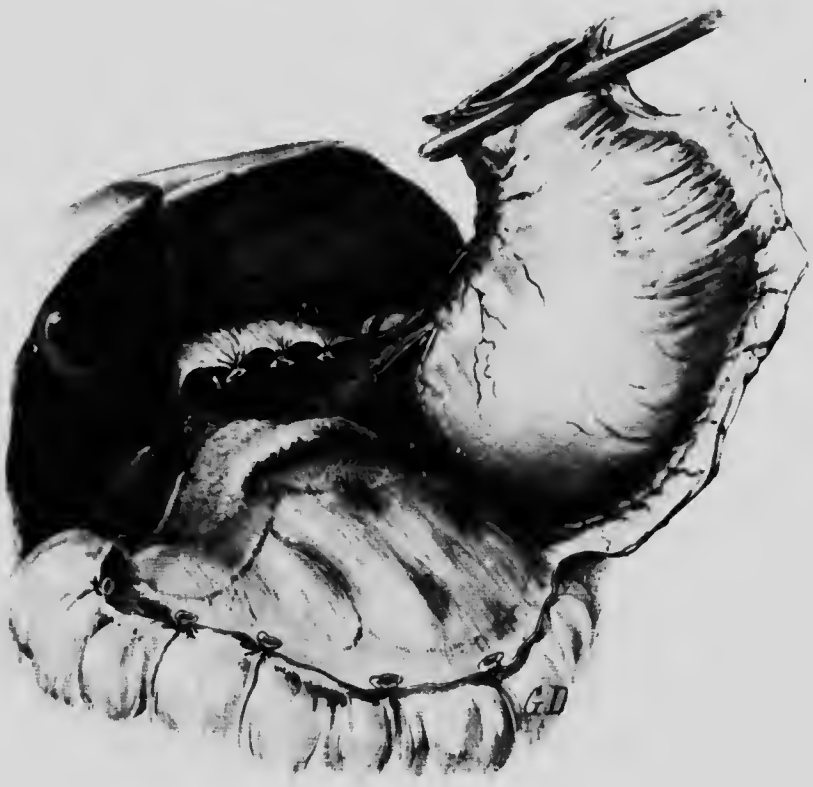

FIG. 158.—Partial Gastrectomy for Carcinoma. The duodenum has been divided and its distal extremity securely closed. The stomach has been raised and drawn over to the left side. Note the peritoneal fold (coronary ligament of the stomach) formed by the peritoneum which surrounds the coronary artery. This fold including the contained artery has been doubly ligatured preliminary to its division. The gastro-duodenal artery is indicated in the vicinity of the closed duodenum at the right side as it descends from its source of origin, *i.e.*, the hepatic artery, in the pancreatico-duodenal sulcus. The transverse colon and its mesentery overlie the general mass of the small intestine (jejuno-ileum).

Stages of the Operation.—This may be regarded as consisting of two parts, viz., the removal of the structures indicated above, supplemented by an anastomosis between the segment of the stomach which remains and the jejunum close to the duodeno-jejunal junction. As a rule the complete operation is performed at one sitting. We have already mentioned the conditions that would determine a two-stage operation.

The Abdominal Incision.—The abdomen is opened by an incision extending vert-

cally for about 4 inches and lying slightly to the left of the middle line. Its lower extremity may reach or possibly extend below the level of the umbilicus.

Examination of the Stomach. A thorough examination of the seat of the disease is essential, for it is always impossible to be certain without such exploration that the radical operation is warranted. The examination is conducted as follows: The liver

FIG. 159. Partial Gastrectomy for Carcinoma. The coronary artery and its retaining peritoneal fold have been divided between ligatures and the stomach drawn over to the left. The line of section of the stomach is represented by a dotted black line, which extends from a point on the lesser curvature close to the cardia to another point which corresponds approximately to the centre of the greater curvature. A loop of the jejunum in the vicinity of the duodeno-jejunal flexure has been drawn through an aperture in the transverse mesocolon and grasped with a clamp. The site selected in the posterior wall of the stomach for the gastro-jejunal anastomosis is represented by the short dotted line.

is raised, the transverse colon drawn down and the entire extent of the stomach examined on its anterior aspect, and the degree of mobility of the viscus noted. Assuming that the conditions so far are favourable, as shown by absence of liver metastases and extensive adhesions, the posterior aspect of the stomach is investigated. This may readily be done by making a limited aperture in the great omentum near the pylorus and sufficiently far from the greater curvature to avoid wounding the epiploic vessels. The index finger introduced through this aperture enters the lesser sac and

will readily detect the presence or absence of adhesions between the stomach and the parts related to its posterior aspect, notably the pancreas. Adhesions to this organ do not necessarily contraindicate further intervention, for, as will be noted later, they can be efficiently dealt with in some cases. If digital exploration yields indefinite results it will be wise to supplement it by a thorough visual examination. This can be carried out by enlarging the aperture in the gastro-colic omentum to an extent sufficient to afford a clear view of the posterior aspect of the stomach and of the posterior ligament of that viscus in which the coronary artery is contained. All bleeding vessels resulting from this incision should be ligatured. Digital examination may be carried out also through an opening in the lesser omentum near the lesser curvature.

The condition of the accessible glands is noted, especially those related to the gastric curvatures and the members of the subpyloric group. In this regard it should be remembered that not all enlarged glands are malignant, neither is normal size an index of non-involvement.

The relation of the growth to the transverse colon demands careful, but not lengthy, attention. Even with a fairly free range of mobility of the stomach, it may be noticed that the colon moves with it and that the two cannot be drawn apart. This does not necessarily indicate invasion of the colon by the disease, but rather that the growth, in the course of its development on the posterior aspect of the stomach, has acquired adhesions to the transverse mesocolon. Such a state of affairs is of serious import and may usually be regarded as evidence that the case is unsuited for a radical operation. If, however, the latter is undertaken it will be necessary to remove not only the implicated mesocolon but also the corresponding area of the transverse colon, otherwise necrosis of the bowel will certainly supervene in consequence of its blood supply having been cut off.

If the operator is quick to grasp the significance of what he sees—and none other should operate—the above exploration will take very few minutes. The patient's life may depend on its thoroughness.

If the decision is in favour of operation the abdominal wound may be extended to the extent of 5 or 6 inches, or even more if necessary.

Bleeding is arrested and the wound margins are protected by suitably adjusted muslin or "tetra" wipes kept in place by forceps. The area of operation within the abdomen is packed off with large swabs rinsed out of hot sterilised saline solution.

Ligature and Division of the Omenta.—The next step consists in dividing and ligaturing the omenta in sections at a safe distance from the respective curves of the stomach. Three or four ligatures are passed through the lesser omentum as close to the liver as possible, the first ligature being introduced near the cardia and the last fully an inch from the right free border of the omentum. These are now tied and the omentum divided below them. At the right extremity of the section the pyloric artery will be found descending to the lesser curvature and the gastro-duodenal artery will also be exposed as it runs downwards to the interval between the duodenum and the head of the pancreas. These vessels are defined by gauze dissection and divided between ligatures.

The division of the great omentum is accomplished as follows: The hand is passed downwards behind the stomach and pylorus and the great omentum lifted forwards. By this means the omentum is separated from the subjacent transverse mesocolon, and the vessels of the latter, on which the vitality of the transverse colon depends, are thus protected from injury, a most essential precaution. A row of ligatures extending from below the pylorus to a point opposite the middle of the greater curvature and lying well below the glands along the latter is introduced and the

ligatures tied. The omentum is now divided above the row of ligatures. The left gastro-epiploic vessels are secured opposite the middle point of the greater curvature.

If adhesions are present between the growth and the pancreas it may be impossible to pass the hand down behind the stomach in the manner described. In such cases the transverse colon should be withdrawn from the abdomen and the mesocolon with the middle colic artery carefully watched during the division of the great omentum.

The stomach, now thoroughly mobilised by the division of the omenta, is drawn forwards and surrounded by warm pads and compresses.

The Duodenal Section. Under the guidance of the finger passed behind the pylorus and duodenum two crushing clamps are applied to the duodenum to the right of the growth and about 1 inch apart (Fig. 157). The blades of the right clamp are forcibly pressed together so as to crush the included part of the gut. When this clamp is loosened and withdrawn the crushed part will appear quite flattened and thinned out. A strong ligature of catgut is applied around this part and securely tied. The duodenum is then divided between the ligature and the remaining clamp. In order to prevent the proximal cut end of the duodenum from escaping from the clamp it is sometimes necessary to pass a suture through the stomach wall and tie it over the blades (Moynihan). The ligatured duodenal stump is inverted either by a purse-string suture or by a continuous Lembert suture. This must be done with great care and thoroughly, additional sutures being inserted or the stump protected by a flap of omentum if there remains the slightest doubt of its secure closure.

The Gastro-jejunostomy.—The stomach is next drawn forwards and to the left side. If adhesions to the pancreas prevent this they are separated by gauze dissection, or if very dense a thin slice of the gland may be removed, any hæmorrhage being checked by ligatures or firm pressure.

When the stomach is drawn to the left the falx coronaria with its contained artery is brought into view. A blunt needle is passed beneath the vessel close to its origin and a ligature applied. A second ligature is similarly applied about ½ inch further out, and both the vessel and the ligament are divided in the intervening interval (Fig. 158). This step frees the lesser curvature quite up to its junction with the œsophagus and enables the stomach to be drawn further forwards. At the same time by a careful process of dry sponging all loose tissue and glands surrounding the coronary artery are wiped away from the region of the cœliac axis.

The gastro-jejunostomy is performed before the gastric section is made as it is much easier to manipulate the stomach now than at a later period.

The anastomosis is carried out in a manner similar to that described under the heading of "Post Gastro-jejunostomy" and needs no further description here. The relation of the parts is represented in Figs. 159, 160. The site of the anastomotic aperture should be arranged sufficiently far to the left so as not to interfere with the subsequent division of the stomach and the inversion of its cut margins.

The Gastric Section.—Two clamps are applied to the stomach, one on each side of the line of section. The proximal clamp should have its blades protected with rubber tubing. Immediately to the left of the line of section a pair of clip forceps grasps the respective curvatures of the stomach so as to prevent the divided margins of the proximal segment of the stomach slipping through the blades. The stomach is now divided between the clamps and the diseased segment removed. The divided margins of the remaining segment are brought together by a continuous suture of catgut or Pagenstecher's thread, which penetrates all the coats and controls all divided blood vessels along the two margins. Some surgeons employ a double row of sutures here, one for the cut mucous edges and another for the serous and muscular coats.

The next line of suture is sero-muscular; it inverts the first suture line and promotes accurate apposition of the opposing peritoneal surfaces (Fig. 161).

The Lymphatic Extirpation. Attention is now directed to the subpyloric and right suprapancreatic groups of glands. Both they and their investing tissues are removed by a process of dry sponging, the greatest care being exercised meanwhile, for the right suprapancreatic glands are intimately related to the hepatic artery.

The operation area is wiped with moist saline swabs and, all packing having been removed, the abdominal wound is closed.

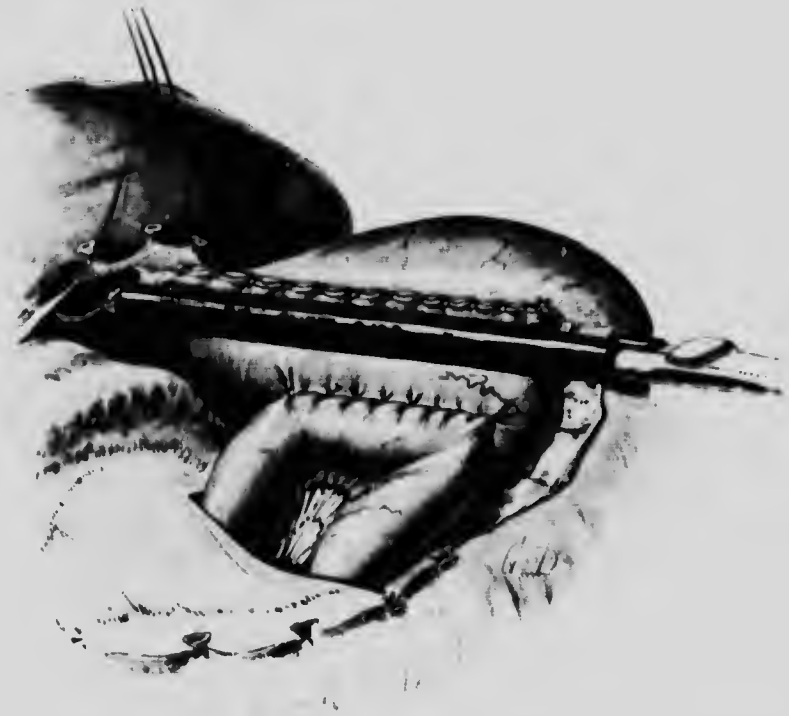

FIG. 160.—Partial Gastrectomy for Carcinoma. The gastro-jejunal anastomosis has been completed, and the diseased segment of the stomach removed. The first or penetrating line of suture has been passed through the cut margins of the part of the stomach left behind before the clamp is removed.

Post-operative Measures.— If necessary, subcutaneous or intravenous saline injections are given immediately or continuous proctoclysis instituted. In the majority of cases, however, half a pint of normal saline solution with an ounce of brandy, given per rectum when the patient gets back to bed, and the same amount of saline repeated every two or three hours if necessary, is all that is called for. An enema of hot coffee is an excellent stimulant.

As soon as the patient returns to consciousness he should be propped up in Fowler's position as a precaution against pulmonary complications. Water in small quantities may be given by the mouth as soon as asked for.

For some days nutrient enemata should be administered, but the staple food

consists of peptonised milk given by the mouth. At the end of seven days an egg may be added. Then soups followed gradually by finely minced chicken and other articles of light diet are indicated.

If the patient is very restless or in pain after the operation one efficient dose of morphia ($\frac{1}{6}$ – $\frac{1}{4}$ gr.) is given.

FIG. 161.—Partial Gastrectomy for Cancer. This figure represents the closure of the gastric aperture as it approaches completion. The first or penetrating suture is invaginated by the second or sero-muscular line of suture. The peritoneal forceps grasp two folds of the stomach wall at the greater curvature, and by exercising moderate traction these are rendered prominent and the passage of the needle thereby facilitated.

COMMENTS.

Operative Results.—The immediate mortality of gastrectomy may be regarded as somewhere between 14 and 20 per cent. Of the patients who recover about 20 per cent. remain free from recurrence within three years, whilst about 12 per cent. are absolutely cured (Paterson). According to Leriche the chances of ultimate cure are 20 per cent.

The chief causes of a fatal issue immediately after operation are: (*a*) leakage from the duodenum or stomach; (*b*) intragastric hæmorrhage; (*c*) acute peritonitis; (*d*) pulmonary complications; (*e*) internal strangulation; (*f*) gangrene of the transverse colon.

Duodenal Leakage may be difficult to prevent when the bowel section has been made far out towards the right side, but as a rule there is sufficient of the gut left in front of the pancreatico-duodenal angle to permit of adequate inversion of the closed aperture. This inversion may in some cases be facilitated by incising the peritoneum over the right kidney about an inch to the outer side of the second stage of the duodenum, thus mobilising the duodenum after the manner of Kocher (Fig. 148). Fixation of a flap of omentum by a few sutures over the closed duodenal stump lends additional security and is a much safer procedure than the use of a tampon or gauze drain leading down to the duodenum. This latter method has an undoubted tendency to promote fistulous formation.

Extravasation of duodenal contents coming on quickly after the operation would excite a general peritonitis, but when an interval of some days has supervened the extravasation is localised by adhesions and may either find an exit through the abdominal wound or determine the formation of a subphrenic abscess. Should the latter occur one will have to contemplate the further possibility of intrathoracic trouble such as empyema or pneumonia.

The Lymphatics. In the account given of the lymphatic vessels it was pointed out that some of the efferents of the right gastro-epiploic glands passed downwards in the great omentum and looped backwards to the suprapancreatic glands by way of the transverse mesocolon in front of the colon. Some cases have been described in which it was found after death that cancer cells had permeated these vessels, giving rise to extensive involvement of the omentum and mesocolon. In some of these the free edge of the omentum had become attached by adhesions infiltrated by cancerous cells to the parietal peritoneum or to the serous covering of the pelvic viscera. On this account free removal of the great omentum and stripping of the upper layer of the transverse mesocolon have been advocated as an essential part of any radical operation (Hey Groves). It is questionable whether even this procedure would be surgically sound, for in all probability some cancer cells would be left in the neighbourhood of the transverse colon. It would appear more advisable to remove the transverse colon itself in the cases in which the glands along the greater curvature are enlarged and the omentum in all probability involved (Paterson).

In this regard it would be important to know whether the lymphatic vessels in the great omentum were afferent or efferent in their relationship to the primary glands; if the latter, the probability is that once they are involved no operation can be really radical. Their removal, therefore, would increase unduly the immediate mortality of the operation, with questionable effect on the ultimate cure.

Cancer at the cardiac extremity of the stomach is badly suited for treatment by radical measures. The few cases in which excision has been undertaken have yielded results far from encouraging. The technical difficulties in removing the associated lymphatics and the probability of involvement of the œsophagus place a radical excision beyond the boundaries of present-day surgery, notwithstanding the efforts of certain surgeons to place the technique of the procedure on a sound basis.

Kocher's Operation for gastric cancer consists in the removal of the diseased segment followed by closure of the stomach wound by a double row of sutures and the implantation of the divided duodenum into the posterior gastric wall an inch or more to the left of the suture line.

This operation is no doubt feasible in cases of non-malignant ulceration and

malignant disease of limited extent situated at the pylorus, but for more extensive cases the approximation of the duodenum, even after mobilisation, to the remaining gastric segment may be impossible. From the standpoint of the lymphatics that are removed Kocher's operation would appear to be inadequate.

THE RESECTION OF GASTRIC ULCERS

The need for surgical treatment in cases of simple gastric ulcer is usually indicated when medical measures have failed or only afforded temporary relief or when certain complications supervene such as perforation, hæmorrhage, etc. To these latter may be added the distortion effects produced by the cicatricial changes which invariably take place with chronic gastric ulcers and lead to such serious conditions as obstructive narrowing of the pylorus and hour-glass stomach.

The proper course of treatment to adopt in these cases has been the subject of diverse opinions. For some time gastro-jejunostomy found many adherents, as the results of this operation seemed very satisfactory owing to the marked relief of symptoms which it afforded. However, apart from ulcers at the pylorus and its immediate vicinity, this method of treatment has not maintained its reputation as a therapeutic measure for ulcers situated in other parts of the stomach. In many cases, in spite of gastro-jejunostomy, the ulcers have persisted, hæmorrhages have recurred, perforation taken place, and, furthermore, evidence would appear convincing that in a considerable proportion of simple gastric ulcers malignant disease makes its appearance at a subsequent date. As already stated, the effects of gastro-jejunostomy are most satisfactory in cases of pyloric ulceration with narrowing of the pyloric outlet. So long as the pylorus is free the natural tendency is for the greater part of the gastric contents to escape by this outlet rather than by the artificial aperture. This latter in cases of unobstructed pylorus tends to undergo a progressive narrowing and may close almost if not completely, with the result that the original state of affairs is re-established.

Seeing that the results of gastro-jejunostomy have fallen short of the expectations of the adherents of this procedure, more especially in cases of ulceration affecting the body of the stomach, the proposal to resort to excision in the majority of cases has met with an increasing amount of support.

The form and extent of the operative procedure will necessarily vary in different cases, depending upon various circumstances, such as the position of the ulcer, its size and the presence or absence of adhesions. The forms of procedure to adopt in the more typical cases will be briefly considered.

Ulcer situated in the Anterior Wall of the Stomach. Before proceeding with the resection of the ulcer the stomach will be carefully examined for other possible ulcerated areas. If adhesions have formed with the anterior abdominal wall they will require to be set free. Another important detail in technique is to surround the implicated part of the stomach with gauze swabs rinsed out of hot saline solution so as to prevent fluids from within the stomach contaminating the peritoneum.

The centre of the indurated area is seized with forceps and drawn forwards, and an incision is made through the stomach wall at one side and carried round in healthy tissue, bleeding vessels being immediately secured. The resulting gastric aperture is closed by sutures passed from above downwards, and not from left to right, in order to prevent any tendency to hour-glass constriction.

After the resection of a large ulcer the stomach may become so altered in shape that the passage of its contents into the duodenum may be rendered difficult. Such a condition might result from an extensive resection in which the extremities of the lesser curvature were brought close together and the stomach bent upon itself in such a way as to form a dependent bag. It would be necessary in a case of this kind to perform a posterior gastro-jejunostomy.

Ulcer in relation to the Lesser Curvature. If the ulcer is of moderate dimensions it may be possible to remove it by means of a wedge-shaped resection. The gastro-hepatic omentum will require to be divided to the necessary extent and ligatures applied to the divided margins. The lesser curvature is thus set free and the finger can be passed down behind it from above. The vessels on each side of the indurated area are ligatured unless the degree of puckering and distortion present renders this step impossible. The ligatures are of catgut and are passed with a blunt needle.

If the stomach has been mobilised to a sufficient extent the part to be excised is drawn forwards between two clamp forceps, which are applied one on each side of the ulcer area and converge so as to come close together at their distal extremities somewhere between the greater and the lesser curvature; it is advisable, however, not to seize so much of the stomach that the V-shaped section would come close to the greater curvature, as this might lead to subsequent distortion of the stomach where the margins of the wound had been brought together.

The first sutures introduced are of catgut or of fine linen thread, and are passed in such a way as to resemble a continuous mattress suture the loops of which appear on the mucous membrane. This arrangement ensures that the serous surfaces of the stomach are brought into contact. A second row of sutures is applied for greater security; it is of the sero-muscular type. If the gastric aperture is small the line of suture should be arranged so as to lie in the long axis of the stomach. When the sutures are introduced from side to side there is a tendency for the lesser curvature to be shortened and the stomach bent upon itself and distorted.

Partial Gastrectomy.—If the ulcer is associated with a large amount of inflammatory thickening and encroaches upon the pyloric area its removal will be accomplished most satisfactorily by means of a partial gastrectomy (Rodman). This is performed by a technique similar to that already described for gastric carcinoma, but the procedures differ in certain important particulars. Thus in inflammatory cases there is no necessity to divide the tissues far away from the indurated mass. The detachment may be effected quite close to the latter and adhesions may to a large extent be separated by means of dry sponging, the chief precaution necessary being not to tear into the ulcer in doing so. It is in the management of the perigastric adhesions that the chief difficulty in these operations consists. When the liver is involved it is usually the left lobe, and the ulcer may have made its way from the stomach into the liver substance. In such a case the easiest way to proceed will probably be by the employment of the actual cautery. The finger is slipped beneath the thin left lobe, and this is divided with the cautery close up to the line of adhesion. In some cases the adherent liver may be detached from the stomach without much trouble and without an undue amount of bleeding, as the liver tissue will have undergone cicatricial changes and become tough and fibrous. When so altered it is easily sutured and the stitches do not cut their way out.

When an ulcer adherent behind is separated from the pancreas the latter may be found to have been involved by extension from the gastric ulcer. The affected part

is wiped clean and gently swabbed with tincture of iodine. If possible it should be covered with a piece of omentum, which is drawn up from below and retained *in situ* by a few sutures.

Adhesions of the stomach behind are most readily dealt with by first dividing the stomach to the right of the indurated mass and then turning its pyloric segment over to the left as in the procedure already described for the resection of gastric cancer. Adhesions are thus exposed to view and may be divided, or, in the case of recent agglutination, the stomach may be detached by the aid of gauze swabs rolled around the finger. Old adhesions when divided may bleed rather freely, but the chief vessels are secured by catgut ligatures, and for the remainder temporary gauze pressure usually suffices. If the pancreas has been implicated and the detachment of a portion necessary, the raw surface of the gland should be covered by a piece of omentum.

Following the resection of the pyloric segment of the stomach the procedure may be terminated by an implantation of the divided duodenum into the posterior aspect of the stomach as recommended by Kocher, after securely closing the distal extremity of the divided viscus. If the approximation of the duodenum to the stomach were impossible even after mobilisation of the former, the rational procedure would be to close the duodenum in the manner already described and anastomose the jejunum near its commencement with the stomach as in the operation of posterior gastro-jejunostomy (Rodman).

If the area of the stomach resected does not reach quite up to the pylorus it may be possible to effect a direct junction between its left and right segments, unless these are of very unequal proportions.

Ulcer on the Posterior Wall of the Stomach.—This part of the stomach may be difficult of access by the ordinary routes, viz., by way of the gastro-hepatic omentum above; through the great omentum or the transverse mesocolon below. For ulcers of limited extent on the posterior wall the best access probably is afforded through an incision in the anterior wall. The direction of the incision in such cases is from left to right midway between the curvatures. Before making it the lesser peritoneal sac is opened by dividing the gastro-hepatic omentum above and the gastro-colic omentum below. Through these apertures the fingers are introduced and, if necessary, adhesions binding down the stomach may be divided. Should bleeding follow it will be arrested without much difficulty by the application of hæmostatic forceps and firm gauze pressure for a few seconds.

When the stomach has been opened from the front the fingers of the left hand passed from above through the aperture in the gastro-hepatic omentum come into contact with the posterior gastric wall and invaginate it in such a way as to cause it to protrude through the aperture in front, the margins of which are held apart by forceps.

The ulcer is protruded in this way and excised, but before the excision is completed the healthy margins of the stomach are brought together by through-and-through sutures passed from above downwards, traction upon the stomach being exerted meanwhile by drawing forwards the partially detached ulcer area. The resection wound in the stomach is closed with care so as to bring serous surfaces into contact and prevent the possibility of leakage. Before commencing the resection the area behind the stomach is protected from contamination by strips of gauze rinsed out of hot sterile salt solution passed from below through the aperture in the great omentum.

The anterior gastric wound is closed in the usual manner by two rows of sutures,

the first of which penetrates all the coats of the viscus and the second the serous and muscular coats only.

As a precautionary measure a gauze drain protected by rubber is introduced behind the stomach from above the lesser curvature and led out through the upper angle of the wound.

THE TREATMENT OF PERFORATION IN GASTRIC AND DUODENAL ULCERS.

In the class of case about to be considered the perforation takes place suddenly, and in the absence of protective adhesions there is an extravasation of the gastric or duodenal contents into the general cavity of the peritoneum.

The Stages of the Operation. *The Abdominal Incision* is made a little to the right of the middle line and should be of sufficient extent to permit of easy access to the stomach and its surroundings. As soon as the peritoneum is divided there may be an escape of gas as well as of fluids. If the latter are bile-stained there is a presumption that the duodenum is the seat of perforation, while if the fluid is colourless or if particles of food are mixed with it it is probable that the perforation is in the stomach.

The Perforation: its Mode of Closure, etc.—The seat of perforation is usually found without much difficulty. Search should first be made along the lesser curvature from the cardia to the pylorus and over the anterior aspect of the duodenum. If some hours have elapsed from the onset of the perforation its site may be indicated by the fibrinous exudate deposited in its immediate vicinity and by the more pronounced vascular unit in the peritoneum.

Some swabs rinsed out of hot saline solution are quickly packed all round and an attempt is made to close the aperture. In many cases this can be accomplished without much difficulty. A single mattress suture of catgut is passed through all the tunics of the stomach on each side and tied with just sufficient force to occlude the opening. Sometimes the tissues bounding the perforation are so friable that a suture will not hold. If the needle be introduced further out the suture will probably hold all right, and in tying it the margins of the aperture are bent and turned inwards. Some additional sutures are introduced through the serous and muscular coats; they cause further invagination and promote a secure degree of occlusion. It is usually a wise precaution to draw a piece of omentum over the sutured perforation and retain it by a few additional stitches.

Should the stomach be full, the process of suturing will be greatly facilitated by washing it out first by the aid of a stomach tube. Its walls are thus rendered lax and tension on the sutures is avoided.

It has been proposed to excise the ulcer-bearing area and its infiltrated margins preparatory to the suturing process, but in view of the necessity for speed in these cases and the precarious condition of the patient such a course may be attended by grave risk.

Cleansing of the Peritoneum.—The amount of extravasation of gastric or intestinal contents varies enormously in different cases. The stomach is usually full when the perforation takes place, and if the aperture is large the extravasation may be considerable; as a rule, however, the aperture is small—in the greater number of our cases it has not exceeded in size the extremity of a cedar pencil.

Some years ago the extravasated matters were removed in a large proportion of

cases by flushing the peritoneum with warm saline solution. This was allowed to flow in freely through the wound so that the entire peritoneal cavity was flooded and particular attention was given to the lumbar recesses, the region around the spleen, and the pelvic cavity. A second opening was made above the pubis, and through it a large amount of fluid was allowed to escape. At the present day this method of cleansing the peritoneum has been largely abandoned, as it is calculated to increase shock, and it does not appear to be more efficacious than the method of cleansing by means of swabs. When these are employed they should be used with gentleness; vigorous rubbing of the peritoneum is to be avoided altogether. The swabs are rinsed out of warm saline solution and are gently pressed against the peritoneal surfaces. The pelvic cavity must not be overlooked, as matters escaping from the aperture in the anterior wall of the stomach gravitate to the pelvis by flowing down over the great omentum. As the gastric contents are usually sterile it will not be necessary to employ drainage in the majority of recent cases.

When there has been much extravasation, and when operation has not been performed for some hours, it will be safer to drain the pelvis through a suprapubic wound.

An unpleasant sequence of gastric or duodenal perforation is subphrenic abscess, and with a view to anticipate its occurrence some surgeons introduce a drain on one or both sides so as to drain the subphrenic space. Similarly in cases where peritonitis has developed drains may be introduced into the lumbar hollow on each side, but as a rule they are not necessary.

Gastro-jejunostomy.—Opinions have been somewhat at variance as to how far this operation is indicated in cases of gastric or duodenal perforation. Stated briefly, we consider it unnecessary in cases where the perforation is in the body of the stomach or near its cardiac extremity. These usually do quite well after closure of the perforation. When the perforation is at or close to the pylorus, however, and when there is reason to expect subsequent narrowing with obstruction to the gastric outflow, we regard a gastro-jejunostomy advisable. Similarly when the perforation is in the duodenum, and when its closure entails a certain degree of narrowing of the lumen of the bowel, gastro-jejunostomy had better be performed.

Appendicostomy.—When the patient is in a condition of serious collapse or if the operation has been postponed unduly, we consider it wise to bring out the appendix through a stab wound in the right iliac fossa before closing the abdomen. We have found this procedure of the greatest utility owing to the facility which it affords for the prompt introduction of normal saline solution into the large intestine.

Post-operative Measures.—The patient is made to assume the half-sitting-up posture as soon as the effects of the anæsthetic have passed off. Saline solution is given per rectum continuously, or if suitable apparatus for its administration be not at hand it may be given at four-hour intervals with a soft rubber tube and funnel, about 10 fluid ounces being introduced each time.

There is no objection to fluids by the mouth in moderate quantity.

THE VERMIFORM APPENDIX.

APPENDICITIS. General Considerations concerning Operative Measures: Time selected for Operation.—This will necessarily depend upon whether the case is seen immediately after the onset of the attack or after the symptoms have been present for some time.

The general consensus of opinion at the present time is to submit each case to surgical treatment at the earliest possible moment after the onset of the attack rather than postpone operation with the hope that the inflammation may subside and resolution take place.

The chief arguments against waiting are that it is always impossible to tell whether the attack will gradually subside or not, that the condition of the appendix may be much more serious than the local and general symptoms would lead one to expect,

FIG. 162.—An Appendix removed within three hours after the onset of the attack. There was a history of two slight attacks previously. The appendix was much enlarged and evidence of incipient gangrene was obvious near its distal extremity. There was also a minute pin-hole perforation. On opening into the appendix after removal three concretions were found; that next to the cæcum had evidently succeeded in blocking the lumen of the appendix, with resulting distension of the latter on the distal side of the obstruction.

and that, even in cases which at first appear to follow a favourable course, serious complications may develop after some days and demand operation when the conditions, both local and general, are much less favourable.

Experience has abundantly shown that it is not safe to rely entirely upon the local signs and the symptoms generally in cases of acute appendicitis. Those symptoms upon the presence or absence of which reliance has been placed are mainly the following: the temperature and the pulse frequency, local tenderness and rigidity, and the general aspect of the patient. It cannot be said, however, that these symptoms either singly or collectively afford the surgeon a true index of the pathological change

in and around the appendix. Even with pronounced disease in the latter there may be but little pain and tenderness in the right iliac fossa, and the rigidity of the abdominal muscles, which is a sign of great value, may be slight although the pathological changes in the appendix are well marked.

The pulse frequency has been regarded as a valuable sign, more especially when it shows a steady acceleration in conjunction with increasing tenderness and rigidity in the right iliac fossa. It may happen, nevertheless, that the condition of the appendix may be very serious and yet no real indication of such be manifested by the pulse rate.

A strong argument in favour of early operation naturally follows from the greater ease and freedom from risk with which an inflamed appendix may be removed within the first few hours after the onset of symptoms. There will not have been sufficient time for adhesions to form, and consequently the appendix, assuming that it is a first attack, will be readily exposed and its removal effected without difficulty. The specimen represented in Fig. 162 was removed exactly three hours after the first seizure of acute abdominal pain, yet it had already perforated, and in addition to being very much dilated it contained three large concretions. The risk attending these early operations is very slight, and it is not necessary as a rule to drain the abdomen. In early fulminating cases immediate operation is without doubt a life-saving procedure.

When the patient is not seen until the symptoms have been in evidence for twenty-four or thirty-six hours operation is still the best course to adopt, more especially if local rigidity and tenderness are pronounced, and if there is evidence that the pulse rate has risen gradually since the commencement of the attack. In any case operation at this period must be regarded as a safer course than waiting in the hope that the symptoms may subside.

When the patient is not seen until three or four days have elapsed the question as to the best course for the surgeon to adopt is one upon which opinions are divided. As a rule we prefer to operate without delay, as we consider that an operation performed with careful attention to technique offers much less risk than expectant treatment. No doubt many of these cases if treated by non-operative measures would do very well, but in a certain proportion a satisfactory convalescence may fail to take place, and instead of resolution an abscess may develop and reveal its presence by a hard, tender mass in the right iliac fossa.

When evidence points to suppuration with appendicitis there is no longer any question as to what should be done. The only course open to the surgeon is to operate at the earliest possible moment. The details of the various procedures are given below.

Operation during the Quiescent Stage.—The period selected is usually after an interval of some weeks from the subsidence of the acute attack. From three to six weeks may be taken as an average interval.

When possible the site of the diseased appendix should be identified during the course of the acute symptoms, so that the surgeon may subsequently be able to select the most direct route for its removal and reduce the degree of damage to the abdominal wall to a minimum.

It has been noted that after the subsidence of the acute symptoms there is a rapid absorption of the intraperitoneal fibrinous exudate, which explains the fact that exposure of the appendix during the quiescent stage often discloses that organ quite free from adhesions.

Operation is always indicated after an attack of appendicitis, no matter how slight it may have been, as it is a well-recognised fact that one attack predisposes to a recurrence owing to the frequency with which pathological changes, such as stenosis and kinking, have been brought about in the appendix which has been the seat of inflammation.

Suppurative Peritonitis with Appendicitis. The involvement of the peritoneum in the region of the appendix is a constant phenomenon, and upon its presence are explained the rigidity and the severe pain which are noted in these cases. In many instances the peritonitis is of the adhesive variety and results in agglutination of the appendix and the parts with which it is immediately related, viz., the cæcum and adjoining coils of small intestine, the great omentum and the peritoneum in the iliac fossa. When the inflammation is of a mild type it merely results in these agglutination changes, and resolution follows without further pathological developments. In severe cases the peritoneal reaction is more intense and the exudate quickly assumes a purulent character. When the peritoneum is involved suddenly, as may happen with perforation or certain cases of gangrene, or when the resisting power of the individual is low, the exudate, which is essentially of a virulent character, rapidly invades the peritoneal cavity, and may quickly involve a large area or even the entire extent of the serous sac. When the exudate is free and progressively extends from below upwards, involving more and more of the peritoneum, it is spoken of as a diffuse or spreading peritonitis. When the entire peritoneal cavity is implicated the resulting peritonitis is termed "total" or "universal." This is a rare form in connection with appendicitis, and when it does occur it usually results from rupture or gangrene of the appendix in association with a virulent form of infection.

Fig. 163. McBurney's Muscle-Splitting Abdominal Incision. The external oblique muscle has been divided in the direction of its fibres and its margins held apart. The deeper muscles, viz., the internal oblique and the transversalis, have been split in a direction at right angles to this.

In the majority of instances, however, the peritoneal changes in the region of the appendix have a gradual onset and are of a conservative nature. The exudate tend to coagulate, and fibrinous adhesions quickly form and shut off the appendix from the general peritoneal cavity. This is known as the local or circumscribed form o

appendicitis. Should suppuration occur the purulent exudate will be encapsulated and prevented from extending to the adjoining healthy districts. Such a collection is favourably situated for surgical treatment, and if promptly evacuated is followed as a rule by a rapid recovery. If adequate treatment, however, be not forthcoming, the consequences may be very serious, as the purulent collection may rupture into the general peritoneal cavity and give rise to a rapidly spreading or diffuse form of peritonitis, or without actual rupture taking place the local suppurative changes may spread gradually *in loco* and result in the formation of a series of loculated abscesses, which burrow in various directions, such as between adjoining coils of small intestine, within the pelvic cavity, or along the ascending colon.

Instead of bursting into the general cavity of the peritoneum these abscesses may discharge their contents into one of the hollow viscera —for example, the colon, rectum, bladder—or into the vagina.

An appendix abscess travelling upwards along the colon on the right side may form a collection in the subhepatic region (hepato-renal recess), and it may extend still further upwards between the liver and the diaphragm (subphrenic abscess). An abscess originating in the right iliac fossa may invade the pelvis and extend from this upwards to the left iliac fossa.

From the preceding observations it will be seen that the surgeon may meet with very varying conditions of the peritoneum in connection with suppurative appendicitis. The main point to be noted is whether the suppurative process is circumscribed by adhesions or is free within the general cavity of the peritoneum.

FIG. 104.—McBurney's incision has been completed and the cæcum with the appendix has been drawn out through the abdominal wound. The appendix has been secured by hæmostatic forceps close to the cæcum.

Localised Peritonitis.—As a rule it is not until the fourth or fifth day after the onset of the attack that granulation tissue begins to replace the fibrinous limiting adhesions and encapsulate the purulent exudate, giving rise to a definite abscess. The newly formed wall of this abscess cavity is at first thin and easily injured, but by the eighth day it is sufficiently firm to permit of intra-abdominal manipulation with safety. Up to this time the purulent exudate is very imperfectly limited by fibrinous adhesions.

The abscess so formed may occupy the usual appendix site, but as the appendix is sometimes abnormally situated the resulting abscess may occupy a correspondingly unusual position; thus it may develop behind the ascending colon, within the pelvic cavity, in the recto-vaginal or recto-vesical pouch, beneath the right costal arch, in the vicinity of the umbilicus, or even in the left iliac fossa. An appendix abscess may also form within a hernial sac in the inguinal, femoral, or umbilical region.

It is of great practical importance to determine whether the wall of the abscess is

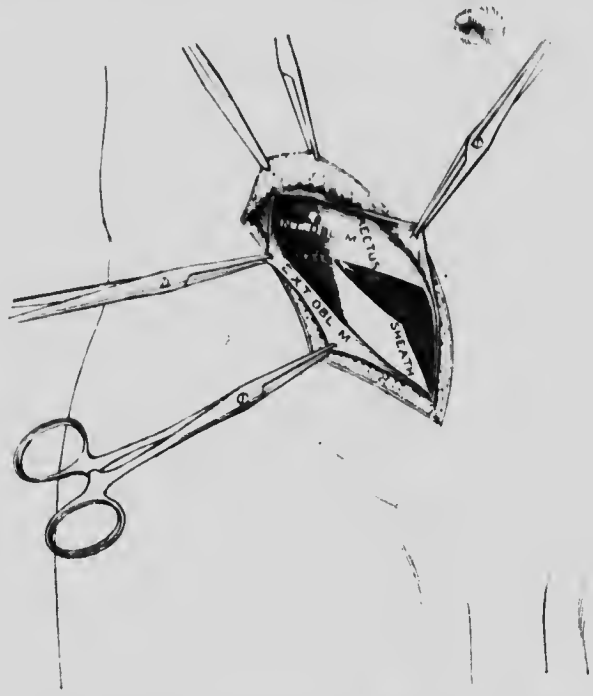

FIG. 165.—A method of extending the Muscle-splitting Incision in Appendicectomy. The margins of the divided tendon of the external oblique have been widely separated and raised and the underlying sheath of the rectus muscle has been incised in a direction at first inwards and then downwards, as represented in the figure. The internal oblique and transversalis muscles are split in the direction shown by the dotted line. This form of incision is further illustrated in the two succeeding figures.

or is not adherent to the anterior abdominal wall. If it is not adherent the general cavity of the peritoneum will of necessity be opened in the course of an operation directed towards the evacuation of the abscess. Such an operation is therefore intraperitoneal. On the other hand, if the inflammatory mass is glued to the peritoneum covering the anterior abdominal wall, the abscess may be reached without opening into the general cavity of the peritoneum; in this case the procedure will be extraperitoneal. These points are more fully considered below in connection with treatment.

APPENDICECTOMY.—The operation about to be described will apply to cases

in which the removal of the appendix is undertaken either at the onset of the acute attack before extensive pathological changes have taken place or during the quiescent period which follows the acute attack.

The Abdominal Incision.—Various forms of incision have been devised for reaching the appendix, their object being to provide good access to the iliac fossa and inflict the minimum of damage upon the muscles and nerves of the abdominal wall. The incision which has been associated with the name of McBurney is one by which the flat abdominal muscles are split instead of being divided at right angles to the direction of their fibres. The skin is divided for a distance of 3 or 4 inches in the direction of the fibres of the external oblique aponeurosis, its mid-point being situated about 1½ inches to the inner side of the anterior superior iliac spine. The aponeurosis of the external oblique muscle is exposed and divided to the full extent of the skin incision, and its edges are retracted by clip forceps. A small transverse incision is now made at the junction of the muscular with the aponeurotic fibres of the internal oblique and transversalis muscles, which are split in the direction of their fibres with the handle of the scalpel (Fig. 163). The transversalis fascia is picked up with forceps and incised, whereupon the peritoneum comes into view and is dealt with in a similar manner. The aperture in the peritoneum is at first of limited extent, as a small opening may suffice if the appendix is movable and can be drawn readily out of the wound. If more room is required the aperture may be extended (Fig. 164).

Although in many cases it is possible to deliver the appendix through the somewhat limited aperture afforded by this incision, yet it is not infrequently inadequate if the appendix is adherent or deeply placed. Under such conditions it becomes necessary to enlarge the wound, and this may be done most satisfactorily in the following ways. The method which is sometimes alluded to as that of Harrington consists in extending the section of the superficial tissues from the lower angle of the wound inwards to the middle line. The anterior layer of the rectus sheath is exposed and divided in the same direction; the muscle, however, is not divided, but is retracted inwards and the posterior layer of its sheath exposed. This latter, together with the peritoneum, is divided in the direction of the middle line and the abdominal aperture correspondingly enlarged.

Another method for extending McBurney's incision is illustrated in the adjoining figures (165 and 166); it is carried out in the following manner. The inner margin of the wound in the aponeurosis of the external oblique is raised and the subjacent tendon of the internal oblique muscle exposed. This is divided vertically for an inch or more, somewhat to the inner side of the outer border of the rectus muscle. With the handle of the scalpel the rectus is displaced inwards, and in doing so the deep epigastric vessels are exposed. Should they come into the way they will require to be doubly ligatured and divided. The peritoneum and fascia transversalis are next divided in the vertical direction also, and with good retractors *in situ* a wound of ample proportions is provided.

Access to an adherent or a deeply placed appendix may be still further facilitated by inclining the table moderately in the Trendelenburg position. The pelvis is raised and the movable coils of the small intestine are displaced towards the diaphragm. This brings the appendix well into view and greatly facilitates the intra-abdominal manipulations.

Another incision which we frequently employ is that of Battle (rectus incision). It has a vertical direction parallel to and about an inch internal to the semilunar line, *i.e.*, the outer border of the rectus muscle. The rectus sheath is divided and its margins held aside with clip forceps. The outer border of the muscle is next

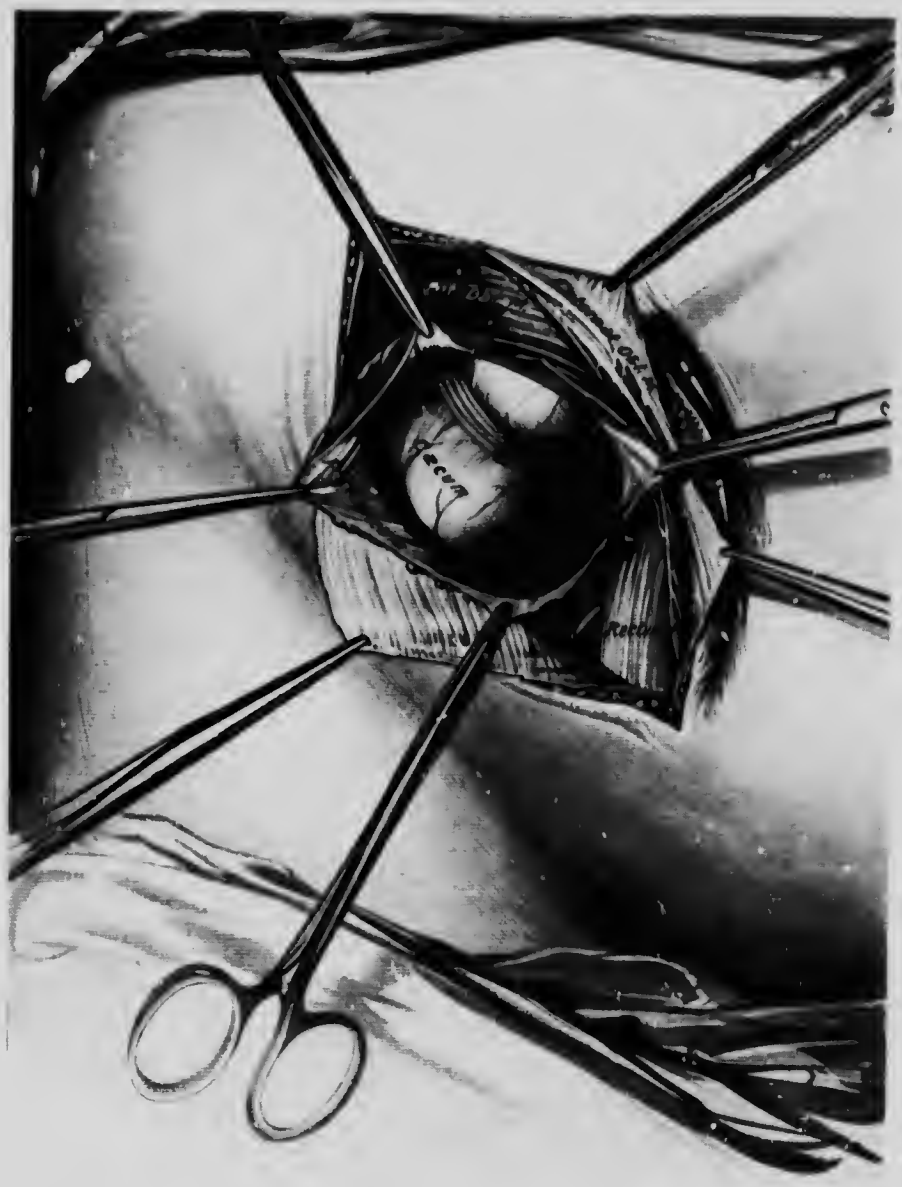

FIG. 166.—The Muscle-splitting Incision extended. The internal oblique and transversalis muscles having been divided and the incision prolonged towards and downwards through the rectus sheath, the transversalis facia and the peritoneum have been incised and the abdominal cavity opened freely. Note the deep epigastric vessels at the lower angle of the wound. The aperture provided by this incision is usually ample for exposing and dealing with the appendix when, in consequence of adhesions and fixity, its removal through the ordinary incision might be difficult or impossible.

FIG. 167.—The Muscle-splitting Incision extended. This figure represents a stage in the suturing process. The first stratum sutured consists of the peritoneum with the fascia transversalis. The second stratum is shown here; it consists of the fleshy portions of the internal oblique and transversalis muscles above, and the fused tendons of these muscles in front of the rectus muscle below. The two remaining strata to be sutured consist of the external oblique muscle and the skin.

defined by a little dissection and drawn inwards by a suitable retractor. The transversalis fascia and the lower portion of the posterior layer of the rectus sheath are divided in the same line as the cutaneous incision, care being taken if possible to displace the intercostal nerves, and the abdominal cavity opened. The deep epigastric vessels, if exposed, are drawn downwards and inwards, or if very much in the way they may be divided between ligatures.

A useful incision in some cases is that introduced by Davis. It measures about 2 inches in length, and at its centre crosses the semilunar line at the horizontal level of the anterior superior spine of the ilium. The aponeurosis of the external oblique muscle is cut across in the line of the cutaneous incision and the sheath of the rectus muscle opened, the internal oblique and transversalis muscles being split in the ordinary manner. If more room is required the wound may readily be enlarged outwards to the anterior superior iliac spine and inwards to the linea alba, the rectus muscle being forcibly retracted inwards.

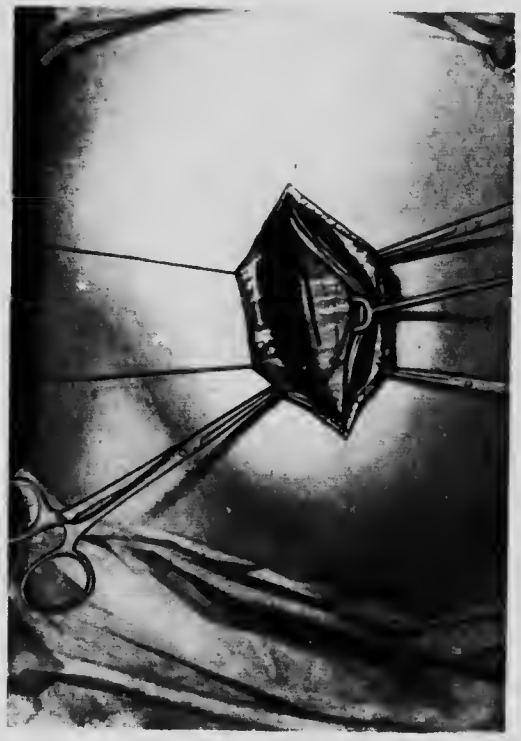

Fig. 168.—Battle's Rectus Incision. The superficial tissues and the anterior layer of the rectus sheath having been divided, the outer margin of the rectus muscle has been defined and drawn inwards by a retractor. The posterior layer of the rectus sheath has thus been exposed and the deep epigastric vessels are seen near the lower angle of the wound. The direction of the peritoneal incision is indicated by a dark line.

Delivery of the Appendix into the Wound.—The index finger of the right hand is passed into the wound and made to sweep along the peritoneal aspect of the anterior abdominal wall and the floor of the iliac fossa until it encounters the cæcum, which is lifted up into the wound and held with a piece of gauze. If the cæcum is not immediately encountered by this method the finger should be drawn upwards from the lower part of the floor of the iliac fossa along the iliac vessels, when it will be stopped by the mesentery of the ileum. The ileum, thus defined, can be followed to the cæcum and hooked up into the wound at the ileo-cæcal junction. The appendix is most readily found by tracing the anterior longitudinal band of the cæcum downwards.

The condition of the appendix will be found to vary very much in different cases, depending upon the extent to which its shape and connections have been affected by preceding inflammatory changes. It may differ but little in appearance from the normal, however, and when such is the case its delivery from the wound is easily accomplished. It is not uncommonly anchored by adhesions to adjoining parts such as the mesentery, the omentum, the wall of the cæcum, or it may be found deep

in the pelvis and adherent to the bladder or to the broad ligament in the female. A diseased appendix may be considerably swollen or sharply bent upon itself, and its distal end is not infrequently distended and bulbous; with this latter condition it is often possible to detect a stricture on the proximal side of the distension. Hard concretions are present occasionally within the appendix and may be detected on grasping it.

Should the appendix occupy one of the unusual sites already indicated its exposure and removal may be attended by difficulty. A common situation for it is the retro-cæcal fossa. It may occupy this pouch and be held down by adhesions within it, or it may even ascend higher behind the bowel and be related posteriorly to the ascending colon.

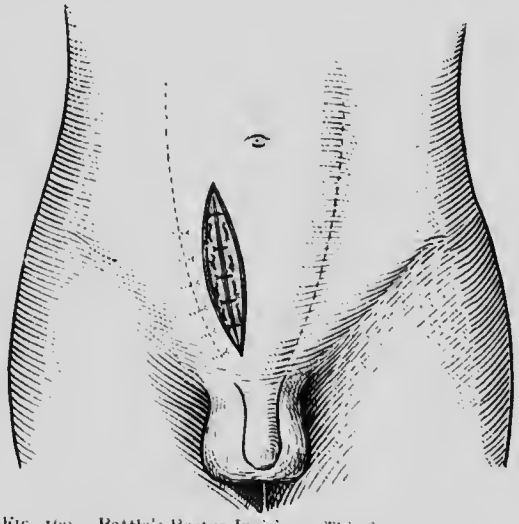

Fig. 169.—Battle's Rectus Incision. This figure represents a stage in the suturing process. The first stratum sutured consists of the peritoneum and part of the posterior layer of the rectus sheath. The rectus muscle has been allowed to resume its normal position and its outer border has been fixed in position by a few sutures, which are represented by dotted lines crossing the semilunar line. The margins of the rectus sheath in front have been connected by a series of interrupted sutures.

Section of the Meso-appendix.—The appendix with a portion of the cæcum having been drawn out through the wound and carefully surrounded with swabs, which at the same time protect the tissues of the parietes, the surgeon proceeds to divide the meso-appendix. When the latter has not become distorted by pathological changes and is free from adhesions it is made tense by drawing on the appendix and the vessels between its layers at the same time are rendered evident. The chief artery of supply to the appendix runs quite close to the free border of the fold, and is readily secured by a ligature passed through the latter at a non-vascular interval (Fig. 170). The ligatured portion of the meso-appendix is divided and a second ligature passed through the mesentery close beside the base of the appendix, where a vessel is usually present and may cause troublesome bleeding unless its presence is suspected. The section of the mesentery is now completed and the appendix fully detached quite up to its basal attachment.

Removal of the Appendix followed by Invagination of its Stump.—The appendix, surrounded by sterile swabs, is seized close to the cæcum with hæmostatic forceps or a special crushing clamp, such as that of Doyen. The part grasped is crushed so as to form a very thin layer consisting of little more than the serous investment of the tube, the other layers having been torn across and having undergone retraction. The clamp is removed and the crushed portion surrounded by a ligature of fine catgut. The appendix is cut across on the distal side of the ligature or divided with the cautery and removed. It is advisable to employ either two hæmostatic forceps or a clamp with blades broad enough to provide a crushed segment of sufficient length to enable the section to be made on the distal side of the ligature, otherwise the lumen of the

appendix will be opened and unnecessary risk of peritoneal soiling incurred. If the divided mucous membrane appears on the cut surface of the stump contamination is avoided by wiping it clean and either cauterising it or applying pure carbolic acid. Thorough crushing renders the application of a ligature unnecessary in many cases. The stump is invaginated either by means of a purse-string suture applied as represented in Fig. 172 or by means of a short line of continuous suture applied in such a way as to raise two folds of peritoneum which come together over the invaginated stump (Fig. 174).

Before returning the protruding intestine it is carefully wiped dry and inspected

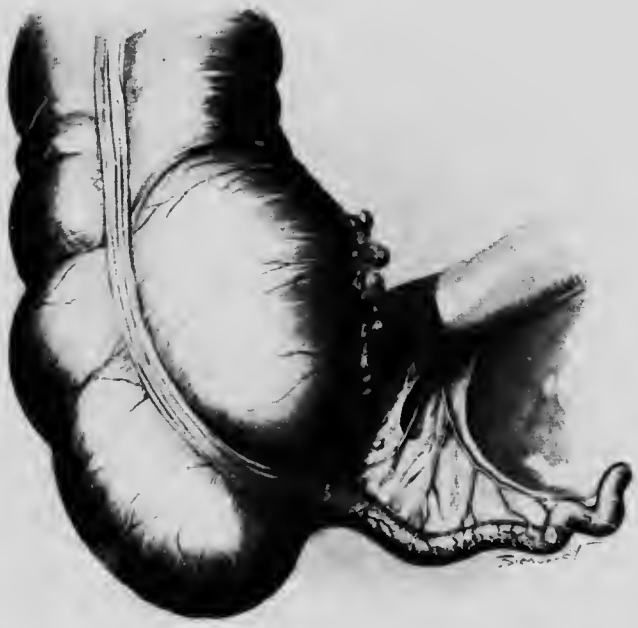

Fig. 170. The Normal Cæcum and Appendix. This figure illustrates the more usual arrangement of the meso-appendix and its contained blood vessels. The principal artery, which is derived from the ileo-colic branch of the superior mesenteric artery, runs quite close to the free border of the meso-appendix. Another small vessel is directed to the angle between the base of the appendix and the cæcum.

for bleeding points; if any such are apparent they are controlled by one or more under-running fine sutures.

Closure of the Abdominal Wound.—The abdominal wound is closed in strata. Following McBurney's incision, the first line of suture engages the cut margins of the peritoneum and transversalis fascia. The transversalis and internal oblique muscles are next sutured, and then the tendinous margins of the external oblique and possibly those of the rectus sheath if this has been divided. Finally the skin and superficial tissues are approximated by two or three interrupted sutures of silkworm gut supplemented by Michel's metallic clips. Drainage is not necessary. The sutured wound is painted with tincture of iodine and a light sterile dressing applied.

COMMENTS.

The Abdominal Incision.—The great advantage claimed for McBurney's muscle-splitting incision is that it entails but slight risk of a ventral post-operative hernia provided that healing takes place without suppuration. As already stated, however, it affords but limited access, and unless extended by one or other of the methods described above it is badly suited for cases in which the appendix is bound down by adhesions or situated in an unusual position such as within the pelvic cavity or behind the cæcum.

FIG. 171.—Excision of the Appendix. The meso-appendix has been ligatured in sections and divided. The appendix has been seized with a pair of hæmostatic forceps close to the cæcum and crushed.

If it were possible to tell beforehand with a fair degree of accuracy the position of the appendix it would be an advantage, as the surgeon could then arrange the abdominal incision accordingly. In those cases where operation is postponed until the subsidence of the acute stage, *i.e.*, in the quiescent interval, cognisance should be taken of the point of maximum pain and tenderness on abdominal palpation during the acute stage, as it may be taken as a guide to the appendix site. By such investigation it may be ascertained if the appendix occupies its normal situation in the iliac fossa or if it has reached a lower level, below the pelvic brim, or lies more posteriorly and at a higher level behind the cæcum, or possibly still further up behind the ascending colon.

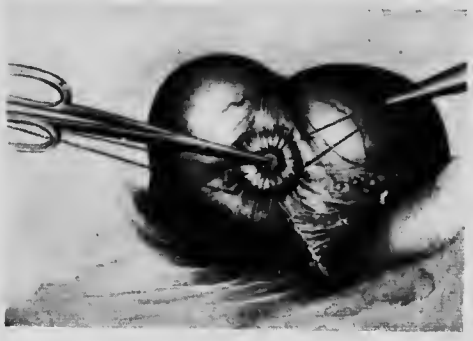

FIG. 172. Excision of the Appendix. This figure represents the crushed and ligatured stump of the appendix in process of being invaginated into the cæcum. A purse-string suture has been passed circumferentially around the base of the appendix. A loop of this suture is being held on one side and the two free ends on the other; this enables the appendix stump to be depressed and buried when the suture is drawn tight.

FIG. 173. Invagination of the Appendix Stump. This figure represents the purse-string suture knotted. The appendix stump has been buried and completely concealed from view by the folds which have been drawn together over it.

Battle's rectus incision is to be recommended in cases where doubt exists as to the

diagnosis of appendicitis or if the exact site of the appendix has not been definitely ascertained. This incision has an advantage over that of McBurney in that, in the event of a mistaken diagnosis, it may be extended upwards so as to give sufficient access to the duodenum, the gall bladder and pylorus, or downwards to expose the uterine appendages or to evacuate a pelvic abscess.

In drawing the rectus muscle inwards one or two of the lower intercostal nerves are usually exposed, and if possible they should not be divided, but retracted to one side and preserved from injury. The peritoneal incision is usually made vertically, but it may be possible to deliver the appendix quite satisfactorily through one directed

FIG. 174.—Invagination of the Appendix Stump. This figure represents a method which we frequently employ. Two folds are raised and are connected together over the appendix stump by a continuous sero-muscular suture.

transversely ; such an incision has the advantage of preserving the nerves from injury. If more room is required it may be supplemented by a second incision in the vertical direction.

Battle's incision is closed by three rows of sutures. The first row includes the peritoneum with the fascia transversalis and the divided portion of the rectus sheath, the rectus muscle being allowed to slip outwards so as to cover and protect the suture line. The next row closes the gap in the rectus sheath in front, and the third row brings together the margins of the skin and the subcutaneous tissues.

The utmost care is necessary in opening the peritoneal cavity to avoid injury to the bowel. In some cases the cæcum will be found to have acquired adhesions to the parietal peritoneum, and unless this possibility be borne in mind serious conse

quences may supervene. The accident is best avoided by picking up a small fold of the serous membrane and dividing it between elip forceps.

The Appendix.—It has been already stated that the position of the appendix is subject to considerable variability and that its delivery from the wound may be rendered difficult by adhesions the result of previous inflammation. An appendix situated behind the cæcum and embedded in adhesions may give much trouble. In a case of this kind the intra-abdominal procedure will be facilitated by inclining the operating table in the Trendelenburg position to a moderate extent and enlarging the parietal wound sufficiently to get a good view of the cæcum and its surroundings (Figs. 165, 166). If the peritoneum at the outer side of the cæcum is now divided the bowel may be raised and displaced inwards and the appendix at the same time rendered sufficiently accessible to permit of its removal.

The usual procedure employed in the removal of an appendix presenting normal relationships or one but slightly adherent has been described. Sometimes the appendix in consequence of adhesions resists attempts to bring it out of the wound. By drawing the cæcum forwards such an appendix may frequently be rendered accessible at its basal extremity while its tip is fixed within the pelvis or possibly away up behind the colon. The best procedure to adopt in a case of this kind is to crush and divide the appendix at its base, the utmost care being taken to prevent peritoneal contamination in doing so, and then to detach it from its surroundings. This step may often be accomplished with singular facility by gauze sponging. The meso-appendix is divided and its vessels secured by one or more ligatures.

Should the peritoneal adhesions around the appendix be still more pronounced the operative difficulties will be correspondingly increased. In a typical case of this kind the appendix is quite devoid of mobility, and when exposed to view it will be found adherent along its entire length. The procedure of decortication described by Kelly is particularly useful here, and is carried out as follows: The appendix having been exposed at its basal extremity, is incised in its longitudinal axis without opening up its lumen. With the aid of a suitable blunt dissector the serous and muscular coats are stripped off without difficulty, leaving the mucous coat with perhaps some of the circular muscular coat as an intact cylinder. This latter is followed towards the cæcum and ligatured. It is then cut across on the distal side of the ligature, the ligatured stump disinfected, and the open extremity of the tube grasped by hæmostatic forceps. The process of decortication is continued until the distal extremity of the appendix is reached. Finally the mucous cylinder is completely detached and the resulting cavity obliterated by means of a continuous suture of fine catgut passed through the serous and muscular tunics of the appendix which remain behind.

The Stump of the Appendix.—As a rule we prefer to apply a ligature to the stump of the appendix. If the crushing has been effectively performed this precaution no doubt may be unnecessary. Several cases of post-operative intracæcal hæmorrhage have been recorded in cases where the application of a ligature has been omitted.

When the appendix is swollen and œdematous or indurated in consequence of inflammatory infiltration, attempts to crush it would probably result in tearing owing to the brittleness of its tissues. A safer method to adopt is to make a circular cut around the appendix near its base and turn back a sleeve-like flap of serous membrane. The lumen of the appendix is occluded by a ligature of catgut applied close to the cæcum, and after the appendix has been divided on the distal side of the ligature and the stump disinfected the sleeve of peritoneum is drawn forwards and its margins connected by a few points of suture.

SUPPURATIVE APPENDICITIS.—Certain facts relative to the pathological changes within the peritoneal cavity in cases of suppurative appendicitis have been alluded to above. It now remains to consider those procedures which are best adapted to bring these cases to a successful issue.

It will be most convenient to divide them into two groups, viz., those in which the peritoneal inflammation is well circumscribed by adhesions and those in which the exudate is free within the peritoneal cavity.

The Abdominal Incision.—The most ready way to reach the area of suppuration is by an incision carried directly through the tissues of the abdominal wall above the outer part of Poupart's ligament and the adjoining portion of the iliac crest or further in parallel to the semilunar line. Such incisions, while affording good access to abscess collections, have the disadvantage of weakening the abdominal wall and facilitating the subsequent development of a hernia, more especially if drainage is employed.

McBurney's muscle-splitting incision is not very suitable, as it does not afford sufficient room to permit of a good exposure of the appendix and its immediate surroundings. We find Battle's rectus incision very suitable in the majority of these suppurative cases. It furnishes a ready approach to an appendix situated in the usual position, and if it is necessary to explore the pelvic cavity lower down or the lumbar hollow at a higher level the abdominal wound may be extended to the necessary extent to provide the fullest access. Objection has been made to this incision that it opens up the rectus sheath and may be followed by a spreading infiltration of the abdominal wall, but in our experience of a large number of cases this objection is imaginary rather than real. We have not observed any tendency to a spreading cellulitis or pocketing of discharges; the wound usually heals well in drainage cases, and the risk of hernia seems to us to be less than when other incisions have been employed.

LOCALISED SUPPURATIVE APPENDICITIS.—The Intra-abdominal Procedure when Adhesions exist between the Inflammatory Tumour and the Abdominal Wall.—As stated above, the hard area representing the inflammatory zone within the right iliac fossa may or may not have acquired adhesions to the anterior abdominal wall. In opening the abdomen by one of the usual incisions the surgeon should be prepared for such contingencies. When adhesions exist the peritoneum will require to be divided with special care so as to avoid a wound of the cæcum or some adjacent coil of intestine, but it frequently happens that these are overlaid and protected by the lower free extremity of the great omentum, which may be found much swollen and congested. This structure serves a most valuable purpose in these cases, seeing the constant part it plays in the adhesive process and the successful manner in which it so frequently shuts off the appendix and averts a rupture of its contents into the general cavity of the peritoneum.

Assuming that the iliac tumour is adherent to the abdominal wall, the surgeon must proceed to open into the cavity of the abscess, but before doing so we consider it a useful procedure to swab the margins of the wound with tincture of iodine.

In some of these cases in which adhesions are present the deeper tissues of the abdominal wall when divided often appear yellow in colour and œdematous, and pus may escape as soon as the peritoneum is incised. When the pus is at a deeper level it will be reached, as a rule, by directing the finger between the outer margin of the tumour and the parietal peritoneum downwards towards the floor of the iliac fossa. In doing so the adhesions, which are soft and friable, readily give way, and

the entrance of the finger into the abscess cavity is immediately followed by the escape of very foul-smelling pus. This is allowed to flow away and is mopped up with muslin swabs. The abscess cavity is now investigated more fully, and its walls are carefully wiped dry with swabs ; this should be done with the utmost gentleness, so as to avoid unnecessary and dangerous breaking down of adhesions. During this cleansing process pus may be seen to ooze from some part of the abscess wall, indicating the presence of a diverticulum, which must be gently explored with the finger. Diverticula are found not infrequently at the upper part of the abscess cavity under the cæcum or along the outer side of the ascending colon. The next most common site is the pelvis.

In all probability these manipulations will reveal the presence of the appendix, which may appear thickened, deeply congested, and covered with granulations or felt as a hard cord in the wall of the abscess. Its most frequent situation is below or behind the cæcum. Beginning at its extremity, the surgeon proceeds to mobilise it gently with the finger. If the meso-appendix can be seen it should be controlled by forceps before the liberation process is completed. In the majority of cases the mesentery is not obvious, and there is some bleeding when the appendix is being freed ; this, however, is readily controlled by gauze pressure or by an artery forceps. When the appendix is sufficiently free it should be ligatured close to its base and divided, preferably by the thermo-cautery. It is not always wise to attempt invagination of the stump, owing to the danger of disturbing adhesions, and it is sometimes impossible if the inflammatory changes have rendered the tissues of the cæcum very friable.

Drainage.—The appendix having been removed, a large split rubber tube with a loose wick of gauze is inserted into the abscess cavity. In those cases in which the pus has travelled upwards behind the colon and downwards into the pelvis a tube should be carried to the bottom of each extension. The surgeon must remember that a stiff rubber drainage tube passing into the pelvis from the right iliac fossa may very readily lie against the iliac vessels and cause erosion.

An extension of the abscess behind the colon, *i.e.*, within the right lumbar hollow, may be drained very successfully by a tube introduced through an opening made posteriorly above the iliac crest. Two fingers introduced through the abdominal wound are made to press backwards in the loin ; the tissues are thus made tense and are rapidly divided. A tube is introduced, and its deep extremity is guided to the recess at the outer side of the colon or behind the cæcum.

A few silkworm-gut sutures will usually be required to diminish the size of the wound. It is better, however, to have a large opening for drainage than a small one.

The Intra-abdominal Procedure when the Inflammatory Tumour is not adherent to the Anterior Abdominal Wall.—When the structures involved in the inflammatory mass in the iliac fossa are not adherent to the anterior abdominal wall it will be necessary to traverse the free peritoneal cavity before reaching the abscess. These cases require some further consideration.

The incision in the abdominal wall is made cautiously, in order to avoid rupture of the abscess and dissemination of its contents. Assuming that the peritoneum has been divided, the utmost gentleness will be necessary in the subsequent manipulations. Some swabs rinsed out of hot saline solution are gently insinuated between the parietal peritoneum and the mass in the iliac fossa. The inner margin of the wound is raised and a large moist gauze swab insinuated beneath it and arranged in such a way as to isolate the abscess in this direction. Another swab is passed upwards

into the right renal pouch and a third downwards into the pelvis. Then and not till then is it permissible to interfere with the inflammatory mass around the appendix, for in many cases the slightest manipulation may cause a flow of pus, and this, in the absence of suitable protecting pads, might become widely extravasated and lead to a diffuse infection of the peritoneum.

The cleansing of the abscess cavity and the search for the appendix are carried out as before, and in doing so it not infrequently happens that a concretion is found free in the cavity; in some acute cases the appendix may come away in the slough. The method of dealing with an adherent and inflamed appendix in these abscess cases has been described above and needs no further comment.

Drainage.—The method for providing suitable drainage is described above; it usually consists in introducing one or more split tubes of good size, and containing iodoform gauze, deeply into the iliac fossa beneath the cæcum and others if necessary into the pelvis and the right loin. In some cases when the pus collection is situated behind the cæcum with a tendency to spread upwards, behind or to the outer side of the ascending colon, drainage may be effectively carried out by means of a tube introduced through a stab wound in the loin, and, provided that the abscess is of moderate extent, the abdominal incision in front may be closed. This, it need hardly be stated, would be a great advantage, as it would favour rapid healing of the wound and lessen the risk of a post-operative ventral hernia.

When the tubes have been arranged in position the wound is finally inspected and its margins wiped dry. The great omentum, which usually lies close at hand, may often be drawn down over the cæcum and arranged alongside the tubes with a view to promote adhesions and segregate the abscess site from the surrounding uninfected regions.

The protective gauze swabs introduced all round the indurated area before the evacuation of the abscess may now be removed, as the danger of spreading infection of the peritoneum after the precautions taken may be regarded as negligible.

Should the Appendix be removed?—The question as to the advisability of removing the appendix in addition to evacuating circumscribed abscesses is one concerning which opinions are divided. When the abscess is merely opened and drained symptoms may be expected to recur in about 15 per cent. of the cases and necessitate another operation at a subsequent date for the removal of the appendix. Again, the diseased organ, if left *in situ*, may keep up a troublesome discharge through a persistent sinus, and, even when no sinus is present, failure to complete the operation may result in persistence of induration and tenderness in the right iliac region.

The chief danger attending the removal of the appendix is that of infection of the general peritoneal cavity, but if the procedure detailed above is followed the risk is slight, as a liberal abdominal incision and careful packing before opening the abscess will reduce this danger to a minimum.

The question is one, however, to which a dogmatic answer cannot be given. Our practice, which has been described above, is to remove the appendix in every case, except when the necessary manipulations would result in the separation of too many protecting adhesions, or so prolong the operation that the risk to the patient's life would be increased.

APPENDICITIS ASSOCIATED WITH DIFFUSE OR SPREADING PERITONITIS.—The procedures described in the preceding paragraphs had reference to the definitely circumscribed forms of peritonitis resulting from appendix inflammation, but it not

infrequently happens that on opening the abdomen the peritoneal exudate is found to have no definite limitations; its tendency is rather to become diffused to an increasing extent throughout the peritoneal cavity.

These cases of diffuse peritonitis differ much in their intensity, and it is often possible by inspection of the exposed peritoneum to discern different degrees of virulency in the infective process.

Diffuse peritonitis is most frequently associated with appendicitis of the perforative or gangrenous form. With these the infection from within the appendix reaches the peritoneum with great suddenness, and often to an overwhelming extent. If the virulency of the organisms is marked the infective process tends to spread with great rapidity, and the toxic effects may be so pronounced that a fatal result follows within a few hours. Failing such a sudden termination, the peritoneum reacts, but to a different degree in different cases. Instead of an exudate richly cellular and with a high degree of bactericidal power, there may be one of a watery character, poor in cells and presenting a dirty, muddy colour. Such a type of exudate is of bad omen, and the cases in which it is encountered usually succumb to the toxic effects of the absorbed products or to a definite septicæmia.

In cases of a less virulent type the exudate, although found free when the abdomen is opened, may present a turbid appearance or a definitely yellow tint with freedom from odour. If operative measures have not been undertaken within the first twelve hours of the attack the exudate will present an increasing degree of turbidity, and it soon acquires a distinctly purulent character.

Some of these cases of diffuse or spreading peritonitis present evidences of attempts at encapsulation as adhesions tend to form, and these may to some extent shut off collections of pus and retard, if not definitely prevent, their spread throughout the surrounding peritoneal districts.

Objects aimed at in the Operation.—The first and the most obvious aim of the surgeon is to remove the source of supply of infective material, *i.e.*, the diseased appendix. In cases operated on early it usually lies free without any encapsulating adhesions, and when the abdomen is opened it will be recognised without difficulty. The next step will consist in removing the infected exudate by appropriate measures and establishing drainage. Finally, everything that is possible must be done to favour a successful reaction on the part of the peritoneum and improve the general condition of the patient.

The Operation.—*The Abdominal Incision.*—We prefer the rectus incision as a rule in these cases, as it possesses the great advantage of being readily extended either upwards or downwards should more room be required in either of these directions. When the parietal peritoneum is divided its margins are securely grasped with forceps and drawn aside so as to permit of a careful inspection of the abdominal contents. The escaping exudate will first be noted; if turbid and of a faint yellow tint, without offensive odour, the case need not be regarded as one of undue gravity, as the peritonitis is probably in quite an early stage, and the peritoneal reaction, as gauged by the character of the exudate, is good. The intestines will probably appear normal in colour, without obvious redness or congestion. Should the exudate present a watery character with a dirty, muddy colour, the outlook must be regarded as bad, as an exudate of this type is usually associated with a very virulent form of infection and a pronounced degree of toxæmia.

The Removal of the Appendix.—The appendix is sought and rendered accessible

by good retraction of the wound margins and gentle mopping up of the exudate by which it is surrounded. Its removal is then undertaken in the usual way, but some difficulty may be encountered if its tissues are gangrenous or if it is perforated, these conditions being very frequent in the type of case now under consideration. Very often the most that can be done is to apply a ligature of catgut to the base of the appendix and cut what remains of it away. Invagination of the ligatured stump may be impossible, and attempts to accomplish it in the face of difficulties had better not be persisted in too long, as they may result in the loss of valuable time and unduly prolong the operation.

Removal of the Peritoneal Exudate.—This may be accomplished in different ways, of which the following are the most important: (1) flushing of the peritoneum with hot, sterile salt solution; (2) mopping with muslin swabs; (3) aspiration with suitable apparatus, of which the best is that on the model of the "Ejector" used by dentists; (4) drainage by means of rubber tubing and gauze without any of the preceding measures.

Flushing of the peritoneum, loudly extolled at one time in cases of diffuse infective peritonitis, has been largely abandoned as a therapeutic measure. The chief objections to it are that it may convey infection to areas of the peritoneum still intact, that it takes time, and may provoke an increased degree of shock in a patient whose condition is already very bad.

Removal of the exudate by mopping with muslin swabs is a method to be recommended. It must be carried out with the utmost gentleness, as any attempt at rough treatment of the intestinal or parietal peritoneum would be attended by serious consequences. Injury of the delicate endothelium facilitates septic absorption by the blood vessels, and it also promotes the formation of permanent fibrous adhesions. As the fluid is being removed by mopping the adjoining coils of intestine are gently separated, successive pockets are opened out and their contents removed. In early cases where the exudate is turbid but odourless there does not appear to be any marked necessity for its complete removal, as the peritoneum is quite capable of dealing with it when the appendix has been excised.

Removal of the exudate by means of aspiration has much to recommend it. A rigid nozzle is connected with a piece of rubber tubing which leads to a glass jar, and this in turn is connected with a suction apparatus of the "Ejector" pattern. The exudate can be removed in this way very quickly and with the minimum of damage to the peritoneum. The nozzle is passed successively into all the recesses around the cæcum and down into the pelvis.

Drainage alone without any attempt to remove the exudate by one of the measures just indicated is sometimes indicated when the condition of the patient is grave and the prolongation of the operation likely to be attended by serious consequences. Secondary abscesses may form no doubt, and may require to be dealt with at a later period, but by that time the great urgency resulting from toxæmia will have been overcome and the patient will be in a more favourable condition to withstand the necessary intervention.

Drainage.—We usually provide for drainage by means of split rubber tubes containing loose meshes of gauze in their interior. One tube is placed in the right iliac fossa with the gauze protruding from its deep extremity in contact with the wall of the cæcum opposite to the ligatured stump of the appendix. Additional tubes may, if necessary, be introduced from the abdominal wound downwards to the bottom of the pelvis or upwards to the right lumbar hollow. It may be thought advisable

also to insert tubes through independent openings in the left iliac fossa and in the right loin. The main abdominal wound on the right side is narrowed somewhat around the tubes by the introduction of a few sutures.

ABSCESSES IN THE REGIONS ADJACENT TO OR REMOTE FROM THE APPENDIX SITE.—In considering the operative measures appropriate for suppuration around the appendix attention has been drawn to the fact that such pus collections may have extensions in an upward or a downward direction. A counter-opening in the loin has been recommended for abscesses situated behind to the outer side of the cæcum and colon. The suppurative process may continue to ascend upon the right side, and abscesses may subsequently develop in the subhepatic or hepato-renal recess, or still higher between the liver and the diaphragm (subphrenic abscess). In a downward direction it is very common to find abscess extensions in the pelvic cavity, between the rectum and the vagina in the female, between the rectum and the bladder in the male. The operative measures suitable for these abscesses must now be considered somewhat in detail.

PELVIC ABSCESSES. A collection of pus within the pelvic cavity may be found in conjunction with that around the appendix, the two abscesses being in direct communication. When such a condition obtains the evacuation of the pus and the arrangements for drainage are similar to the procedures already described. With the patient in the half-sitting-up posture such intrapelvic collections of pus can usually be drained satisfactorily by means of rubber tubing fenestrated at its distal extremity and containing a gauze wick passed down to the pelvic floor. It has been proved that under such conditions the intra-abdominal pressure is sufficient to promote the escape of the exudate by way of the iliac wound. Additional facility for drainage, however, may be provided by an incision extending into the pouch of Douglas through the posterior vaginal wall. This step can be readily accomplished, and through the vaginal aperture a piece of rubber tubing is introduced. Its deep extremity is fenestrated and lies in Douglas's pouch, and its superficial extremity is arranged so as to lie just within the vaginal orifice.

When the intrapelvic collection develops at some period subsequent to the operation for the appendix abscess in the right iliac fossa it may be reached either from above or from below (vagina or rectum). Should the intrapelvic abscess have ascended so as to lie behind the anterior abdominal wall it will be reached most readily by an incision in this region, but it may fail to attain such a high level, and if approached from above some free coils of intestine will probably be encountered before the abscess is reached. With suitable precautions, however, to shut off the parts around with gauze compresses before opening into the abscess its evacuation may be accomplished without undue risk and drainage established. The alternative consists in making an incision into the abscess through the vaginal or rectal wall, but although an aperture here has the advantage of occupying a dependent position, yet it is attended by risk of injury to the bowel, and it is just possible that in some cases a vaginal or rectal puncture may fail to reach pus. A vaginal incision may be preferred to one through the abdominal wall when the condition of the patient is such that surgical intervention should be reduced to a minimum.

ABSCESS IN THE SUBHEPATIC REGION—HEPATO-RENAL RECESS.—These abscesses are merely upward extensions of those collections already alluded to in the retrocæcal region and to the outer side of or behind the colon. They are most

satisfactorily reached and drained by an oblique incision in the loin, below and parallel to the last r[illegible]. The pus collection may possibly be tapped without opening into the free pe[illegible] cavity. If the latter should be opened, however, before the abscess is re[illegible], the aperture should be enlarged sufficiently to permit of some gauze being introduced to protect the parts from infection before the wall of the abscess is broken through by the finger. The contents are then evacuated and a large tube of rubber is introduced for drainage. Should the subhepatic collection communicate with a further extension between the liver and the diaphragm, both abscesses may be drained through the lumbar wound, a second tube being passed upwards so as to li within the subphrenic space.

SUBPHRENIC ABSCESS.—In cases of definite pus collections between the diaphragm and the liver the best route for their evacuation and subsequent drainage is by way of the lower thoracic wall posteriorly (transpleural route). The diagnosis of pus in this region is usually confirmed by exploration with an aspiration needle, and we have found an X-ray examination with the fluorescent screen very helpful in some cases.

The usual sites for exploratory puncture are the three or four lower intercostal spaces in the line of the angle of the scapula or further forwards in the mid-axillary line. If pus is withdrawn by the needle the surgeon proceeds to open into the abscess. Local anæsthesia, if properly carried out, suffices in the majority of instances; we usually employ novocain and adrenalin, and two tabloids dissolved in 1 fluid ounce of warm sterilised water form a solution of adequate strength. The superficial tissues are incised over the rib selected (eighth, ninth, or tenth), and this is exposed to a sufficient extent to permit of the excision of a segment about 3 inches in length. The pleural cavity may now be opened. If this should occur the margins of the parietal pleura must be sutured to the diaphragm. Very probably, however, the pleural cavity at this level will have been obliterated by adhesions. Finally the diaphragm is incised and the abscess opened. A few additional sutures may now be introduced to connect the margins of the aperture in the diaphragm with the chest wall. A good-sized rubber tube is introduced for drainage.

SUPPLEMENTARY THERAPEUTIC MEASURES.—Attitude of the Patient. It is advisable in all cases of appendicitis from the very commencement to have the patient placed in the half-sitting-up posture, sometimes alluded to as Fowler's position. It tends to promote the gravitation of the fluid exudate to the lower abdominal and pelvic regions, where absorption takes place more slowly than in the upper or subdiaphragmatic region. This position too, after operation, is favourable to drainage, and it facilitates the localisation or encapsulation of the inflammatory process.

The Administration of Normal Saline Solution.—The introduction of normal saline solution into the circulation may be effected in three ways, viz., subcutaneously, intravenously, and by way of the rectum.

The rectal method of administration is the one which is most generally employed, and its great value in cases of appendicitis accompanied by suppurative peritonitis has been amply proved. Its foremost advocate, Dr. John B. Murphy, of Chicago, has had extraordinary good results in his cases of diffuse peritonitis. Out of sixty-nine cases operated on he had only two deaths—truly a marvellous record, and one of which any surgeon may well feel proud.

By Murphy's method the saline solution is introduced slowly into the rectal ampulla,

and various forms of apparatus have been devised to facilitate its administration. When properly introduced it is astonishing what a large quantity may be absorbed, as much as 15 to 18 pints in twenty-four hours. Sometimes this method of continuous administration may not be well tolerated by the patient or may be attended by difficulty. As an alternative in such cases the solution may be introduced at four-hourly or six-hourly intervals in quantities of 10 to 20 fluid ounces. In addition to saline given by the rectum in this way we sometimes add an ounce of liquid peptonoids and a little brandy when the patient's condition calls for stimulation. In bad cases where the condition of the patient is grave the more rapid administration of saline solution by the intravenous method may be employed with advantage.

Sedatives for Pain.—The administration of morphia in cases of appendicitis at the commencement of the attack and before the plan of surgical treatment has been decided upon should be avoided, as it tends to mask symptoms and possibly may lead the surgeon to underestimate the gravity of the case.

If operation has been decided upon or already performed we do not object to a hypodermic of morphia; indeed it would appear to us both cruel and harmful to withhold it; it tends to allay restlessness and maintain the strength of the patient.

Paralytic Ileus. This will be manifested by continuing or increasing abdominal distension, and may be associated with vomiting of a distressing type. Lavage of the stomach has been recommended and very widely employed in such conditions, but we cannot express ourselves keenly in its favour, as it often worries the patient and may further exhaust him in his already lowered state. When distension continues or increases after an operation for the evacuation of an appendix abscess the wound may be opened up without causing the patient any marked pain or discomfort and the cæcum opened by a small incision. This often suffices to permit of the escape of gas and thin fæcal matter, with resulting marked improvement. When great distension is present on the occasion of first opening into the abdomen it may be relieved by withdrawing a distended coil, opening it by a stab wound, and allowing both gas and fæces to escape. The aperture is then closed by a few sutures in the manner described in another section (p. 238). The return of peristalsis may be encouraged by enemata, and in some cases we have had very good results from pituitary extract administered subcutaneously.

Local Treatment. In abscess cases while drainage is being carried on the frequent application of hot moist compresses to the abdomen is very soothing and greatly appreciated by the patient. Thick layers of gauzee tissue rinsed out of hot boracic solution are excellent for the purpose, and when applied they are protected by a layer of waterproof material. When the discharge from the tubes is free the dressings must be frequently changed.

After the establishment of a fæcal fistula in the cæcum or in the small bowel the discharging bowel contents are very apt to cause irritation and excoriation of the surrounding skin. To prevent this the area surrounding the wound should be smeared with sterilised vaseline, and in addition some carbonate of magnesia may be dusted over the surface with a view to diminish the irritating character of the acrid discharges.

INTESTINAL RESECTION.

ENTERECTOMY.

Indications.—The following are the more usual conditions for which resection of a segment of intestine may be performed:—

(1) Gangrene, in cases of external strangulated hernia, or following intestinal obstruction (internal strangulation). (2) Wounds of the intestine, whether of the gunshot variety or caused by severe abdominal contusion, or stabs. (3) Stricture of the intestine resulting from tuberculous ulceration, or from the loss of tissue which follows sloughing of the mucous membrane. (4) New growths—cancer; sarcoma; tuberculous disease. (5) Irreducible intussusception. (6) Some cases of volvulus. (7) Mesenteric growths, in the removal of which the blood supply of the adjacent bowel is obviously compromised. (8) For the cure of certain cases of fæcal fistula and artificial anus.

FIG. 175.—Intussusception of the Cæcum and the Vermiform Appendix. This specimen was obtained from a child, aged five years, in whom an intussusception had taken place. At the operation it was possible to reduce the intussusception, with the exception of the part which involved the cæcum. The latter appeared to contain a hard mass, and the tip of the appendix only could be detected from the exterior. A section taken through the resected specimen revealed an intussusception of the appendix into the cæcum. The pin seen in the figure occupies the lumen of the appendix. The ileo-cæcal valve is situated to the right of the invaginated cæcum and appendix.

Intestinal Junctions.—After resection of a segment of intestine the continuity of the intestinal canal may be re-established by effecting—(1) an end-to-end or axial junction; (2) a lateral implantation of the end of one bowel segment into the other; (3) a side-to-side junction after closure of the open extremity of each bowel segment.

ENTERECTOMY.—This term signifies resection of a portion of the small intestine. In the operation about to be described the resection will be followed by end-to-end junction.

The Abdominal Incision will depend upon the supposed situation of the affected segment of intestine, and will require to be fairly free so that sufficient access may be provided for inspecting the affected parts and for carrying out the necessary manipulations.

Isolation and Drawing forward of the Bowel to be resected.—The bowel to be resected is delivered through the abdominal wound. In order to do this it is sometimes necessary to divide adhesions, which may be of recent date or of long standing; in the latter case the adhesions should be cut between ligatures, while in the former gentle and patient gauze wiping is usually sufficient to free the loop. If it is found impossible to free the bowel sufficiently to withdraw it through the abdominal wound, it may be wise in cases of acute obstruction to have recourse to enterostomy on the proximal

side of obstruction. The isolated bowel is surrounded by swabs rinsed out of hot saline solution. Those first arranged around the protruding parts should be carefully placed and must remain until the completion of the resection: other swabs

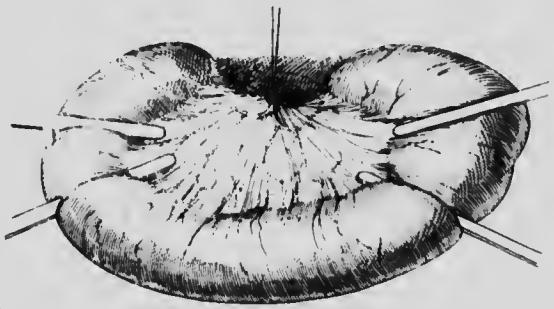

FIG. 176. Resection of a Segment of the Small Intestine. Four clamps have been applied, two on the distal and two on the proximal side of the segment to be removed. The ligature seen in the figure has been applied to a vessel situated at the apex of the triangular piece of mesentery which it is intended to excise.

superficially placed supplement these; they catch escaping bowel contents and blood and are changed from time to time as the operation progresses.

By this means all contamination of the peritoneum and abdominal viscera from the

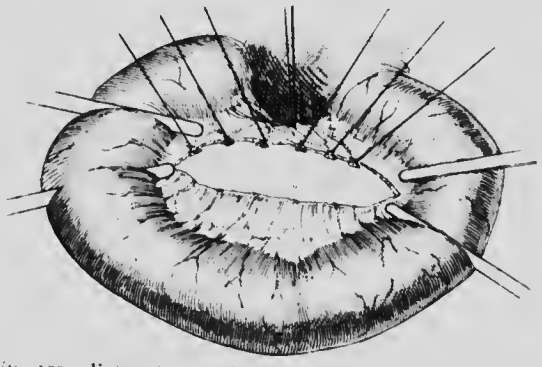

FIG. 177. Enterectomy. Commencing at the distal side of the ligatured vessel represented in the figure opposite the level at which the limbs of the loop diverge, the mesentery has been ligatured in sections and divided, the lines of section extending in the direction of the bowel.

divided intestine is avoided, for the contents of the latter may be of a highly septic character in cases of obstruction.

The Application of the Clamps.—The extent of intestine to be resected is determined and the lines of section planned. It is essential that the latter should lie in healthy portions of the gut, otherwise the sutures subsequently placed will inevitably cut through the softened tissues and leakage ensue; moreover, in cases of gangrene, if the resection be performed too sparingly, there is danger of the gangrenous process

extending beyond the site of suture. It is better to err on the side of removing too much than too little. The affected coil is emptied by gently squeezing its contents into the adjacent segments of bowel, and the clamps are then applied, two on the proximal and two on the distal side of the part to be removed. About 2 inches of bowel intervene between adjoining pairs of clamps, and these have their blades directed obliquely so that the distal and proximal clamps converge as they cross the mesentery (Fig. 176).

The Mesenteric Section.—The mesenteric section is made most conveniently before the bowel is divided. It may extend along close to the intestine, or a V-shaped portion of the mesentery may be excised. Assuming the latter to be required, a ligature is passed through the mesentery at the apex of the V and tied (Fig. 176). In passing this ligature care should be exercised not to encroach upon the large arterial arches in the mesentery, otherwise the blood supply of the bowel left behind may be jeopardised. The mesentery is now divided in front of the ligature to a limited extent, and proceeding from this aperture, the mesentery forming the limbs of the V is progressively ligatured and cut until the bowel is reached near the clamps holding the part to be resected. The ends of the ligatures are left long (Fig. 177).

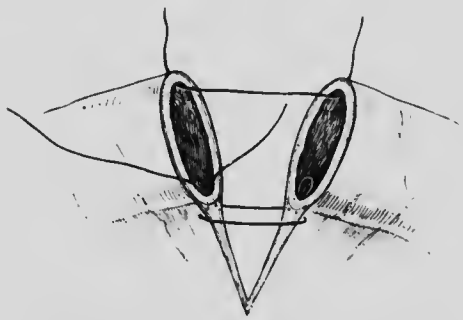

Fig. 178. Enterectomy. End-to-end or Axial Union. The segments of intestine about to be united are first connected by two sutures, one of which is introduced at the site of mesenteric attachment and the other at the convex margins of each section. The mesenteric stitch (Lee's) is deserving of note. Its two free ends appear within the bowel segment on the left and its loop within the segment on the right. By drawing it tight and knotting its free ends the two pieces of intestine are brought into contact, and the layers of the mesentery on each side are made to approximate each other and at the same time diminish, as far as possible, the area devoid of peritoneum, *i.e.*, where the layers of the mesentery diverge.

The Resection.—The gut is now divided on each side near the clamp holding the diseased portion, and the line of section crosses the bowel with a slight obliquity, so that of the cylinder left behind more is removed from its convex than from its mesenteric border. Care should be taken that the portions of intestine about to be connected are well provided with a mesentery quite up to their cut margins. This precaution, together with the oblique section of the bowel, ensures the integrity of the blood supply.

The Intestinal Junction.—The two open extremities of the intestine are drawn alongside each other, and the protruding mucous membrane of each is wiped dry.

The first line of suture penetrates all the coats of the bowel close to the cut margins; it runs continuously around the entire circumference, thereby establishing the continuity of the intestinal tube. The introduction of this suture demands care where the mesentery meets the gut. In this situation a small triangular gap is left where the two layers of the mesentery separate to enclose the gut, and it is here that subsequent leakage is most likely to occur. A suitable form of suture for approximating the mesenteric border of the intestine and at the same time obliterating the gap in the mesentery is that represented in Fig. 178 (Lee's stitch). The introduction of this stitch is carried out as follows: The needle is passed from the mucous surface of the bowel through all its coats and through the layer of mesentery forming one side of the triangular gap; it is then carried across to a corresponding point of the mesentery

attached to the other segment of gut and passed through it and through the intestinal wall into the lumen of the bowel; the needle is again passed from the mucosa through all the coats and picks up the other leaf of the mesentery; it is then carried from the mesentery to the mucosa of the first portion of bowel and emerges a short distance from its original point of entry. In this manner a loop of the suture is left in the lumen of one segment and the free ends remain in the other (Fig. 178). When the thread is drawn taut and tied the gap in the mesentery is obliterated and secure approximation obtained at the mesenteric border of the gut. Another suture is now introduced so as to approximate corresponding points of the two intestinal cylinders

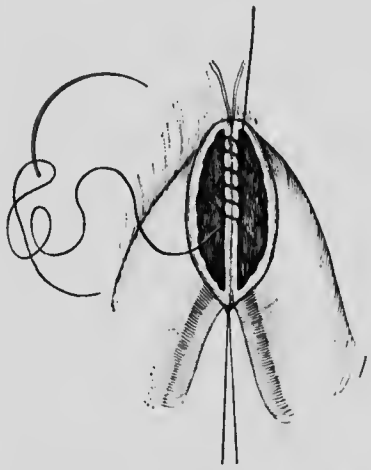

Fig. 179. End-to-end Union of Two Segments of Intestine after Resection. The two cylinders have been connected at their points of mesenteric attachment and at the convex margins. The first line of suture is being introduced. It penetrates all the coats of the bowel, and is represented as extending from the mesenteric attachments towards the convex margins of the two cylinders.

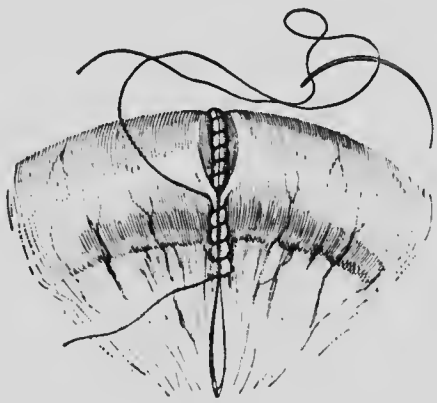

Fig. 180. End-to-end Union of Two Segments of Intestine. The inner or penetrating suture has been completed and the outer or sero-muscular suture has been commenced. It is represented in the figure as extending from the serous layer of the mesentery close to the attachment of the bowel. It invaginates the first or penetrating line of suture and brings serous surfaces everywhere into apposition.

most remote from their mesenteric attachments (Fig. 179). These sutures are useful for traction purposes, and facilitate the rapid insertion of the first line of suture, which proceeds from the mesenteric junction to the convex borders of the approximated segments and back again to the starting point, where the two free ends are knotted. The corner is turned exactly the same fashion as has already been described and figured under "Gastro-enterostomy" (p. 252). The clamps are now removed and the line of suture inspected to see if bleeding occurs. Any unsecured vessel will thus be recognised, and may be controlled by an additional under-running stitch. The outer or sero-muscular line of suture runs continuously, and may be commenced either at the mesenteric border or immediately opposite this. It inverts the first line of suture and brings the serous surfaces everywhere into contact, especial care being devoted to accurate adjustment at the mesenteric border.

Instead of performing the anastomosis in the manner described above, the ends

of the intestinal tube may be joined in exactly the same fashion in which a gastro-jejunal junction is carried out. A continuous sero-muscular suture is first introduced; it begins at and includes the adjacent layers of the mesentery forming the triangular gap at the mesenteric border of the bowel and extends to the free border of the gut. The needle is now laid aside, and the continuous penetrating suture, introduced as before, is completed and tied. The non-penetrating suture is then resumed and

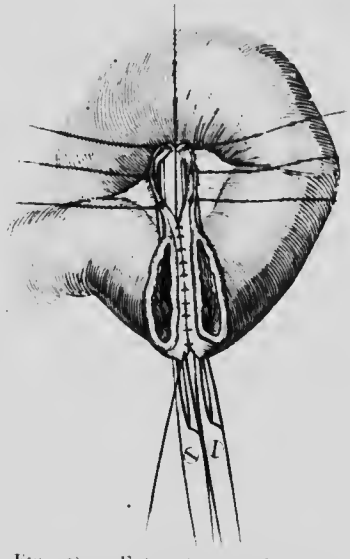

FIG. 181.—Enterectomy. In this method of effecting an end-to-end junction the two intestinal cylinders appear side by side, securely retained by clamp forceps. The first line of suture has been introduced. It is a sero-muscular or non-penetrating suture, and in the figure it is represented as extending from a point near their mesenteric attachments to the convex margins of the two pieces of bowel; it runs about one sixth of an inch from the cut margins.

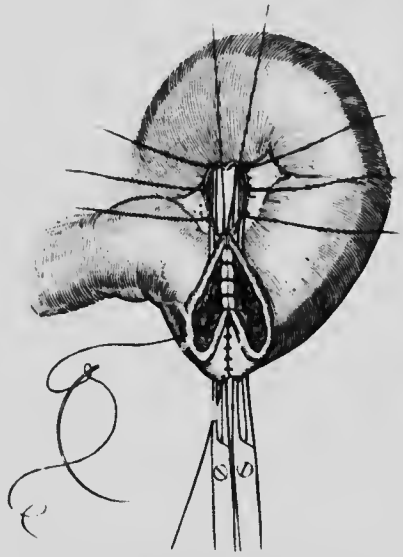

FIG. 182.—Enterectomy. The inner or penetrating suture has been commenced by connecting the divided extremities of the bowel at their respective points of mesenteric attachment (Fig. 178). The suture is represented as extending towards the convex margins of the two intestinal cylinders; it traverses all the coats of the bowel and the stitches are placed closely together.

continued back to the point at which it began. A reference to the Figures from 181 to 186 will make this method clear.

The Mesenteric Junction.—The margins of the V-shaped deficiency in the mesentery are brought into contact. This is most easily accomplished by knotting together the ligatures securing the blood vessels on one limb of the V with those on the other (Fig. 186). A continuous suture connecting the two margins is not to be recommended as the needle in passing through would almost certainly pierce some of the vessels and cause trouble from the development of a hæmatoma between the layers of the mesentery. Moreover, some impairment of the blood supply to the site of anastomosis might be occasioned by the inclusion of a vessel in the suture.

The sutured parts are wiped with a swab rinsed out of hot sterile saline solution. The swabs which were primarily placed round the affected segment are removed and

the sutured parts are replaced within the abdomen. The abdominal wound is then closed.

LATERAL INTESTINAL ANASTOMOSIS.—The open extremities of the bowel segments are closed, and the two cylinders are arranged alongside each other in such a way as to ensure iso-peristalsis and the junction is effected (Fig. 198).

Methods of closing the Ends of the Bowel.—1. The bowel before division is crushed by means of a powerful clamp until the part between the blades of the instrument is

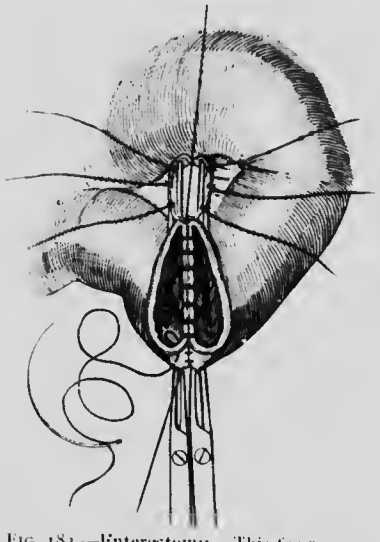

FIG. 183.—Enterectomy. This figure represents a further stage of the penetrating suture seen in the preceding figure. The posterior margins of the two cylinders have been brought together and the suture is now continued back to their mesenteric attachments connecting their anterior margins. Note the manner in which the needle is made to traverse the bowel in turning round the corner when passing from the posterior to the anterior line of suture.

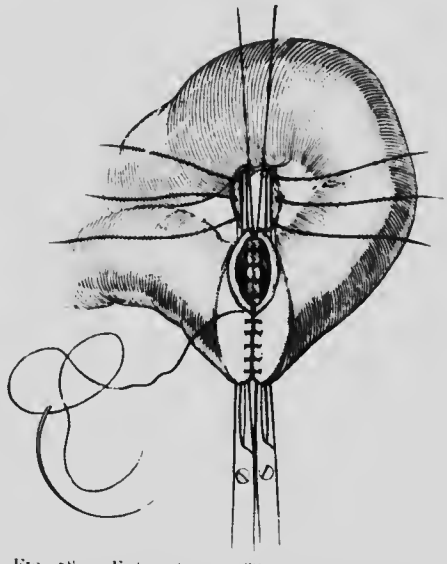

FIG. 184.—Enterectomy. The penetrating line of suture returning from the free or convex margins of the two intestinal cylinders to its starting point at the level of their mesenteric attachments.

reduced to the thinness of a piece of ribbon. This crushed part is firmly tied with a strong ligature and the bowel is cut across immediately beyond the ligature, between the latter and an ordinary intestinal clamp. A purse-string suture is now introduced in such a manner that its free ends meet on the border of the bowel opposite the mesenteric attachment, and a loop is cut immediately to one side of the mesentery (Fig. 188). By holding the free ends in one hand and the loop in the other the surgeon steadies the bowel while his assistant invaginates the stump, which should have been reduced to the smallest possible proportions.

2. The bowel is divided and a perforating suture is passed circumferentially through its cut margin. This suture enters the mucosa at the centre of the convex border of

the bowel; it includes all the coats, and is continued to the mesenteric attachment, at which point it passes from the mucous lining, through the leaf of the mesentery forming one side of the triangular gap in this situation, then through t' e other leaf

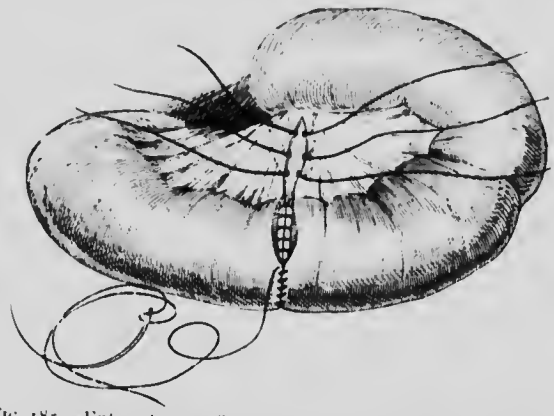

Fig. 185.—Enterectomy. The clamps have been removed and the process of suturing is being completed by continuing the outer or sero-muscular suture from the point where it was left off (Fig. 181) back to the mesentery. It invaginates the inner or penetrating line of suture.

and intestinal wall to the mucosa again; from this it is carried back till it emerges on the mucous surface close to its original point of entry (Fig. 189). By tying this suture tightly the bowel opening is securely occluded. The tied extremity is in-

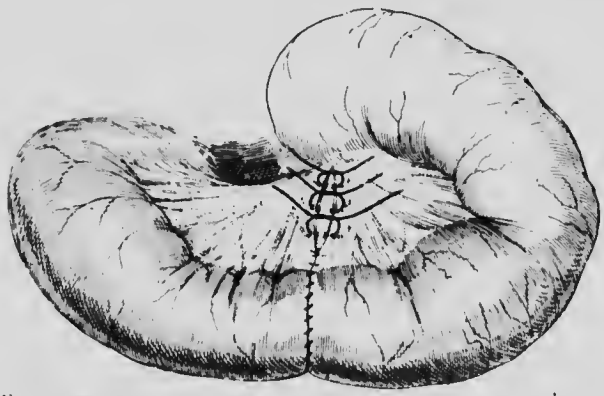

Fig. 186.—Enterectomy. The outer or sero-muscular suture having been completed, the triangular gap in the mesentery is brought together by knotting the free ends of the threads which have been applied as ligatures to the divided vessels of the mesentery on each side.

vaginated either by means of a purse-string suture or by a continuous inverting sero-muscular suture. If preferred the latter may be discarded for a series of interrupted sero-muscular sutures.

The occlusion of the ends having been completed, the two segments of intestine are held in clamps placed alongside each other and an anastomosis performed in the same manner as in a gastro-jejunostomy. Care should be taken not to allow any considerable length of bowel to intervene between the site of the anastomosis and the two closed extremities. The new aperture should be as near to these extremities as is consistent with safety.

It is advisable to have the anastomotic opening placed somewhat on the sides of the adjacent portions of intestine rather than on the extreme convex margins. The bleeding from the cut mesentery is controlled as in the end-to-end junction.

When the intestinal segments are placed side by side the respective portions of mesentery, which will necessarily overlap, may have their free edges secured with a few points of suture to the adjoining mesentery, care being taken not to include any obvious vessels.

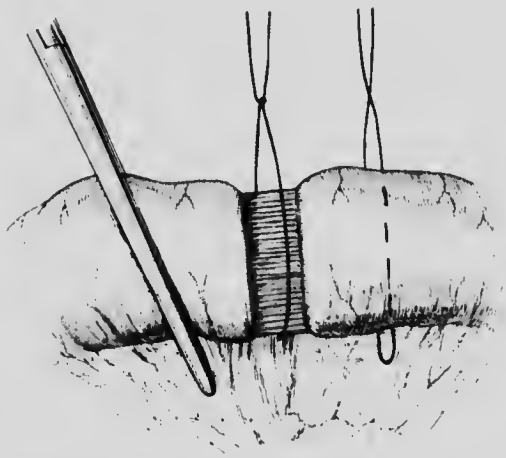

Fig. 187.—Crushing of the Intestine preliminary to its division and the invagination of its closed extremities.

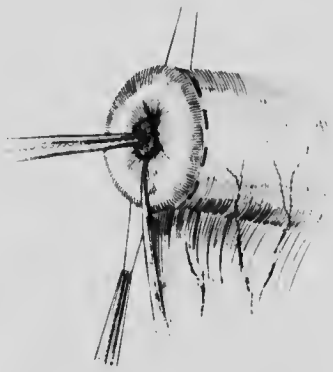

Fig. 188. Ligature and Invagination of a divided piece of Intestine. The crushed segment of the bowel has been ligatured and divided. The purse-string suture is held taut and the ligatured stump, held with forceps, is depressed and invaginated into the lumen of the bowel. By drawing on the free ends of the purse-string suture the serous surfaces of the bowel are brought together and the stump securely buried.

Advantages of this Method of Intestinal Junction. It is somewhat easier of execution than the end-to-end procedure, and there is not the same degree of danger of diminishing the lumen of the bowel. The anastomotic aperture may be made as free as the surgeon desires, and, moreover, it is easy to connect two intestinal segments of unequal calibre by this method.

END-TO-SIDE ANASTOMOSIS, OR TERMINO-LATERAL JUNCTION.—The open extremity of the lower segment is closed and the upper segment is implanted into it in the manner represented in Fig. 199. The method of closing the divided bowel has been described in the section on "Lateral Anastomosis." As in the latter procedure, the site selected for the anastomotic aperture should be near the occluded end.

The method of suture adopted in effecting the junction has already been described under "Gastro-enterostomy en-Y" (p. 260).

Lateral implantation is most useful in those cases in which there is considerable disproportion in calibre between the two coils of intestine. The end of the large segment is occluded and that of the narrow segment implanted laterally. Kocher employs this method of anastomosis as a means of joining the stomach to the duodenum after gastrectomy. But it is in the performance of an anastomosis between the small intestine and the large that it is most often indicated in such operations for instance as ileo-sigmoidostomy or ileo-colostomy. When compared with side-to-side junction it shares the same disadvantage as end-to-end anastomosis, namely, the risk of consequent stenosis. This danger has probably been exaggerated, for it is simply a sequel

Fig. 189.—Method of Closing and Invaginating the divided extremity of a piece of Intestine. A continuous suture has been made to traverse the cut margin of the intestine from its convex to its mesenteric border and back again to its starting point. When the free ends of this ligature are drawn tight and knotted the stump is invaginated in the manner represented in Figs. 188 and 190.

Fig. 190. Invagination of the occluded end of a divided Segment of the Intestine.

of faulty technique and of a too free enfolding of the line of penetrating suture. Undoubtedly, however, lateral anastomosis is the method to be employed by the surgeon of limited experience. A skilful operator will adapt himself to any method, and each method has its field of usefulness.

INTESTINAL JUNCTION BY MEANS OF ARTIFICIAL APPLIANCES.—Various appliances have been devised and employed with a view to facilitate the junction of divided segments of bowel. The best known of these is perhaps the ingenious metallic button introduced by Dr. J. B. Murphy. Bone rings and bobbins have also been extensively employed, but with improved methods of suturing and a more accurate technique these appliances have been given up almost completely in favour of simple suturing.

COMMENTS.

The Amount of Intestine resected.—In all cases the amount of intestine removed must be determined by the necessity of bringing healthy segments of the bowel togethe

for anastomosis. It is futile to attempt to suture deeply congested, paralysed or greatly distended gut. It is probable that more patients die after a too sparing removal than from being left with too little functional intestine. As much as 11 feet or so of the intestine has been successfully removed with no ill effects, and it has been shown both by experiments on animals and observations on man that removal of half the small intestine is not incompatible with life. The jejunal segment of the small intestine is the most important, but large sections of the ileum and all the colon can be removed with relative impunity. If the surgeon finds that an excessive length appears to require resection it may be wise to relieve the urgent toxæmic symptoms by an enterostomy and to proceed later with an enterectomy when the local conditions will be more favourable.

Resection in Cases of Gangrene.—What has been said regarding the extent of bowel to be resected applies with special force to cases of gangrene, for the gangrenous process may spread beyond the site of suture if too limited a removal is effected. When gangrene ensues after strangulation of an external hernia the resection can be proceeded with after enlarging the wound to an extent sufficient to withdraw healthy portions of gut. When, however, the hernia is of the femoral variety and a considerable extent of bowel must be removed the abdomen will be opened above Poupart's ligament. The mesentery is tied, the gangrenous loop excised, the open ends of the intestine cleansed, ligatured and wrapped in aseptic gauze, and then drawn through the hernial opening into the abdominal cavity, where the resection is completed.

In many cases the intestine on the proximal side of the site of strangulation is distended and filled with highly toxic contents. It is therefore wise after separating the mesentery and placing the distal pair of clamps to divide the bowel between the latter and then to remove the clamp from the segment to be resected so that the contents of the intestine may flow into a receptacle. When this has been done the resection is continued.

Axial Junction of Two Bowel Segments. The accurate approximation of the segments of the bowel at the mesenteric attachment is the chief point in end-to-end anastomosis, on which emphasis should be laid. If this is not performed carefully there is considerable danger of leakage taking place afterwards.

Subsequent narrowing at the site of union sometimes occurs, and for this reason lateral junction is often preferred.

Resection in Cases of New Growth.—Whether the resection should be performed in two stages or should be completed at once depends largely on the condition of the patient, on the presence or absence of obstruction, and on the local relationships of the growth. If the patient suffers from inability to take food, nausea, and vomiting, if there is pronounced distension of the intestines, or if, on opening the abdomen, the growth is found large, fixed by adhesions, and in a situation difficult of access, complete resection is absolutely contraindicated.

The length of time taken to free the growth, the impediment offered by the distended intestinal coils, and the certainty of the sutures cutting through the paralysed gut above and below the obstruction all determine a preliminary enterostomy, to be followed under more favourable auspices by the re-establishment of the continuity of the bowel.

It is of the greatest importance therefore that patients suffering from chronic intestinal obstruction should have the diagnosis of the cause made certain, if necessary

by an exploratory laparotomy, before distension ensues and before an attack of acute obstruction complicates the operative procedure and endangers life.

Methods of dealing with the Mesentery. (*a*) In the performance of resection for gangrene of the intestine it is wise to remove a wedge-shaped portion of the mesentery in the manner described above, for in such cases the veins may be the seat of septic thrombosis and the blood supply seriously implicated. A similar procedure is also indicated when a new growth calls for removal, for in this condition a wide resection of the affected loop and of the gland-containing mesentery offers the most certain hope of radical cure. (*b*) When, however, a simple stricture requires resection, or when the latter is indicated in wounds of the intestine, removal of a wedge of mesentery is not necessary; it is sufficient to divide it close to its attachment to the intestine, ligature all bleeding points, and fold the redundant part on itself.

Axial Junction of Two Bowel Segments of Unequal Calibre. In order to adapt the cut ends of the intestine the surgeon may proceed in one of two ways: (*a*) The smaller segment is cut obliquely from its convex border to its mesenteric attachment in such a fashion that more is removed from the free border of the intestine than from its attached portion. A section made in the opposite direction would endanger the blood supply to the convex border. (*b*) A longitudinal incision is made for a short distance from the cut edge in the long axis of the smaller segment and opposite the mesentery.

By these two methods the smaller aperture is enlarged so as to conform with the opening in the larger segment.

Omental Flaps and Grafts.—If any doubt remains as to the security of a line of suture it is well to tear a small portion from the free end of the great omentum and secure it over the weak spot by means of a few sutures.

Omental grafts are most serviceable in resections of the transverse colon and large intestine or in such a procedure as ileo-colostomy by the lateral implantation method. They are not suitable nor are they often necessary in resections of the small intestine.

Resection of the Large contrasted with that of the Small Intestine. -The blood vessels of the small intestine are arranged in a very uniform manner, so that wherever a section is made the cut edges will always have a free blood supply. In the case of the large intestine, however, it is always necessary to place the lines of section with due regard to the position of the chief arteries. This subject is considered in detail in the section on "The Surgery of the Large Intestine."

The small intestine has a complete serous coat, whereas the peritoneal covering of certain portions of the large intestine is deficient posteriorly, especially in its ascending and descending segments. Consequently it is difficult to perform an axial anastomosis in these portions of the colon in such a way that there is accurate apposition of serous surfaces at every point. For this reason lateral or side-to-side junction is the method to be employed in resections of portions of large intestine which have not a complete serous investment.

In cases of acute obstruction of the large bowel it is more often necessary to perform resection in two stages than when the small intestine is involved. The contents of the large intestine are of a more virulently infective nature, and statistics show that in these cases the mortality consequent upon excision with immediate anastomosis is alarmingly high.

In the large intestine, again, the presence of the appendices epiploicæ and the variations in the thickness of the bowel wall add to the difficulties of suturing.

The chief causes of failure in intestinal junction operations are all referable to faulty technique. Neglect to obliterate completely the V-shaped gap left by the divergence of the two leaves of mesentery as they pass to the intestine is perhaps the commonest cause of leakage.

Too free enfolding of the cut edges in end-to-end anastomosis may determine consequent stenosis. In all cases the suturing of unhealthy or paralysed segments of gut is bound to be followed by disaster.

7. **CLOSURE OF FÆCAL FISTULÆ.** When a faecal fistula involves a considerable portion of the intestine or when an artificial anus with a distinct spur has been formed, it is usually necessary to resort to resection of the involved segment with axial anastomosis.

The cutaneous opening of the fistula is securely closed with sutures and an elliptical incision made around it down to the peritoneum. The latter is then carefully opened and the attached loop of gut identified. By cutting through the peritoneum in the line of the skin incision an elliptical area of the abdominal parietes is set free except at its attachment to the intestine.

The portion of gut involved is now clamped and resected together with a wedge-shaped portion of mesentery and an end-to-end anastomosis performed.

If the fistulous opening is small and concerns but a limited area of the intestinal periphery, the most suitable procedure is to surround the cutaneous aperture with an elliptical incision and dissect down to the peritoneum so as to set the intestine free and enable it to be drawn forwards. Excess of tissue is removed from around the intestinal opening and its closure is then proceeded with, the sutures being introduced, as a rule, from above downwards, *i.e.*, in the long axis of the bowel and not in the transverse direction, as this might lead to a serious degree of narrowing. Two rows of sutures will be required. The first sutures penetrate all the coats, the second are of the sero-muscular type.

COLECTOMY.

Indications. The chief conditions which call for resection of a part of the colon are :– (1) Malignant disease. This is usually either of the tuberous or stenosing type, and in the majority of cases it is situated in the left iliac or pelvic (sigmoid) portion of the colon. (2) Ileo-cæcal tuberculosis. (3) Some cases of intussusception and volvulus. (4) Adhesion of the colon to a tumour, the removal of which necessitates resection of the bowel also. (5) Certain cases of chronic constipation (Arbuthnot Lane), but the necessity for this radical procedure is a subject upon which opinions are divided. (6) Some cases of inflammatory origin with tumour formation resembling carcinoma, but the real nature of which is probably diverticulitis. This inflammatory condition is usually met with in the pelvic colon, a portion of the large bowel which may be regarded as a faecal reservoir, and presumably therefore more liable to inflammation.

Resection of the Colon for Malignant Disease. The operative treatment of malignant disease of the colon has hitherto been very inadequate. Disinclination on the part of operators to extend the limit of intestinal resection and the fact that individuals suffering from malignant disease of the colon die more frequently from the obstructing

effects of the growth than as a result of its extension to the lymphatic glands and liver have contributed to limited resections and to non-interference with the areas of lymphatic drainage (Buthin).

The investigations of Gerota, Manasse, Poirier, Archibald, and Jamieson have shown, however, that removal of the lymphatic glands receiving vessels from the affected area is an essential feature in any operation which can be called radical.

FIG. 191.—Ileo-cæcal Carcinoma of the tuberous or adenomatous type.

Moreover, in the case of the colon wide resection is often necessary in order that the ends of the divided bowel may be well supplied with blood.

When obstruction exists in consequence of stenosis of the colon due to malignant disease resection of the latter must be preceded by some measure calculated to relieve the obstruction. In such cases the bowel contents are highly toxic, the virulence of the colon bacillus is increased, the tissues of the distended bowel are swollen and œdematous, and its mucous membrane may be ulcerated. Under such circumstances the prospect of a successful resection is very remote. Failure of union, with fatal peritonitis, would almost certainly occur.

The operative treatment of malignant disease of the large intestine will be considered first in connection with cases in which no obvious obstruction exists, and subsequently the means of dealing with existing obstruction will be reviewed.

Colectomy for Malignant Disease of the Colon when Symptoms of Obstruction are absent. It is an enormous advantage to have an opportunity of carrying out operative measures in cases of malignant disease of the colon before symptoms of obstruction become apparent. A clear exposure of the diseased part is then possible and an extensive resection may be performed with due regard to the lymphatic areas concerned.

Too often, however, the early symptoms of the disease are vague and are overlooked till an attack of acute obstruction at once clears up the diagnosis and threatens the patient's life. In cases of individuals about middle age suffering from flatulent dyspepsia, griping pains and constipation, especially if these be accompanied by anæmia or wasting, irreparable harm is done by delay. If the diagnosis cannot be promptly established by consideration of the symptoms and an X-ray examination after a meal containing bismuth in suspension, an exploratory laparatomy must be performed, for during the period of waiting the growth may progress beyond the peritoneal covering of the intestine, with resulting adhesions to adjoining surfaces, and the area of lymphatic infection may become so extensive that no operative measure, no matter how comprehensive, can possibly reach beyond the distal extensions of the disease.

Fig. 192.—Colloid Carcinoma affecting the Cæcum and the Ascending Colon. The growth had given rise to a tumour which was easily detected by external palpation. The resection included the terminal portion of the ileum, the cæcum ascending colon and half of the transverse colon. The bowel was sharply bent upon itself at the hepatic flexure and the transverse colon at its commencement had become adherent to the ascending colon and invaded by the growth.

ILEO-CÆCAL RESECTION FOR MALIGNANT DISEASE. As far as operative treatment is concerned malignant growths originating in the cæcum, the appendix, and the commencement of the ascending colon may be considered together.

Malignant disease occurring in the ileo-cæcal segment of the intestine is usually associated with tumour formation, which can be appreciated clinically (Fig. 191). Ulceration and suppuration sometimes ensue, and the resemblance to appendicitis with periappendicular abscess may determine a mistaken diagnosis of the latter. Owing partly to the contents of the bowel in the cæcal region being fluid, symptoms of obstruction seldom supervene till a late period in the progress of the disease, so that their absence is of no value in the question of operative intervention.

ANATOMY. The Ileo-cæcal Blood Vessels. Owing to the intimate relationship of the blood vessels of the colon with the glands into which the lymphatic vessels of this portion of the bowel drain, it is of the first importance to have an accurate know-

ledge of the distribution of the arteries in the large intestine. Moreover, the lines of section in excision of any segment of the colon must be placed in areas that are plentifully supplied with blood.

The Ileo-colic Artery is the chief vessel of supply to the ileo-cæcal segment of the intestine. This vessel takes origin from the superior mesenteric artery just below the pancreas and is distributed to the terminal portion of the ileum, the cæcum, the appendix, and part of the ascending colon. Lying at first on the third stage of the duodenum, it soon leaves the mesenteric root to descend behind the parietal peritoneum towards the angle between the ileum and the ascending colon (Fig. 193). Just before it reaches this angle it breaks up into its terminal branches—viz., (*a*) appendicular, (*b*) anterior ileo-colic, (*c*) posterior ileo-colic, (*d*) ileal, and (*e*) colic.

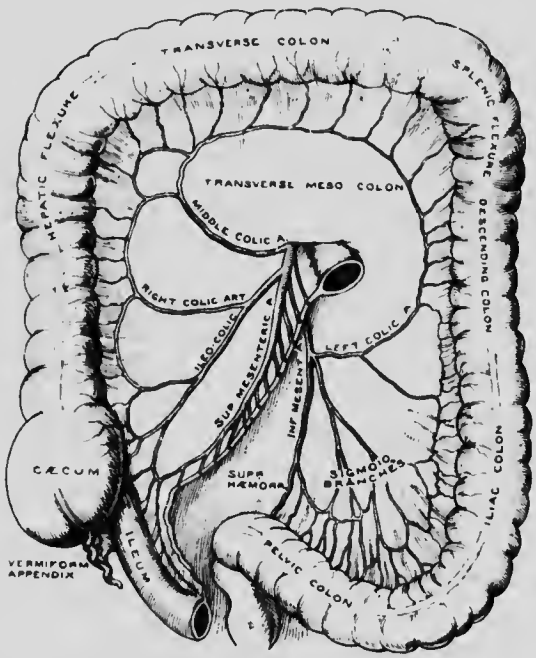

Fig. 193.—The Blood Vessels of the Colon.

In many cases the right colic artery springs from the ileo-colic near its origin, but it may have an independent origin from the superior mesenteric trunk.

The terminal branches just enumerated are somewhat inconstant in their mode of origin. The appendicular usually springs from the main artery, which then divides into its anterior and posterior ileo-colic branches. The anterior branch gives off the ileal artery; the posterior, the colic.

The appendicular artery runs close to the free margin of the meso-appendix and terminates near the tip of that organ (Fig. 170).

The ileal artery passes between the leaves of the mesentery to anastomose with the terminal portion of the superior mesenteric; it supplies about 5 or 6 inches of the terminal part of the ileum.

The ileo-colic branches supply the cæcum and commencement of the ascending colon. The posterior in addition commonly sends some branches to the proximal portion of the appendix and to the termination of the ileum.

The colic branch runs upwards close to the inner side of the ascending colon and anastomoses with the right colic artery.

The Ileo-colic Lymphatic Vessels and Glands.—The following account is mainly derived from the admirable paper by Jamieson and Dobson:—

Throughout its entire course the ileo-colic artery is accompanied by a chain of lymphatic glands, varying in number from ten to twenty, which is continuous at its

upper extremity with the glands around the trunk of the superior mesenteric artery (Fig. 200).

These glands may be divided somewhat arbitrarily into two groups, an upper in relation to the lower border of the third stage of the duodenum, and a lower close to and around the point of division of the artery. The latter group is continued into a series of minor groups corresponding to the terminal branches of the ileo-colic artery. These are:- (1) The anterior ileo-colic glands, from one to four in number, lying in the ileo-colic fold close to the wall of the cæcum. (2) The posterior ileo-colic glands, which are in direct continuity with the main ileo-colic chain. They are found mainly in the angle between the ileum and the colon, but some occupy the groove between the cæcum and the ascending colon. Not infrequently one or two of these glands get between the layers of the meso-appendix close to the cæcum. (3) The appendicular gland is found near the free border of the meso-appendix alongside the appendicular artery. It is probably to be regarded as one of the lower glands of the main ileo-colic group. (4) The ileal glands lie in the mesentery in association with the ileal branch of the ileo-colic artery. (5) The right colic glands are arranged in close contact with the wall of the colon. They are associated with the colic branch of the ileo-colic artery and with the branches of the right colic artery.

The Lymphatics of the Appendix.—The lymphatic vessels which drain the appendix from its tip to a point near its base enter the meso-appendix and accompany the appendicular artery, around which they become closely arranged. Having reached the point of origin of the artery, they meet the lower glands of the main ileo-colic chain, in which they for the most part end; some few, however, ascend to the glands of the upper group. Some of these lymphatics have been traced directly from the appendix to a gland in front of the duodenum.

The appendicular gland when present receives vessels from various parts of the appendix.

The lymphatics which issue from the basal part of the appendix form two groups, anterior and posterior. The anterior vessels proceed over the front of the cæcum and enter the ileo-colic fold, but as a rule they pass by the glands in this situation to reach those of the lower ileo-colic group. Some may even pass beyond this group to enter a gland of the upper set just below the duodenum.

The posterior vessels are connected with the posterior ileo-colic glands, but a few may continue onwards to reach the lower glands of the main ileo-colic chain.

The Lymphatics of the Cæcum.—The lymphatic vessels issuing from the wall of the cæcum are arranged in an anterior and a posterior set and have a course and destination practically identical with the respective groups passing from the base of the appendix.

The Lymphatics from the Terminal Part of the Ileum. The majority of these vessels end in the ileal group of glands situated between the layers of the mesentery. Some vessels instead of entering the mesentery proceed to the right along the bowel to join the anterior ileo-colic glands or to end in the lower members of the main group. One of these vessels reaches the cæcal end of the meso-appendix and terminates in a gland of the posterior ileo-colic group.

The Lymphatics of the Ascending Colon.—From the lower part of the colon and from its posterior aspect the lymphatic vessels proceed directly to the posterior ileo-colic glands.

The vessels from the ascending colon have a transverse direction, and converge to a chain of small glands lying in close contact with the bowel wall and termed the right colic group. A certain number pass further inwards to reach the glands of the main ileo-colic chain.

Practical Deductions. From the foregoing account it would appear that whereas the general tendency of the lymphatic vessels issuing from the ileo-cæcal segment of the bowel is to end in the nearest glands, yet many of these vessels are connected with the upper and lower groups of the main ileo-colic glandular chain. Various forms of disease—pyogenic, tuberculous, and malignant—arising, for instance, in the appendix, may be followed by glandular involvement far from their point of origin, even at a point so remote as the commencement of the ileo-colic artery.

It follows from this established fact that in cases of cancer in the ileo-cæcal region an attempt should be made to remove all glands which are possibly infected, and therefore the upper ileo-colic glands will come within the scope of the operation.

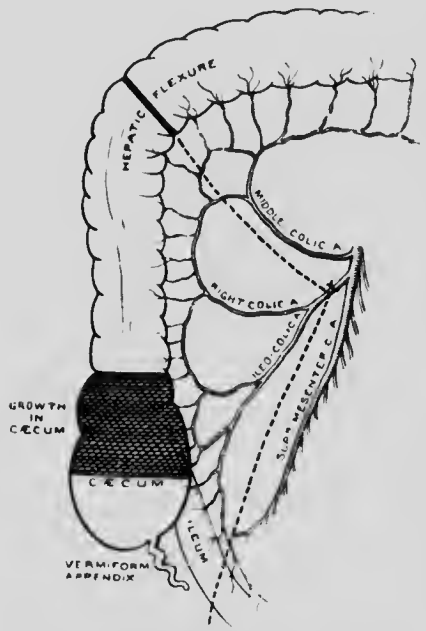

FIG. 191.—Ileo-cæcal Resection of the Intestine for Carcinoma. This diagram represents the extent to which the removal of the intestine is carried out in accordance with the investigations of Jamieson and Dobson. Note the site selected for ligature of the ileo-colic artery close to its commencement.

The Operation.—As the essential feature of the procedure about to be described is the extensive removal of the lymphatic vessels and glands in direct communication with the diseased area, the ileo-colic vessels around which these glands and lymphatics are intimately arranged must be ligatured and divided close to their parent stems.

Ligature of the ileo-colic artery, from which the right colic artery very frequently springs, will deprive a large segment of intestine of its blood supply, viz., the lower 5 or 6 inches of the ileum, the cæcum with the appendix and all the ascending colon. It will be necessary, therefore, in all cases of resection of cancerous growths in the cæcum and adjoining part of the colon to remove the portion of bowel thus indicated.

The Abdominal Incision. The patient having been anæsthetised, the table is moderately inclined in the Trendelenburg position. A cushion or sand-bag beneath the lower dorsal spine facilitates the later procedures.

The abdominal incision must be free in order to give good access to the field of operation. The most convenient incision for this purpose is one extending vertically from the level of the umbilicus through the sheath of the right rectus muscle near its outer border.

Examination of the Diseased Parts.—As soon as the abdomen has been opened and the presence of a growth in the ileo-cæcal segment of bowel ascertained, the hand should be passed upwards to the liver in order to discover whether secondary growths

are present in that organ. If the latter be found studded with hard nodules a radical operation would be unjustifiable. If, however, the liver be normal on palpation, the condition of the growth should be thoroughly investigated. Its mobility or fixity

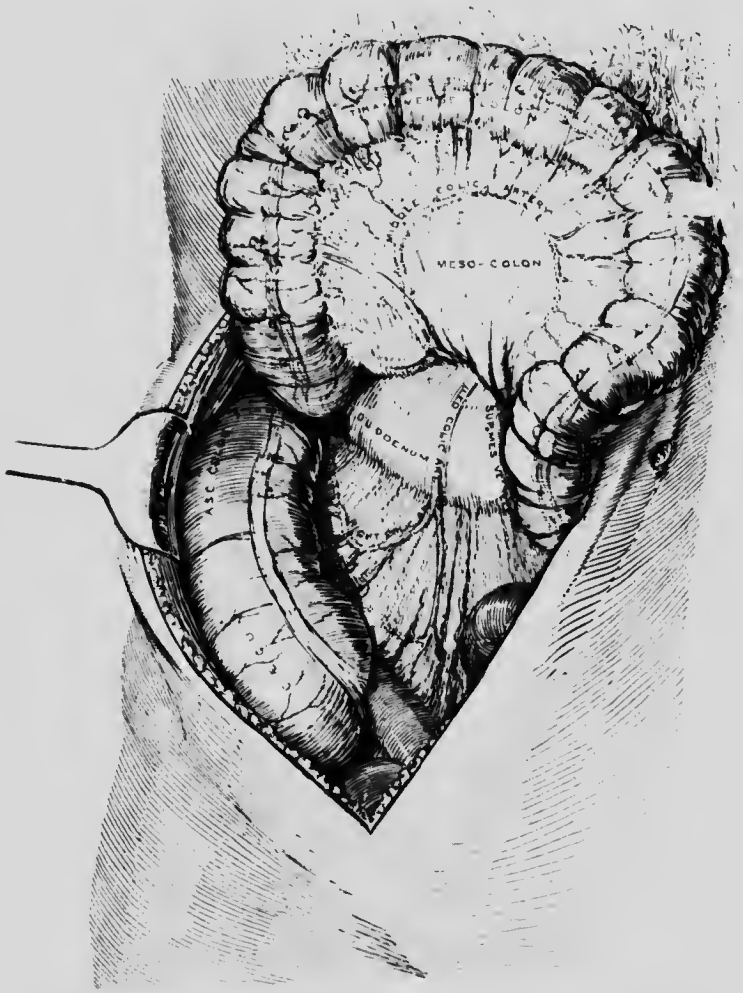

FIG. 195. – Ileo Cæcal Resection of the Intestine for Carcinoma. The abdomen has been opened by a free incision close to the right semilunar line. The small intestines have been displaced to the left and the transverse colon drawn upwards in order to permit of the exposure and ligature of the upper part of the ileo-colic artery as it crosses the third stage of the duodenum.

and the presence or absence of adhesions are the chief local features to which attention must be paid. In some cases the growth may be so firmly fixed to the posterior abdominal wall or so densely adherent to coils of small intestine that hope of complete extirpation must be abandoned. Care must be exercised not to overlook the tumour

when associated with a large abscess, for growths in this region are sometimes accompanied with suppuration, a fact which complicates the operative treatment to a considerable extent. The glands in relation to the seat of disease must be examined, and in a minority of cases they may be found extensively enlarged and hard. It must be remembered, however, that a definite diagnosis between enlargement due to septic absorption and that due to cancerous involvement is not always possible

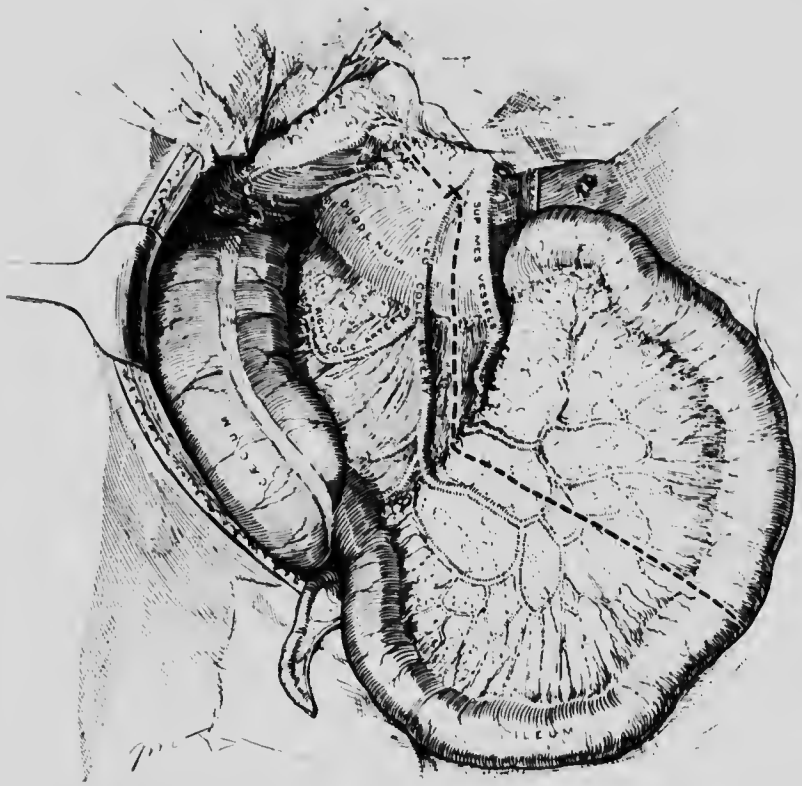

FIG. 199.—Ileo-Cæcal Resection of the Intestine for Carcinoma. The general mass of the intestines has been displaced to the left side, and the terminal loop of the ileum has been drawn out through the abdominal wound. The site selected for the ligature of the ileo-colic artery is indicated by a cross (X), and extending from this downwards the line of section of the peritoneum, which covers the posterior abdominal wall and the mesentery, is represented by a heavy interrupted black line. Part of the upper line of peritoneal section is represented as it extends from the site of ligature of the ileo-colic vessels into the transverse mesocolon.

macroscopically, so that enlarged glands *per se* are by no means a contraindication to the completion of the operation.

The preliminary examination having been performed, the wound is enlarged if necessary and its edges protected by tetra cloths or squares of muslin held in position by forceps of the Moynihan pattern. The great omentum is raised, the coils of small intestine are displaced towards the left, and the whole area of operation carefully excluded from the general abdominal cavity by suitably arranged swabs.

Division and Ligature of the Ileo-colic Vessels. The lower border of the third stage of the duodenum is defined, the peritoneum over it is divided to a limited extent, and search made for the ileo-colic vessels (Fig. 195). These are carefully isolated and

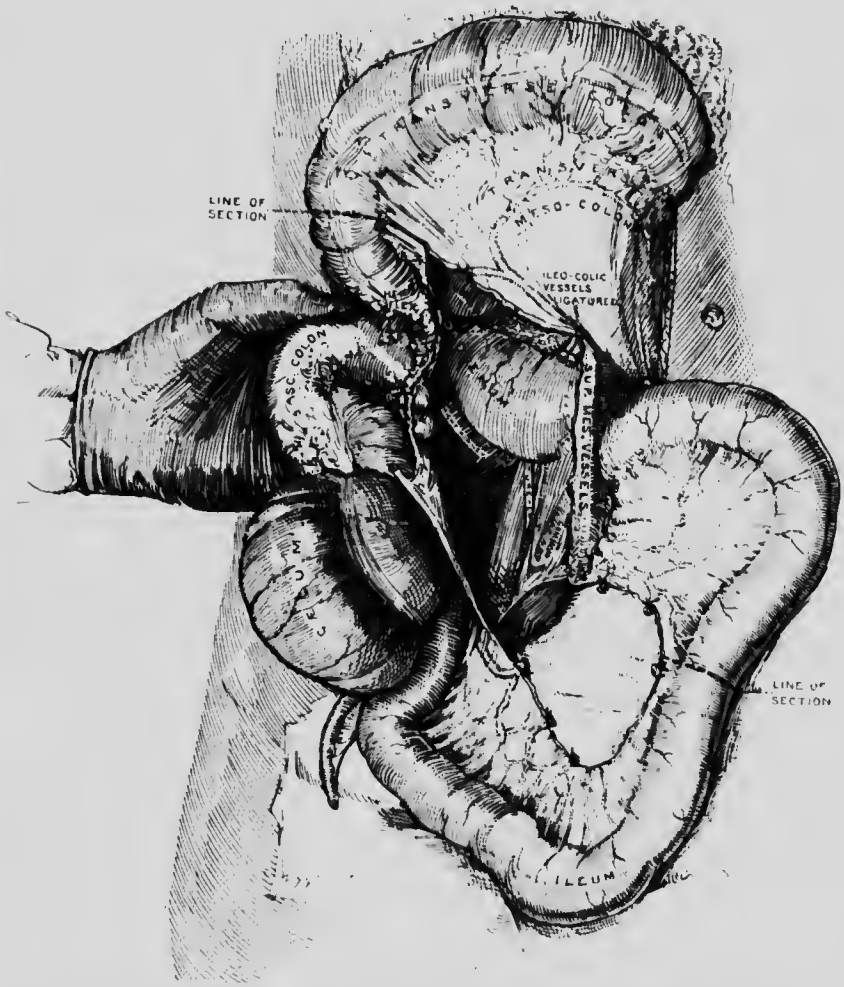

FIG. 197.—Ileo-Cæcal Resection of the Intestine for Carcinoma. The ileo-colic vessels have been ligatured and the peritoneal sections carried from this point respectively to the right segment of the transverse colon above and the terminal stage of the ileum below. The part of the bowel to be resected has been detached from its surroundings. Note the levels selected for the division of the colon and the ileum.

divided between ligatures close to the mesenteric trunk. The surrounding fatty tissue is at the same time pushed downwards by careful sponging with gauze, the duodenum meanwhile being protected from injury.

The Resection.—That part of the transverse colon or the hepatic flexure where the

section will subsequently be made is now selected and secured by a clamp or surrounded by a ligature.

The peritoneum between the site of ligature of the ileo-colic vessels and the selected point on the colon is divided. The line of section passes through some branches of the middle colic artery, which must be caught and ligatured (Figs. 195, 197). If the right colic artery has an independent origin from the superior mesenteric it also will be divided in this peritoneal section.

The peritoneum is next divided in a downward direction from the duodenum to the ileum. This line of section lies between the superior mesenteric artery and its ileo-colic branch; it crosses the loop formed by the terminal stage of the former with the ileal branch of the latter, and having traversed the lower part of the mesentery, it reaches the ileum about 6 inches from the ileo-cæcal valve. Any bleeding points in the cut mesentery are tied and a clamp applied to the gut, or the latter may be surrounded by a ligature.

Beginning at the point of division of the ileo-colic artery, this vessel and the right colic artery with the accompanying glands, the overlying peritoneum, and all loose tissue, are stripped off the subjacent structures. As this dissection is being carried downwards in the direction of the ileum the ureter and spermatic vessels will be exposed and must be carefully protected from injury (Fig. 197). In this connection it must be remembered that the ureter is usually more adherent to the peritoneum than to the posterior abdominal wall and that consequently there is a great tendency to strip it off the latter along with the peritoneum.

The peritoneum at the outer side of the cæcum and ascending colon is divided in a vertical direction and the fingers passed behind the ascending colon, whereupon the whole of that structure with the cæcum, appendix, and the terminal part of the ileum, the ileo-colic and right colic vessels, and the accompanying groups of lymphatic glands can be delivered through the abdominal wound (Fig. 197).

The colon is divided between clamps at the point already selected and the distal end is occluded and invaginated.

Another clamp is applied to the ileum at a point proximal to the one already placed and the small bowel is divided between them. This section lies opposite the arch formed by the termination of the superior mesenteric artery and the ileal branch of the ileo-colic. Division of the ileum close to the cæcum may be followed by gangrene of that portion of the bowel which is dependent on the ileal artery for its blood supply.

The diseased segment of intestine is now removed and the end of the ileum closed and invaginated (Figs. 189, 190).

Continuity of the Bowel re-established.—The ileum is brought alongside the transverse colon, clamps are applied to each segment, and the continuity of the intestinal lumen is established either by a side-to-side anastomosis or by a termino-lateral implantation of the ileum into the colon (Figs. 198 and 199). If the latter form of junction be practised the end of the ileum will have been left patent and not occluded immediately after section.

Peritonisation of the Posterior Abdominal Wall.—When such a wide resection as is described above is performed a considerable area of the posterior abdominal wall is denuded of its peritoneal covering. It is desirable to cover this with peritoneum to prevent the formation of subsequent pathological adhesions. This can be accomplished to some extent by applying the ileum to the colon in such a manner that the mesentery of the former will lie over the bare area. A few points of suture will retain the mesentery in position until firm adhesion has taken place. If this procedure still leaves some raw surface an attempt may be made by mobilising the parietal

peritoneum to draw the latter over the denuded part. If any traction be exerted on the peritoneum in the region of the pelvic brim the ureter must first be freed, otherwise there is some danger of kinking this structure.

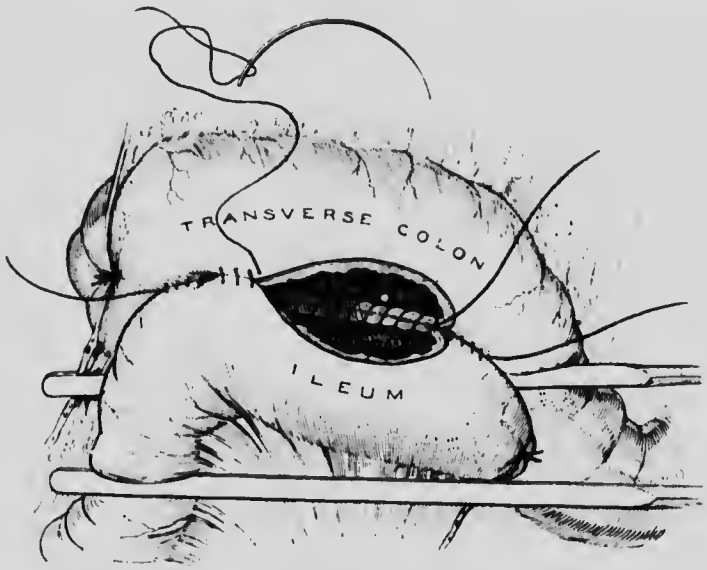

FIG. 198. Lateral or Side-to-Side Anastomosis of the Intestine. This represents the usual procedure adopted for connecting the ileum with the transverse colon after ileo-cæcal resection.

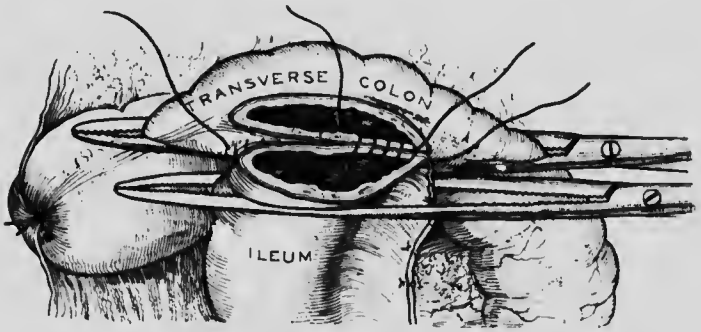

FIG. 199.—Termino-Lateral or End-to-Side Anastomosis of the Intestine. This method of intestinal junction may be employed in connecting the small with the large intestine.

All gauze packing is removed. A portion of the great omentum may be drawn over the site of anastomosis as an additional protection to the line of suture.

Drainage is seldom indicated, but if considered necessary it may be established by introducing a tube through a stab wound in the loin.

The abdominal wound is closed.

COLECTOMY FOR MALIGNANT DISEASE INVOLVING THE TRANSVERSE COLON : ANATOMY.—The operative surgery of malignant disease affecting the transverse colon demands a review of the blood vessels, and also of the lymphatic vessels and glands which are concerned with this segment of the bowel.

Blood Vessels.—The transverse colon is supplied for the most part by the superior mesenteric artery through its right colic and middle colic branches. Its left extremity is supplied by a branch of the left colic artery from the inferior mesenteric.

The Right Colic Artery arises from the superior mesenteric directly in less than 50 per cent. of cases. In about 30 per cent. it has its origin from the ileo-colic artery, while it is sometimes represented by a branch of the middle colic anastomosing with an enlarged branch of the ileo-colic. The right colic artery is directed outwards to the upper part of the ascending colon and soon divides into two branches. Its descending branch anastomoses with the colic branch of the ileo-colic artery and its ascending with the right division of the middle colic artery.

The Middle Colic Artery arises from the superior mesenteric just below the body of the pancreas. It proceeds downwards and to the right between the layers of the transverse mesocolon and divides into two trunks about midway between the root of the latter and the bowel. These diverge and each subdivides into two branches. The four resulting arteries form three distinct arcades. The first of these, on the right, opposite the hepatic flexure, is formed in conjunction with the right colic artery. The middle arcade, under the right extremity of the transverse colon, is usually of small size; while the left, which is completed by the left colic artery, is usually large. This arcade lies about two fingers' breadth from the gut, and circumscribes a wide area of the mesocolon which is devoid of visible blood vessels. It will be noticed that this arterial loop is most slender at the level of the middle with the left third of the transverse colon, and this point may consequently be regarded as marking the line of demarcation between the vascular territories of the middle and left colic arteries. The middle colic artery therefore supplies the upper part of the ascending colon, the hepatic flexure, and about two-thirds of the transverse colon.

Lymphatics.—In a very full and clear account of the lymphatics of this segment of the colon Jamieson and Dobson describe the corresponding glands as arranged in groups, named respectively *epicolic*, *paracolic*, *intermediate*, and *main groups* of glands. It must not be imagined, however, that these groups are really separate and distinct; in reality, as one proceeds from the bowel towards the middle line the various members of the glandular series succeed each other without any definite segregation.

The lymphatic vessels or glands about to be described are those related to the middle colic branch of the superior mesenteric artery.

The Epicolic Glands lie on the intestinal wall under the peritoneum and in the appendices epiploicæ. They intercept the majority of the vessels emerging from the intestine and their efferents reach the paracolic or the intermediate group, or may even terminate in the main glands. Some of the lymphatic vessels issuing from the colon, especially from the region of the hepatic flexure, may pass directly without interruption by the epicolic series to the paracolic, intermediate, or main groups. Again, some few of the vessels from the left segment of the transverse colon, on its anterior

aspect, enter the gastro-colic omentum and, turning to the left between the layers of this fold, eventually reach the glands at the hilum of the spleen.

The Paracolic Glands lie along the mesenteric margin of the gut, between it and the arterial arcades, and usually also on the latter.

As the lymphatics leaving the bowel run with the blood vessels and not in the non-

FIG. 200.—The Blood Vessels and the Lymphatics of the Ileo-Cæcal Segment of the Intestine and the various subdivisions of the colon according to the investigations of Jamieson and Dobson.

vascular intervals, those draining the transverse colon associate themselves with the arterial arcades and consequently stream in one direction or the other towards the paracolic glands by which they are intercepted, so that they do not succeed in getting as far as the intermediate group on the middle colic artery (Fig. 200). In any segment of the colon, therefore, supplied by long arterial arcades it is probable that

the paracolic glands at some little distance from the seat of disease may become affected, and for this reason they must be removed.

The Intermediate Glands lie between the layers of the mesocolon midway between the hepatic flexure of the colon and the origin of the middle colic artery, *i.e.*, at or close to the bifurcation of the latter. In some cases they are situated so close to the origin of the artery that no line of separation can be drawn between them and those constituting the main group.

The intermediate glands receive most of the efferents of the paracolic glands as well as those vessels which in rare cases pass without interruption from the colon. The frequency with which lymphatic vessels pass directly to the intermediate group varies in different regions. Such an arrangement is observed as the rule in the hepatic flexure, the upper end of the ascending colon, and the right extremity of the transverse colon, while it has not been demonstrated by injection methods in the central portion of the transverse colon.

The Glands of the Main Group lie on the middle colic artery as it enters the transverse mesocolon. As a rule they can be differentiated from the glands of the superior mesenteric chain, but sometimes both groups become merged together. This main glandular group receives the efferents of the intermediate glands, some of those from the paracolic glands, and, not uncommonly, vessels from the intestine itself.

CANCER INVOLVING THE HEPATIC FLEXURE OF THE COLON. It will be convenient to include with the hepatic flexure the upper part of the ascending colon and the right extremity of the transverse colon.

As indicated above, the primary lymphatic area corresponding to this portion of the colon comprises—(1) the epicolic and paracolic glands; (2) the intermediate glands; (3) the main group of glands of the middle colic chain.

For the adequate removal of this area it will be necessary to tie the middle colic artery close to its origin and to remove the mesocolon from this point to the bowel. This entails the cutting off of the direct blood supply to the upper part of the ascending colon and about two-thirds of the transverse colon. The gut will require to be divided, therefore, at the middle of the ascending colon and approximately at the junction of the middle and left thirds of the transverse colon.

Out of one hundred cases of cancer of the colon treated by resection by Dr. W. J. Mayo the transverse colon was concerned in seven instances. According to this distinguished surgeon, the percentage of inoperable carcinomata of the transverse colon was higher than in any other group as there appeared to be relatively early involvement of the lymphatic glands about the head of the pancreas.

The Operation. *The Abdominal Incision.*—This may be made either close to the middle line through the rectus muscle or at the outer border of the latter. The centre of the incision lies opposite the umbilicus. The abdominal wound must be sufficiently large to afford easy access to the parts which are to be resected.

The intra-abdominal manipulations may be facilitated by placing a sand-bag or air-cushion under the spine in the dorso-lumbar region.

Examination of the Affected Bowel.—The diagnosis having been confirmed, the extent of the growth and its surroundings are carefully examined. As pointed out in the resection of ileo-cæcal growths, the chief points to be considered are the presence or absence of metastases in the liver, the condition of the lymphatic glands, the presence of adhesions, and the mobility of the growth.

Ligature of the Middle Colic Vessels.—The wound margins are protected with sterile cloths as in the preceding operation.

The transverse colon is drawn out of the abdomen and the mesocolon exposed. Swabs are carefully arranged round the area of operation in order to exclude it from the general peritoneal cavity.

The middle colic artery is found close to its origin from the superior mesenteric and just above the upper border of the third stage of the duodenum. In this situation it lies between the two layers of the transverse mesocolon. This vessel having been carefully identified, is securely ligatured along with its accompanying vein.

The Resection: Section of the Ascending Colon.—The layer of peritoneum reflected from the outer aspect of the ascending colon and hepatic flexure on to the posterior abdominal wall and right kidney is now divided. This division is best carried out by making a limited incision through the membrane opposite the lower portion of the ascending colon and then cutting upwards parallel to the gut with a pair of curved blunt-pointed scissors in the manner described and figured below under "Mobilisation of the Descending Colon." The fingers can now be introduced behind the ascending colon and the hepatic flexure and these portions of the gut freed from the underlying structures and displaced inwards. The short upper leaf of the transverse mesocolon, passing to the front of the second stage of the duodenum, can now be divided under the guidance of the eye with scissors. The whole hepatic flexure and the immediately adjacent segments of bowel are thus mobilised and can be withdrawn through the wound.

Clamps are applied to the ascending colon just distal to the level of the right colic artery, *i.e.*, about the middle point of this portion of bowel. The gut is divided between the clamps and the cut ends wiped clean. The end of the lower segment is occluded and invaginated. The upper end is covered and protected by a swab. Proceeding from the level of the line of section of the colon, the peritoneum is raised from the posterior abdominal wall and is divided progressively until the point of ligature of the middle colic vessels is reached, all bleeding vessels being secured and tied as the peritoneal section is performed.

Section of the Transverse Colon.—The point selected is usually at the junction of the outer and middle thirds of the transverse colon, but the line of section may be placed with advantage as near as possible to the splenic flexure so as to ensure a freer blood supply from the left colic artery.

Clamps are applied and the bowel is divided between them. The distal end is closed and invaginated. From the level of the bowel section the incision is prolonged through the mesocolon till the site of division of the middle colic artery is reached.

The great omentum is divided from its free border to the line of section of the colon and from this point the division is carried in a transverse direction to the right, above the upper border of the colon, till the portion of the latter to be removed retains no connection with the stomach. The divided omentum is secured by interlocking ligatures.

The bowel is now completely free and can be removed.

The Re-establishment of the Continuity of the Bowel.—The alternatives that present themselves for the restoration of the continuity of the bowel are (1) ileo-sigmoidostomy; or (2) the performance of a more extensive operation, which includes the whole ascending colon, the cæcum and the terminal 6 inches of the ileum in the part removed, followed by an anastomosis between the ileum and the remaining portion of the transverse colon.

The former procedure entails the complete exclusion of the cæcum and first portion

of the ascending colon, while the remainder of the transverse colon and the descending colon also are partially excluded.

Jamieson and Dobson advocate the performance of the more extensive operation, which certainly possesses some distinct advantages. The growth is freely mobilised; the blood supply of the parts remaining is assured; free access is provided to the site of disease, so that the surgeon is enabled to bring the intestine out of the abdomen and to secure the field of operation from contamination when the gut is divided. It also enables movable bowel segments to be brought together without tension.

CANCER OF THE CENTRAL SEGMENT OF THE TRANSVERSE COLON. – **The Lymphatics.** The lymphatics proceeding from this segment of the colon are intercepted by the mid-colic glands and do not pass directly to those of the intermediate and main group.

The operation for the removal of a malignant growth in this locality consists in dividing the colon on each side of the diseased area and excising that part of the mesocolon which contains the lymphatic glands for a little distance on each side of the growth.

The Operation. *Paramedian Incision.* As in the operation just described, a free paramedian incision is made with its central point opposite the umbilicus.

The Resection. The parts are examined, and if the conditions present indicate resection the wound margins are protected with cloths, the transverse colon and great omentum are drawn out, and the area of operation is shut off by carefully placed swabs. The sites of section of the colon are determined and the great omentum is divided on each side of the growth from its free border up to the points at which division of the colon is to be performed. The mesocolon is divided, the line of section being placed on the distal side of the large arcades of the middle colic artery. Bleeding points in the cut edge of the mesocolon are caught and ligatured. The colon is doubly divided between clamps and the diseased part removed. The open ends of the bowel are closed and invaginated.

The Re-establishment of the Continuity of the Bowel.– This is carried out most satisfactorily by a side-to-side anastomosis. An end-to-end junction might be performed, but in the colon this is more difficult than lateral anastomosis and is not so safe a procedure.

Following the establishment of the anastomosis, the sutured parts are protected by covering them with a portion of the great omentum.

The bowel is now restored to the abdominal cavity and the abdominal wound is closed.

COLECTOMY FOR MALIGNANT DISEASE INVOLVING THE LEFT SEGMENT OF THE COLON.– It is necessary to consider briefly the anatomy of the blood vessels and lymphatics of this part of the colon before giving a description of the procedure required for the removal of malignant disease in its different parts. The account given by Jamieson and Dobson will be followed.

Blood Vessels.—The Inferior Mesenteric Artery arises from the left side of the aorta from 1½ to 2 inches above its bifurcation. From its origin under cover of the duodenum it is directed obliquely downwards over the psoas muscle and left common iliac artery. As it passes over the latter structure it becomes the superior hæmorrhoidal artery, which descends between the layers of the pelvic mesocolon to the back of the rectum, where it divides into a right and left terminal branch. The inferior mesenteric vein accompanies the corresponding artery in its lower part, but soon leaves it

to incline gradually outwards. The left spermatic vessels lie about a finger's breadth to the outer side of the artery and the left ureter descends close to its outer side, coming into very intimate relationship with it just above the left common iliac artery. The artery is surrounded by the inferior mesenteric sympathetic plexus of nerves. The left colic and sigmoid branches of the inferior mesenteric artery are given off from its outer side.

The Left Colic Artery. This artery arises from the inferior mesenteric at the level of the lower border of the duodenum. The first inch of its course is directly outwards towards the lower pole of the left kidney; it then comes into relationship with the inferior mesenteric vein and turns upwards across the kidney towards the splenic flexure. Opposite the hilum of the kidney the vein turns inwards across the artery, and from this point the latter is accompanied by the left colic vein. Reaching the lower border of the pancreas, it passes forwards into the left extremity of the transverse mesocolon and ends by dividing into two branches to the right of the splenic flexure. The right terminal branch, anastomosing with the middle colic artery forms the arcade along the transverse colon.

The descending or left branch, anastomosing with the superior sigmoid artery, forms a long arcade along the inner side of the descending colon. In many cases several small arterial loops take the place of this arcade.

The Sigmoid Arteries. These arise from the inferior mesenteric, or the left colic, or both, and are from one to four in number.

The highest sigmoid branch, arising from the left colic or the inferior mesenteric stem, runs outwards between the lower pole of the kidney and the iliac crest and supplies the lower end of the descending colon and the iliac colon.

The remaining sigmoid arteries, arising irregularly from the stem of the inferior mesenteric, are always to be found descending in front of the psoas to enter the meso-sigmoid.

The lowest branch is usually situated to the outer side of the common iliac artery.

All these branches form simple arcades with each other in the mesosigmoid, and the lowest sigmoid artery anastomoses with the superior hæmorrhoidal. The point of junction between the latter two vessels lies at a considerable distance from the bowel, and below it there is no further anastomosis between them, so that if the superior hæmorrhoidal artery be ligatured below this point blood could not reach the lower part of the gut through the system of sigmoidal arcades, whereas if the ligature is applied above this point blood can pass freely from the lowest sigmoid loop to the superior hæmorrhoidal artery and reach the area supplied by the latter. The term "critical point" has been employed to indicate the junction between the lowest sigmoid loop and the superior hæmorrhoidal artery. According to Davis ("Annals of Surgery," 1910) the "critical point" is situated about 15 cm. below the promontory of the sacrum in the majority of cases.

The Superior Hæmorrhoidal Vein as it crosses the common iliac artery becomes the inferior mesenteric vein. The latter vessel ascends along the outer side of the corresponding artery, crossing the sigmoid branches for about 2 inches. It then leaves the artery and proceeds upwards to join the ascending portion of the left colic branch. Accompanying this vessel for an inch or two, it then turns sharply inwards and disappears under the pancreas to join the splenic or the superior mesenteric vein.

The conspicuous arch formed by this sudden change of direction lies between the pancreas above and the duodeno-jejunal flexure below.

The tributaries of the superior hæmorrhoidal and inferior mesenteric veins correspond to the branches of the respective arteries.

The Lymphatic Vessels and Glands. The Epicolic and Paracolic Glands have the same topographical relationships to the descending, iliac and pelvic segments of the colon as have been described in the case of the transverse colon. The epicolic glands are specially numerous in the pelvic colon.

The Glands of the Intermediate Group are arranged around the left colic and sigmoid branches of the inferior mesenteric artery. Those related to the left colic branch are situated just above the point at which the inferior mesenteric vein crosses in front of the hilum of the left kidney.

On the upper sigmoid arteries the intermediate glands lie in the retroperitoneal tissue between the crest of the ileum and the lower pole of the kidney. Those related to the lower sigmoid arteries are situated at the base of the pelvic mesocolon.

The relationship of these glands to the colon is somewhat variable; they may be situated so close to it that they can only be distinguished from the paracolic glands by the fact that they lie on the sigmoid arteries and are capable of being removed without exposing the inferior mesenteric trunk. All the glands of the intermediate group are situated to the outer side of the inferior mesenteric vein. Like the corresponding glands in the transverse mesocolon, they receive most of the efferents of the paracolic glands, but some of the vessels from the bowel may pass directly into them.

The efferents proceeding from the intermediate glands reach the main group.

The Main Group of Glands related to the left colic artery is divided into two sets. One lies mainly around the horizontal part of the artery near its origin and is continuous with the inferior mesenteric main group above the origin of the left colic artery. The glands of this subdivision receive some of the efferents of the left colic intermediate group and also some of the efferents of the paracolic glands accompanying the branches of the left colic artery which supply the descending colon.

In none of the injections made by Dr. Jamieson could any lymphatic vessel be traced from the gut directly to this main group.

The second subdivision of the main group lies on the terminal portion of the inferior mesenteric vein in front of the head of the pancreas and below the body of that structure to the left of the superior mesenteric root glands. This group receives some of the efferents of the left colic intermediate glands, but apparently no direct vessels nor any of the efferents of the paracolic glands pass into it.

The lymphatic vessels emerging from the main group communicate with the superior mesenteric, the cœliac, and lumbar glands.

The Inferior Mesenteric Main Group is related to the stem of the inferior mesenteric artery up to the level of the left colic artery. It joins the left colic main group at this point and becomes continuous with the lumbar glands.

The pelvic colon is closely related to the inferior mesenteric artery at the pelvic brim, and consequently the lower glands of the main group receive the efferents of the paracolic glands and frequently direct vessels from the lower part of this colic loop; in this respect they stand in the same relation to the bowel as the intermediate glands in other regions.

The lowest glands of this main group are quite close to the terminal part of the pelvic colon and the commencement of the rectum, and receive the greater number of the direct vessels from the gut, corresponding thus with the paracolic glands elsewhere. An important fact to note in connection with the inferior mesenteric main group is that all along the entire chain efferents pass to the right into the glands of the lumbar group. The inferior mesenteric group therefore is not merely continuous with the lumbar glands at its upper part, but along its whole length. It may be regarded in fact as a lateral extension of the lumbar group.

The glands of the inferior mesenteric main group receive the efferents of the intermediate group situated on the sigmoid arteries, some efferents of the paracolic glands, and direct vessels from the pelvic colon. From the diagonally opposite segments of the colon, the hepatic flexure, and the pelvic loop, these direct vessels to the main groups are more common than from the intestine between these segments.

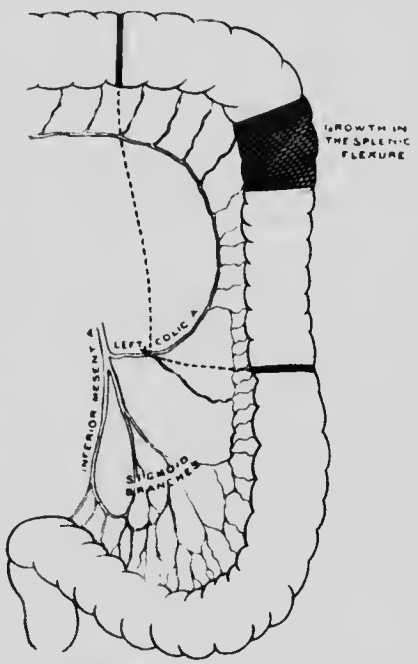

FIG. 301.—Resection of the Splenic Flexure of the Colon for Carcinoma. The left colic artery is ligatured close to its origin, and from this point two incisions are directed to the bowel, one upwards to the left segment of the transverse colon and another outwards to the descending colon near its lower part.

Practical Deductions to be derived from the Normal and Pathological Anatomy of the Lymphatics of the Colon.—(*a*) Although secondary cancer does occur in the glands in cases of cancer of the colon the invasion is not invariable, and when it does occur it is at a late stage in the progress of the disease. Advanced primary growths have frequently been found without any signs of glandular metastases. (*b*) Enlarged glands have been found which failed to reveal evidences of malignant disease on microscopical examination. This is explained by the supposition that septic absorption from ulcerated surfaces at and above the area of growth had taken place. (*c*) The following are the main reasons in favour of extensive glandular removal: Glandular recurrence does take place in a large percentage of cases after resection. In twenty cases operated on by Mickulicz glandular metastasis developed subsequently in ten.

Allowing for recurrence *in situ*, due most likely to persistence of disease existing at the time of operation, and for metastases in the liver, the great majority of recurrences are due to metastases in the lymphatic glands.

If glands become affected at some stage of the disease and in a certain proportion at an early stage, and if it is impossible for the surgeon to determine at the time of operation whether a growth in the colon has given rise to secondary gland infection or not, it is obviously desirable that, in addition to the growth, those glands should be removed which are likely to have become infected. All glands therefore which can be proved to be related primarily with the seat of disease should be included in the parts removed, seeing that one primary gland is just as likely to become affected as

another, whatever may be their comparative position with regard to the colon (Jamieson and Dobson).

In some districts, as for instance the splenic flexure of the colon, it may be impossible to remove the whole of the lymphatic area primarily involved.

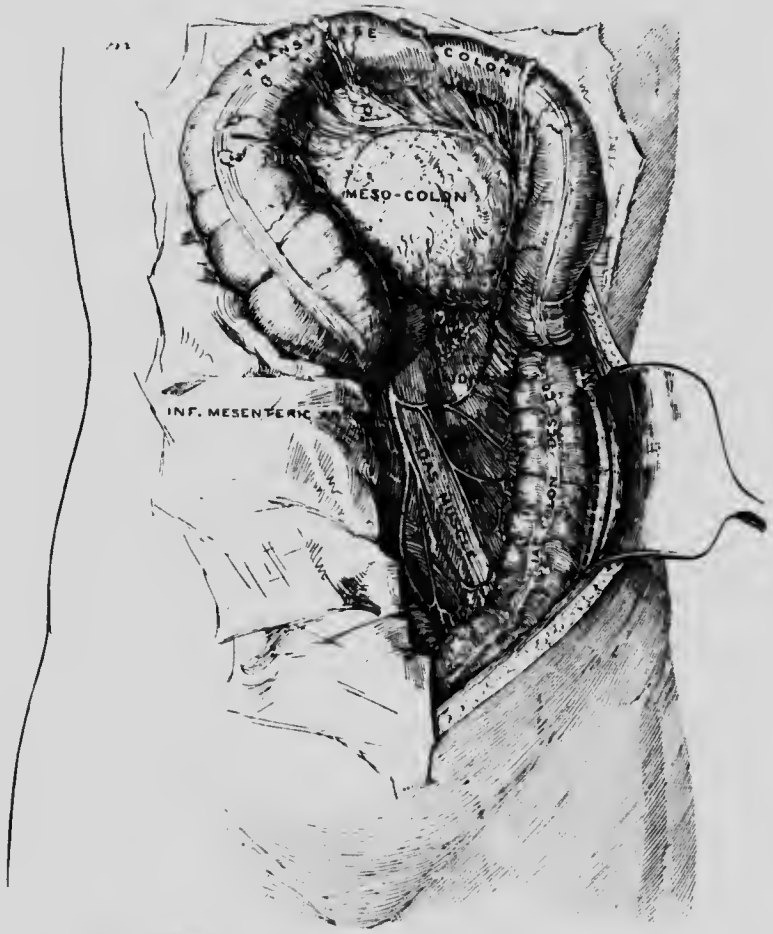

FIG. 202.—Mobilisation of the Left Segment of the Colon. The abdomen has been opened by a vertical incision just within the left semilunar line, and the general mass of the intestines has been displaced to the right side. The left segment of the transverse colon, the splenic flexure and the descending colon have been exposed. The left margin of the abdominal wound has been retracted in order to show the line of incision of the peritoneum at the outer side of the colon.

The necessary extension in the range of the operations usually practised may add somewhat to the immediate risk, but this is amply compensated for by the diminished likelihood of recurrence.

With regard to the removal of the secondary glands if the primary are obviously diseased, a review of the anatomy of the lymphatics of the colon will show how

impossible it is to remove the secondary glands, much though it might be desired.

There is no relationship between the operability of the primary growth and the involvement of the secondary glands, so that the latter may be obviously diseased while excision of the growth is quite possible.

Under such conditions it would probably be useless to proceed with the operation

FIG. 203.—Mobilisation of the Left Segment of the Colon. The peritoneum has been divided at the outer side of the descending colon and the line of section is about to be extended upwards through the phrenic-colic ligament.

except as a palliative measure. In this connection, however, the doubtful nature of glandular enlargement must be taken into account, and it may be advisable to remove the growth together with the primary glands and trust to the possibility of the enlargement of the secondary glands being due to septic absorption.

RESECTION OF CANCER INVOLVING THE SPLENIC FLEXURE OF THE COLON.—Following the principles adopted in the preceding operations, the resection will aim at including the lymphatic area related to the diseased bowel segment.

The glands will include those of the epicolic and paracolic groups together with the intermediate glands lying on the branches of the left colic artery. The last named were found primarily affected in four out of fourteen cases. From the splenic flexure as well as from the left half or two-thirds of the transverse colon there is an additional outlet for the lymphatics between the layers of the gastro-colic omentum to the glands at the hilum of the spleen. It is obvious that it will be impossible to remove the lymphatic area in this locality as the splenic glands cannot be efficiently attacked.

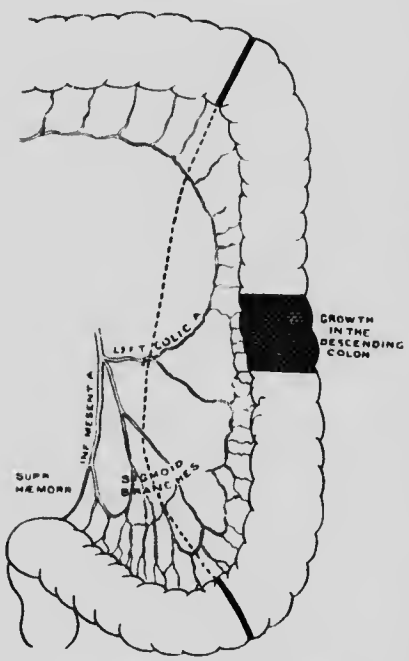

FIG. 201.—Resection of a Carcinoma in the descending Colon. The extent of bowel to be resected is determined by the level selected for ligature of the left colic artery, as represented in the figure, and the extent of the lymphatic dissection necessary according to Jamieson and Dobson. Starting from the site of ligature an incision is prolonged upwards to the left extremity of the transverse colon and another downwards to the centre of the pelvic loop of the colon.

According to W. J. Mayo "involvement of the splenic flexure is prone to early and extensive adhesions, and local extension along these pathways of the carcinomatous process is a more frequent bar to resection than lymph metastases."

It is interesting, however, to note that Madelung regards the prognosis as good after the removal of growths of the splenic flexure, even if the disease be advanced, on account of the paucity of the lymph paths, and that metastases are comparatively uncommon (Makins in Burghard's "Surgery").

The operation will include the excision of the primary growth and that portion of the lymphatic area in relationship to the branches of the left colic artery.

The Operation.—*The Abdominal Incision* may be made either vertically through the outer border of the left rectus muscle or obliquely below and parallel to the left costal margin. The diseased parts having been inspected and the site of operation having been walled off from the rest of the abdominal cavity by carefully placed swabs, the resection proceeds as follows:—

Ligature of the Left Colic Artery and Vein.—The left colic artery is defined at the outer side of the inferior mesenteric vein and is ligatured with its accompanying vein at this point.

Mobilisation of the Splenic Flexure and Descending Colon.—The peritoneum to the outer side of the descending colon and splenic flexure is divided with curved scissors and the incision prolonged upwards through the phrenico-colic ligament (Fig. 203). The fingers can now be passed behind the colon and the latter, along with the growth, the subperitoneal tissues and glands, displaced inwards. The great omentum is treated in the manner already described.

The Resection.—An incision is carried upwards from the point of ligature of the left colic artery to the level of section of the transverse colon. The level selected for the division of the latter is determined by the area of distribution of the middle colic

artery. The left branch of this vessel supplies the transverse colon as far as the junction of its middle and left thirds.

Another incision is directed from the point of ligature of the left colic artery downwards and to the left to the descending colon in its lower part. The line of section of the descending colon will lie immediately above the level of the highest sigmoid artery (Fig. 201).

The transverse and descending segments of the colon are divided at the respective points selected and the intermediate portion of bowel containing the growth is removed.

Re-establishment of the Continuity of the Bowel. The operation may be completed by an end-to-end anastomosis or, if preferred, the cut ends of the bowel may be occluded and a lateral anastomosis performed.

All swabs are removed and the abdominal wound is closed.

Fig. 205.—Carcinoma of the Colon. This specimen, which was removed from the pelvic segment of the colon, is a good example of the scirrhus variety of intestinal carcinoma. The bowel above the growth was enormously dilated and hypertrophied. The site of the disease is indicated by a deep constriction, as if a piece of string had been tied around the bowel—"Wire-cord Stricture."

RESECTION OF CANCER INVOLVING THE DESCENDING AND ILIAC SEGMENTS OF THE COLON.

In a case of cancer situated in the descending colon the glands which may be involved primarily are the epicolic, the paracolic, and the intermediate glands on the branches of the left colic artery, including those on the first sigmoid artery. Removal of this lymphatic area may be inadequate as some of the vessels from the upper part of the descending colon pass upwards to the splenic glands.

The operation very much resembles the foregoing procedure, except that the lower line of bowel section is placed in the pelvic instead of in the descending colon (compare Figs. 201, 204).

The Abdominal Incision is made vertically through the outer part of the left rectus muscle or through the left linea semilunaris.

Ligature of the Left Colic Artery and Vein.—The left colic artery is exposed in front of the hilum of the kidney to the outer side of the inferior mesenteric vein and ligatured along with its companion vein.

Mobilisation of the Colon.—The peritoneum is divided vertically along the outer side of the descending colon and the splenic flexure and the bowel is then raised together with the peritoneum attached to its inner side, the subperitoneal tissue, blood vessels and lymphatics.

The Resection.—From the point of ligature of the left colic artery an incision is carried upwards to the transverse colon, which it meets at a point corresponding to the junction of its middle and left thirds.

Another peritoneal incision is directed from the ligatured left colic vessels down-

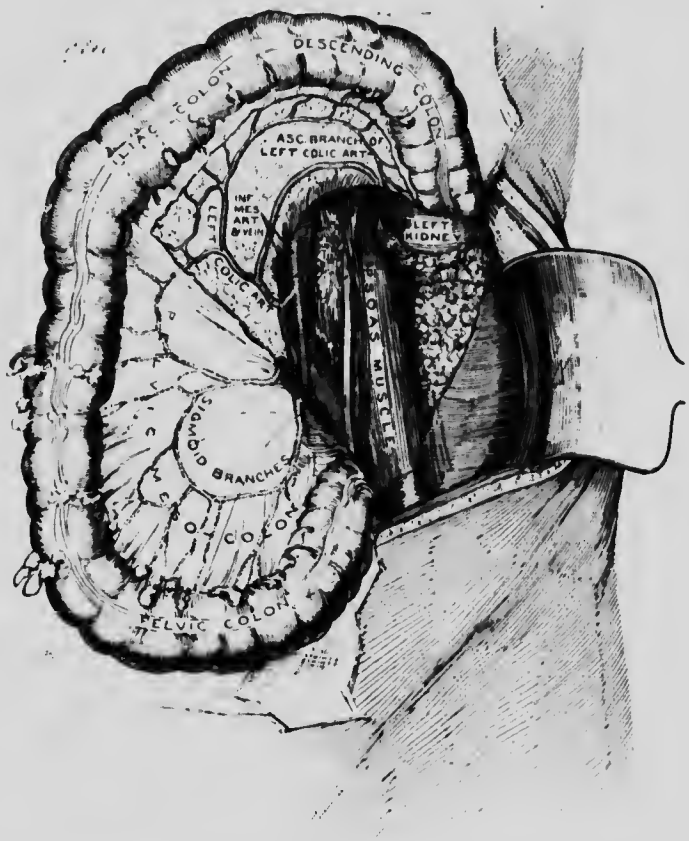

FIG. 206.—Mobilisation of the Left Segment of the Colon. The peritoneum has been divided along the outer side of the descending colon up to and including the phrenico-colic ligament, and the bowel has been carefully raised and drawn inwards. In the exposed retroperitoneal area will be observed the lower pole of the left kidney, the psoas muscle, the spermatic vessels, the left ureter, and the aorta with its inferior mesenteric and left common iliac branches. The blood-vessels which are distributed to the descending, iliac and pelvic segments of the colon and which proceed from the inferior mesenteric artery are clearly represented.

wards and outwards to the upper part of the pelvic colon. The colon is now divided opposite the points at which the peritoneal incisions meet it and the diseased segment removed. The open ends of the bowel are occluded and the continuity of the intestinal passage is re-established by the performance of a side-to-side anastomosis. The abdominal wound is closed.

THE RESECTION OF CANCER INVOLVING THE PELVIC COLON. This loop of bowel is connected by a mesentery which extends from the left iliac fossa to the front of the third sacral vertebral segment, and when empty it usually lies coiled up within the pelvic cavity.

There is some variability in the extent and mobility of this loop.

The operative measures indicated and the difficulties encountered in the treatment of cancer in the pelvic colon depend upon the part of the loop affected. It will be convenient to consider first the method of dealing with a growth in the lower part of the loop and subsequently that suitable for cancer at or about the middle of the loop.

The Lymphatics of the Pelvic Colon. The lymphatic glands which may be primarily involved from a cancer at this level form a fairly extensive chain, and include the epicolic and paracolic glands in the near vicinity of the growth and also the glands of the intermediate group and those of the main group along the inferior mesenteric artery. According to Jamieson and Dobson it has been shown that the examination of infected specimens reveals the fact that direct vessels proceeding from this part do not enter glands at a higher level than that corresponding to the junction of the middle and upper thirds of the inferior mesenteric artery.

The apex of the wedge of tissue to be removed will accordingly lie on the inferior mesenteric artery below its left colic branch, and the parts removed will include the lower sigmoid arteries, the glands already indicated, the lymphatic vessels, and the subperitoneal tissue in which these structures lie.

The upper bowel section will be made in the loop. It is not necessary to make it at a higher level seeing that the left colic artery is intact and the blood supply of the upper part of the pelvic loop assured by the free anastomosis between this vessel and the sigmoid branches.

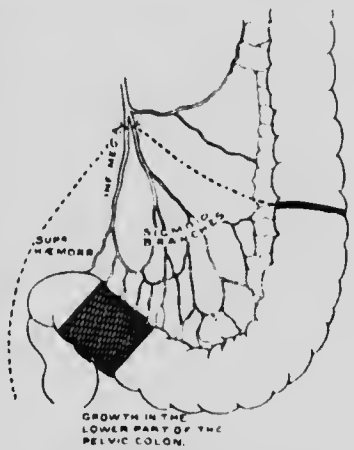

FIG. 207.—Carcinoma involving the lower part of the Pelvic Loop of the Colon. This diagram represents the extent of the resection required for carcinoma situated in this part of the bowel, according to Jamieson and Dobson. The inferior mesenteric artery is ligatured just beyond its left colic branch, and from this level two lines of peritoneal incision are directed respectively outwards to the middle of the pelvic loop of the colon and downwards over the promontory of the sacrum to a point just above the commencement of the rectum.

Blood Vessels. The removal of the lymphatic area just indicated will necessitate the ligature and division of the inferior mesenteric artery below its left colic branch.

Ligature of the trunk of the inferior mesenteric artery at its origin has been recommended, but division of the vessel at this level would endanger the blood supply of the upper segment of the bowel as it would then depend entirely on the single anastomosis between the middle and left colic arteries.

Although injection may be made to travel in the cadaver from the middle colic artery into the sigmoid arteries after ligature of the inferior mesenteric at its origin, and although it is possible for the circulation to be maintained in animals after the artery has been tied at this level, it does not follow that such would happen in people advanced in years and whose vessels are perhaps diseased and their circulation feeble. The connection therefore between the middle colic and inferior mesenteric arteries

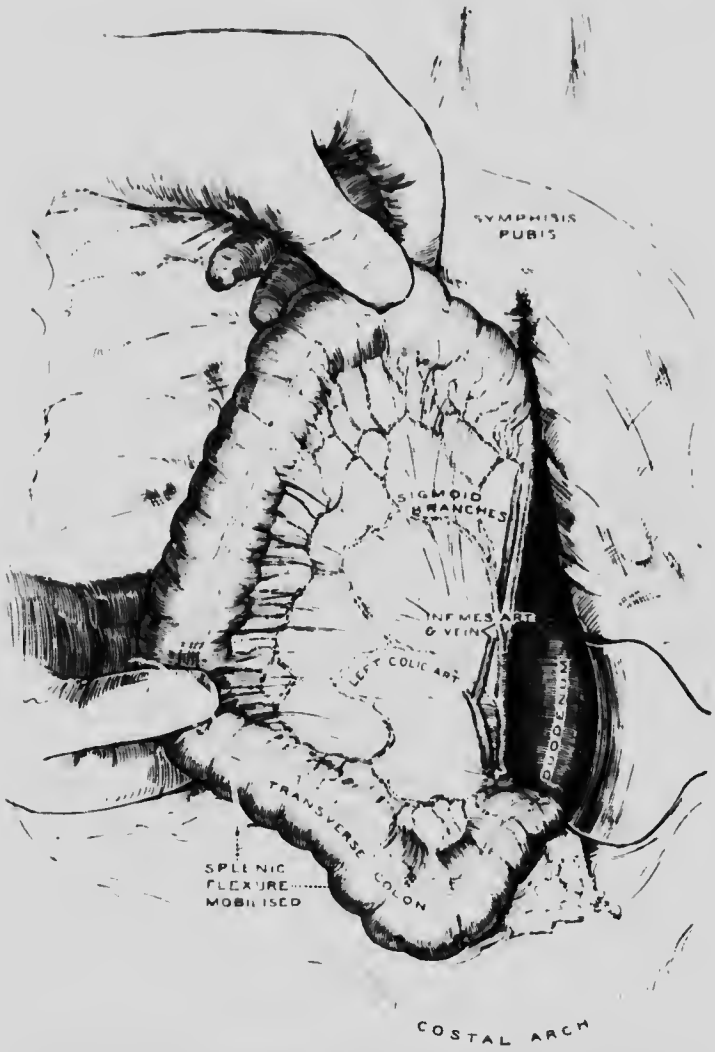

FIG. 208.—Resection of a Carcinoma situated in the lower part of the Pelvic Loop of the Colon. The parts are viewed as they appear with the body in the Trendelenburg position. The descending colon and the splenic flexure have been mobilised in the manner represented in Fig. 206. A large sterile swab has been introduced into the left lumbar hollow and the mobilised colon, which includes its left flexure together with its descending and iliac segments, has been drawn over to the left side. Note the anastomotic arch formed by the ascending branch of the left colic artery also the series of loops formed by the left colic and the sigmoid arteries.

may be anatomically perfect but physiologically inadequate (Jamieson and Dobson).

The position of the lower bowel section is determined partly by the necessity of going well below the growth, but more particularly by a consideration of the blood

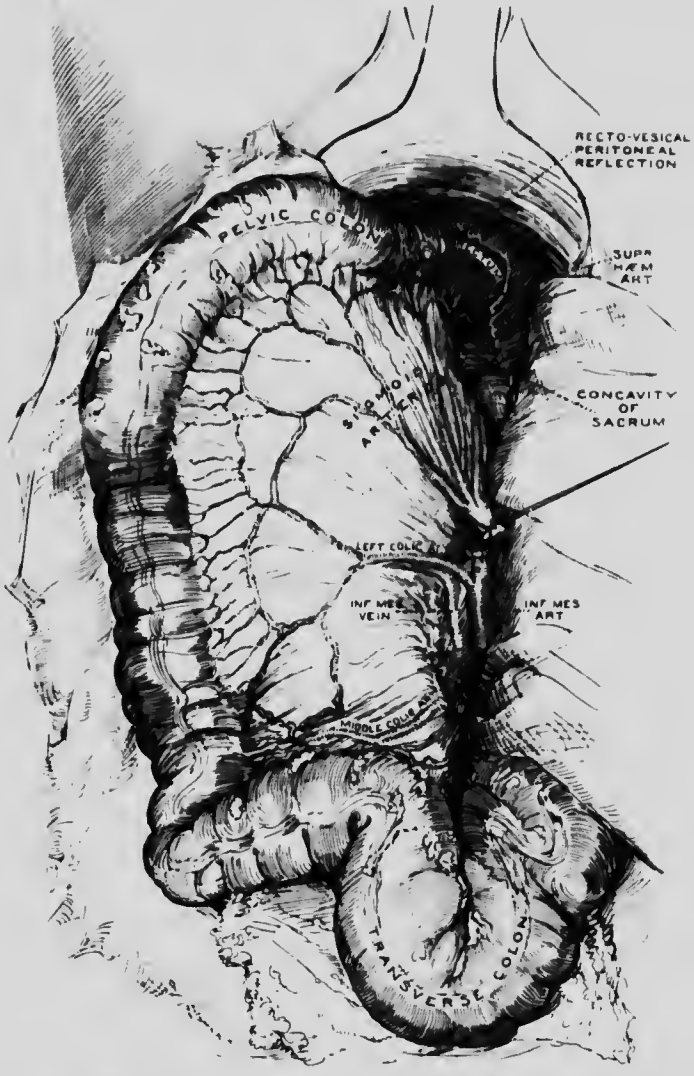

FIG. 209.—Resection of a Carcinoma situated in the lower part of the Pelvic Loop of the Colon. This figure represents a stage in the process of mobilisation of the colon, and is viewed with the body inclined in the Trendelenburg position. The peritoneum along the outer side of the colon has been divided and the descending colon including the splenic flexure raised in the manner represented in Fig. 206. A large swab of sterile muslin has been introduced behind the colon into the left lumbar hollow. The site selected for ligature of the inferior mesenteric vessels, viz., on the distal side of the left colic artery is especially to be noted, also the line of peritoneal incision extending downwards over the promontory of the sacrum to the bottom of the recto-vesical pouch.

supply. The vitality of the lower segment of the colon will depend on the middle and inferior hæmorrhoidal arteries and branches of the sacral arteries. It is not

certain that these vessels would suffice to maintain the vitality of this portion of bowel. The lower bowel section, therefore, will be made through the pelvic colon as the latter descends in relation to the left wall of the pelvis. Before attempting to restore the continuity of the bowel it is necessary to ascertain by the amount of bleeding from the lower stump if its circulation is sufficiently free to render the junction safe. If free bleeding does not occur on relaxing the pressure exerted by the retaining clamp certain alternatives must be considered. From the deep position of the lower portion of the pelvic loop the establishment of the continuity of the colon is attended by considerable difficulty and risk.

RESECTION OF CANCER INVOLVING THE LOWER PART OF THE PELVIC COLON. *The Abdominal Incision.* The abdomen is opened by a left paramedian incision or by one in the left semilunar line.

The intrapelvic manipulations will be greatly facilitated by adopting the high Trendelenburg position.

The exploration of the site of operation and the walling off of the diseased area by swabs are performed as usual.

Mobilisation of the Colon and Ligature of the Inferior Mesenteric Vessels.—A long incision is made in the peritoneum to the outer side of the pelvic mesocolon and the descending colon, if necessary, up to the splenic flexure. The gut is then freely mobilised by means of dry sponging and the process of stripping extended towards the middle line. The ureter, which is usually adherent to the peritoneum, and the spermatic vessels will be exposed and must be carefully guarded.

The inferior mesenteric vessels are now defined just below the origin of the left colic artery and are divided between ligatures.

The Resection.—The parts removed include a wedge-shaped area having its apex at the site of ligature of the inferior mesenteric vessels. The upper bowel section crosses the pelvic loop at its middle and the lower line of division passes through the pelvic colon close to its junction with the rectum.

In carrying the incision from the point of ligature of the inferior mesenteric vessels to the middle of the pelvic loop the secondary arches of the sigmoid arteries are preserved (Fig. 208).

The other peritoneal incision, which begins at the ligatured vessels, is carried downwards between the inferior mesenteric vessels and the promontory of the sacrum along the inner side of the pelvic mesocolon until it reaches the level of section of the bowel. The wedge-shaped mass of tissue included between these incisions is then stripped forwards from the upper part of the concavity of the sacrum and the gut clamped and divided at the points already determined.

The blood supply of the upper segment is practically assured by the preservation of the left colic artery; that of the lower portion depends on the middle and inferior haemorrhoidal arteries, and its efficiency may be somewhat doubtful. It may be tested by relaxing the blades of the clamp and observing if the cut edge of the bowel bleeds freely. If the circulation appears satisfactory the operation may be terminated by an end-to-end anastomosis. If, however, the blood supply be deemed inadequate, the following alternatives must be considered.

Alternatives to the Re-establishment of the Continuity of the Two Bowel Segments.

1. *Left Inguinal Colostomy.*—It would appear that this is probably the safest procedure in a large percentage of cases in which cancer is situated in the lower part of the pelvic loop.

2. *Resection of the Lower Segment, including the Rectum.* The rectum is separated from its pelvic surroundings in front, laterally and behind, down to the pelvic diaphragm. Forceps are then introduced from below through the anus and the upper end of the rectum is seized and everted through the anal aperture. The greater part of the protruding bowel is removed, leaving, however, a ring of well-vascularised rectal tissues projecting beyond the anus. The upper segment of the colon, which has been freely mobilised, is drawn down through this inverted cylinder and the two are united by suture and allowed to recede within the anal aperture. This procedure is attended by grave risk, and the published records of excision of high rectal cancer by this method reveal a very high mortality; in Kraske's series of cases it reached 40 per cent.

RESECTION OF CANCER INVOLVING THE MIDDLE AND UPPER PARTS OF THE PELVIC COLON.—The extent of glandular involvement when cancer originates at these levels corresponds with that already indicated in connection with the lower part of the pelvic loop. The vessels which drain this segment of the colon pass directly not only to the epicolic and paracolic glands, but also to the intermediate glands lying on the sigmoid arteries and to those of the main group on the inferior mesenteric artery. In other words, these several glandular groups may all be connected primarily with the diseased area.

The facts mentioned above in regard to the blood vessels in resection of the lower part of the pelvic colon are equally applicable in connection with these segments of the pelvic loop.

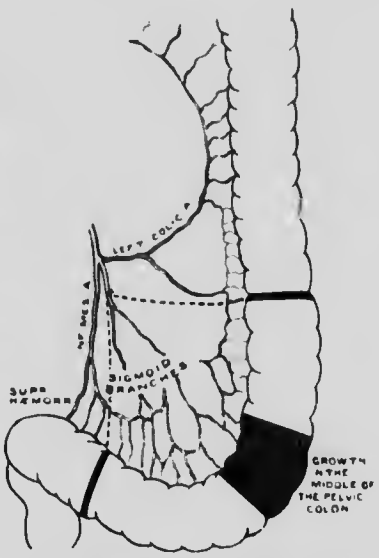

FIG. 210.—Resection of a Carcinoma situated at the middle of the Pelvic Loop of the Colon. The site of ligature of the sigmoid arteries is represented; the lowest sigmoid branch, however, is not included. Starting from the site of ligature, two lines of incision are directed to the colon, the upper to the level of junction of its descending and iliac segments, and the lower to the distal portion of its pelvic loop.

Scope of the Operation.—The ideal form of operation would be carried out on lines very similar to those of the preceding operation. More of the mesentery, however, would require removal, and the colon would be divided at a somewhat higher level, viz., at the commencement of its iliac segment.

The difficulty in carrying out the ideal operation mainly depends upon the uncertainty as to the adequacy of the blood supply of the lower segment of the colon following division of the inferior mesenteric artery. The anastomoses between this vessel and the other arteries of the rectum—the middle and inferior hæmorrhoidal and the middle sacral—might prove inadequate. Assuming, however, that they were capable of vascularising the lower part of the loop, great care would be required in determining the site at which the latter was to be divided. If possible the line of section in the mesocolon should be so arranged as to preserve intact the lowest sigmoid artery, otherwise the circulation could not be carried from the superior hæmorrhoidal artery and its vertically descending branches to the system of arcades derived from the

sigmoid vessels. This will be rendered evident by a reference to Fig. 210. If the lower section cannot be made so as to ensure the lowest sigmoid artery it had better be made lower down, well within the territory of the superior hæmorrhoidal artery. The small portion of bowel between the part supplied by the lowest of the arterial arcades and that supplied by the vertical branches of the superior hæmorrhoidal artery should be eliminated, as it would very probably perish if deprived of the blood carried to it by the lowest sigmoid artery.

Considering the risks entailed in re-establishing the continuity of the colon after the "ideal" resection just indicated, it might be deemed advisable to close the lower segment and establish an artificial anus in the left iliac region, or even to resect the remainder of the pelvic colon together with the greater part of the rectum and bring the upper segment down and out through the anus, where, the lower part of the rectum having been everted, the two cylinders could be connected in a manner resembling Maunsell's method of enterorrhaphy.

The difficulties and dangers just pointed out in carrying out this "ideal" type of operation are such that any reasonable alternative should receive careful consideration. In favour of a less extensive procedure may be mentioned the fact that, in many instances, a purely local excision of cancerous growths in the pelvic colon has been attended by a considerable measure of success.

In the operation about to be described the inferior mesenteric vessels are preserved so as to safeguard the nutrition of the lower segment after the growth has been excised (Jamieson and Dobson).

The Operation.—*The Abdominal Incision* is made vertically through the lower part of the left rectus muscle.

Mobilisation of the Colon.—The descending, iliac, and pelvic segments of the colon are next mobilised in the way already described.

The Inferior Mesenteric Vessels are exposed by dividing the peritoneum which covers them. By following these vessels downwards from the left colic branch to the lowest sigmoid artery any visible glands may be stripped away, every precaution being taken to avoid damage to the vessels themselves.

The sigmoid arteries are doubly ligatured and divided close to their origin, but the lowest of the series is preserved unless its removal be necessitated by the position of the growth.

The Resection.—The upper colon section is made at the termination of the descending colon or in its iliac segment. The lower section is made in the lower part of the pelvic loop. Some care is necessary in making this lower section. If the lowest sigmoid artery must be divided at its origin the level of the lower section of the gut should be below the brim of the pelvis. Failure to adopt this precaution may result in necrosis of portion of the lower sigmoid owing to the cessation of the arterial arcades at the lowest sigmoid artery and the non-union of this vessel with the branches of the superior hæmorrhoidal artery.

The Re-establishment of the Continuity of the Bowel.—The remarks made under this head and the alternatives offered to it in the description of the preceding operation apply with equal force in this procedure.

PROCEDURES APPLICABLE TO MALIGNANT GROWTHS IN THE LARGE BOWEL WHEN SYMPTOMS OF OBSTRUCTION ARE PRESENT.

In the preceding section certain operative procedures were considered which had for their object the removal of growths originating in different portions of the large bowel. The form of colectomy so far considered is termed *primary*, as the growth is removed without any preliminary procedure. There are, however, certain well-founded objections to this form of colectomy, and cases frequently occur in which it may be impossible of accomplishment. The main fact which must be borne in mind in connection with resection of the colon for malignant disease is that no operation can be considered safe unless carried out in the absence of obstruction to the faecal current. As such a condition is rather infrequent in cases of cancer of the large bowel it necessarily follows that the occasions on which a primary resection can be performed are relatively few.

In order to render the performance of a primary colectomy with immediate union of the distal and proximal bowel segments a safe procedure it would be necessary to have the intestinal tissues in a sound, healthy state, but this is rarely possible, for not only is the bowel on the proximal side of the growth frequently dilated and hypertrophied, but its mucous and submucous layers are infiltrated with inflammatory products and its contents are in a highly septic state. The distal segment will on the other hand be thin and atrophic, and consequently the performance of a colonic anastomosis will be attended by considerable practical difficulties, quite apart from the great danger of infection of the line of suture. Additional dangers which must not be overlooked in cases of primary resection are gaseous distension, faecal accumulation at the site of junction, and post-operative intestinal paresis. It is unnecessary to state that these latter would interfere seriously with the success of any primary suturing operation.

Another objection to primary colectomy is the greater degree of shock which it entails, and this may render it inadvisable in elderly individuals, more especially those of a stout or flabby type, in whom any prolonged abdominal operation would be attended by considerable risk.

In thus drawing attention to the more obvious difficulties and risks attending the primary resection of malignant disease of the colon it should be noted that these are considerably less in cases in which the growths are situated on the right side, as in the cæcum, ascending colon, hepatic flexure, and the right half of the transverse colon, than in the bowel beyond this. The resection of growths so situated, as described in the preceding section, may be carried out on an extensive scale and with a due regard to the various lymphatic districts likely to be involved by the extension of the disease.

When malignant growths involve the left segment of the colon they are frequently of the hard, contracting type and of small proportions, giving rise to marked stenosis of the bowel (whipcord stricture). These growths when submitted for treatment are usually associated with intestinal obstruction, and are therefore unsuited to resection with primary junction of the distal and proximal bowel segments.

To overcome these difficulties certain operative procedures have been devised.

1. Colectomy with a Temporary Artificial Anus on the Proximal Side of the Junction.— In addition to the colectomy with primary union of the healthy bowel segments an artificial anus is established on the proximal side of the junction for the

purpose of allowing the escape of the intestinal contents and preventing any possibility of faecal accumulation and distension at the junction site.

2. Paul's Two-stage Operation. The two-stage operation of primary colectomy with secondary union which is usually associated with the name of Mr. Paul, of Liverpool, consists in mobilising and resecting the malignant growth, fixing the two bowel segments to the margin of the abdominal wound, draining the bowel by specially devised glass tubes, and re-establishing the continuity of the bowel at a later date.

The method of carrying out Paul's operation is as follows: As it is usually difficult or impossible to locate the exact site of the growth in the bowel, an exploratory operation will first be required. At the present day, however, the value of X-rays in locating these growths is generally recognised, and the information afforded by this method of investigation is very great.

Should an exploration be necessary the abdominal incision is made in the middle line, and when the growth has been located another incision of ample extent is made directly over it and the median wound closed.

The growth is drawn forwards, adhesions are suitably dealt with, and the mesentery retaining the diseased bowel is ligatured in sections with the help of an aneurysm needle. It is divided to a sufficient extent to free the bowel well beyond the growth on each side.

The loop of bowel containing the growth will now have been sufficiently loosened to enable it to hang out of the abdomen. By drawing it forwards its two limbs are made to lie together and are connected by sutures which traverse the margins of the divided mesentery and the adjacent serous surfaces of the gut. The connected pieces of bowel are sutured all round to the parietal peritoneum of the abdominal wound. Each limb of the protruding loop is divided, whereupon a glass drainage tube (Paul's) is introduced and securely fixed *in situ*. The diseased segment is removed.

The wound margins are brought together around the protruding bowel by a few sutures of silkworm gut which traverse all the layers of the abdominal wall.

In the second stage of Paul's operation the spur formed by the two intestinal cylinders at the site of the artificial anus is broken down with an enterotome and the artificial anus closed by detaching the mucous membrane all round from the skin, turning it in, and bringing the raw tissues of the abdominal parietes together over it.

Paul's method has been modified in certain of its details by various operators, but the principle of the procedure remains the same in all.

3. The Procedure of Mikulicz. Mikulicz's method of exteriorisation of the tumour differs from that of Paul in that the diseased bowel segment is not immediately removed and tubes introduced, but only after some days. If the evacuation of the bowel contents is imperative the modification proposed by Hochenegg may be adopted, viz., the introduction of a tube through a lateral opening into that part of the protruding loop situated on the proximal side of the growth. The chief advantage of these procedures is that they can usually be carried out rapidly, with the avoidance of shock, and they are not attended by the risks of primary resection and union.

The difficulties attending the procedures of Paul and Mikulicz are not great provided the growth is situated in a movable segment of the colon so that the affected loop may be drawn out through the abdominal wound. If the part affected, however, is fixed and deeply placed, viz., the flexures or the descending colon, it will be necessary to mobilise the bowel freely in the manner described and figured in the preceding section before it can be safely delivered through the wound. With tumours that are large

and adherent this mobilisation may be both tedious and difficult and attended by considerable shock. It will be readily understood, therefore, that neither Paul's nor Mikulicz's operation is to be recommended in cases where obvious obstruction exists or where infected glands are present, as these latter require a more extensive mesenteric and intestinal resection. Some surgeons, however, are satisfied to undertake a less extensive bowel resection than that which appears necessary, bearing in mind the probable extent of the disease in the adjoining lymphatic districts, and it cannot be denied that in many instances comparatively limited resections of the colon for cancer have been followed by the most satisfactory results both immediate and remote.

The final step of these operations, viz., the closure of the artificial anus and the re-establishment of the continuity of the intestinal passage, may be attended by considerable difficulty; it may entail several operations, and it is by no means devoid of risk. Stated briefly, the procedures of Paul and Mikulicz are not generally applicable to right-sided tumours and they are not possible for tumours low down in the pelvic colon. They are best adapted to tumours in the transverse and left colic segments, with which the degree of intestinal obstruction is moderate and the glandular involvement not pronounced. They are to be preferred to primary resection and junction when the condition of the patient is such that a prolonged operation would be inadvisable.

The procedures of Paul and Mikulicz give good immediate results but allow of a rather limited resection, which, in the light of the recent work on the lymphatics of the colon, is inadequate for the efficient eradication of the disease.

4. The Three-stage Operation. Another procedure is known as the "three-stage operation." A preliminary artificial anus is established and the growth subsequently resected. Finally the artificial anus is closed (Schloffer). It is especially to be recommended in cases with obstruction either of an acute or chronic type. Even when no obstruction exists it is regarded by many surgeons as the best procedure, as it increases the prospect of success of excision of the growth and the immediate union of the distal and proximal bowel segments.

The artificial anus should be placed in a part of the colon as far as possible on the proximal side of the disease. As a rule, therefore, the cæcum is the site selected. Very exceptionally the opening is made in the ileum. After an interval of two or three weeks the resection is undertaken. A free abdominal incision will be required in order to permit of the manipulations attending the mobilisation and withdrawal of the diseased portion of the colon. The resection is followed either by an end-to-end or a lateral junction of the proximal and distal segments. The presence of the artificial anus in such cases is a valuable safeguard, and it tends greatly to diminish the risk of failure of the intestinal junction. The third stage of the operation may be undertaken as soon as it appears that the junction is secure.

With the exception of the cæcum this operation may be regarded as applicable to any segment of the colon. For cancers involving the cæcum the best procedure, unless the necessity for the relief of existing obstruction renders it impossible, is a primary colectomy followed by immediate union of the ileum with the transverse colon. This operation has been fully described above (p. 322). The closure of a cæcal opening also can be accomplished much more easily than the artificial anus resulting from the procedures of Paul or Mikulicz. The disadvantages of a cæcal anus are that unless very large it may fail to allow the complete escape of the bowel contents, and it is troublesome owing to the almost continuous flow of liquid material,

which irritates the skin surrounding the artificial anus and may render it very sore or even acutely inflamed.

One of the disadvantages which may result from the establishment of a cæcal artificial anus is the not infrequent filling up of the bowel between the ascending colon and the seat of obstruction with solid fæces; thus the transverse colon and the descending colon may become enormously dilated, with resulting colic and toxæmia, and require the subsequent establishment of a left iliac anus. Distension of the bowel on the proximal side of the growth would of necessity cause difficulty in performing the resection and uniting the two segments afterwards. The persisting infiltration of the bowel walls and the offensive character of the contained fæcal matter would tend to cause failure of union just as much as if no preliminary artificial anus had been established. If the growth should prove to be unsuited for resection an artificial anus upon the left side would be far preferable to one in the right iliac region. Should a cæcal anus, however, have been established it will require to be closed after performing a colostomy upon the left side.

5. Entero-anastomosis followed by Secondary Colectomy. This procedure has been performed and recommended by certain continental surgeons, more especially Hochenegg and Langemak. A short circuit is established by anastomosing the bowel on the proximal with that on the distal side of the growth and resecting the growth at a second operation. This method of procedure appears to have its chief indication in cases of malignant disease of the cæcum, complicated by inflammation and abscess. For growths in the more distal parts of the colon it presents no advantages over the three-stage operation, and its accomplishment may not be possible when the growth is situated low down in the sigmoid. The short-circuiting procedure is not to be recommended when obstruction is pronounced.

6. Colectomy with a Permanent Artificial Anus. This form of procedure may be necessary in cases of tumours low down in the pelvic colon where the risks attending an attempt at union are very great.

PALLIATIVE PROCEDURES IN CASES OF MALIGNANT DISEASE OF THE COLON.

Palliative measures are usually indicated when symptoms of intestinal obstruction supervene and when the existing conditions are such that the resection of the growth is contraindicated. Those deserving of mention are (a) colostomy, or the establishing of a permanent artificial anus; (b) entero-anastomosis, or the short circuiting of the diseased segment of the bowel.

Colostomy. The establishment of a permanent artificial anus is attended by slight risk to life, and it is the most widely applicable measure available. It entails the minimum of intervention within the abdomen, and for this reason it is specially to be recommended, seeing that extensive manipulation of the bowel is to be avoided in inoperable cases.

It is desirable that the artificial anus should be situated as far as possible from the ileum.

The procedures about to be described have for their object the establishment of an opening in the colon leading to the surface.

These operations are indicated when the presence of certain pathological conditions renders it impossible for the intestinal contents to pursue their normal course towards the anus and it becomes necessary to provide an artificial aperture to permit of their escape. To such an opening the term "artificial anus" has been applied, and the terms "colotomy" and "colostomy" have been used indiscriminately to indicate its establishment, although the respective procedures present many points of difference.

Cæcal and Colonic Fistulæ. These terms are applied to those procedures in which the large bowel is opened at its convex margin and sutured to the abdominal parietes. In this manner a lateral intestinal fistula is formed which permits of the unloading of the obstructed intestine. The same operation may be performed in order to carry out lavage of the colon, or to make possible the direct application of certain chemical compounds to the diseased mucous membrane.

The operation of colostomy differs from the preceding, inasmuch as complete evacuation of the intestinal contents through an artificial aperture is the surgeon's object. It is for an opening of this kind that the term "artificial anus" should be reserved. A temporary or permanent aperture may be established by colostomy.

COLONIC FISTULA.

The establishment of a colonic fistula is usually an operation of urgency, and is performed in those cases of obstruction of the colon in which great abdominal distension or profound toxæmia contraindicates any radical method of dealing with the primary cause.

In many instances local anæsthesia must be employed, for the patient is already in such a degree of inanition from auto-intoxication that a general anæsthetic might determine a fatal issue. In more favourable cases, however, ether may safely be administered, never neglecting the precaution of washing out the stomach immediately before anæsthesia is induced, otherwise regurgitated fluids may gain access to the air passages with disastrous consequences.

The Abdominal Incision.—According to existing indications the abdominal incision is made either in the right or left iliac region at the junction of the outer and middle thirds of a line joining the anterior superior iliac spine with the umbilicus. The incision is about 2½ inches in length and is carried down to the peritoneum by the method of McBurney. The abdomen is opened with great care, as the distended intestinal coils lie in immediate apposition with the parietes.

Suture of the Colon to the Abdominal Wall.—The colon may protrude immediately when the parietal peritoneum is divided, but more frequently the small intestine or a portion of the great omentum comes into view. These are pushed towards the middle line and search is made for the colon, which is usually recognised without difficulty. If the colon does not come into view immediately the finger is passed from without inwards along the floor of the iliac fossa until it encounters the mesentery of the iliac colon on the left side or on the right side of the body, the cæcum. If the cæcum is not distended and time presses, the first distended loop found may be selected as the site of the artificial aperture.

The part of the bowel so selected is drawn forwards into the wound until its convex border projects slightly beyond the level of the surrounding skin. The base of the protruding part is connected all round to the parietal peritoneum and the deeper muscular strata of the abdominal wound by means of a continuous sero-muscular

suture. The introduction of this suture may be facilitated by the insertion of a separate suture traversing the serous and muscular coats of the bowel and the abdominal wall at each angle of the wound. Great gentleness should be employed in manipulating the gut and in the introduction of the sutures, as the distension present will have produced material weakening and distinct thinning of the intestinal wall.

If the abdominal wound appears unnecessarily large it will need to be reduced in extent by means of one or more deep sutures introduced at each angle.

Incision of the Colon.— If the condition of the patient permit, it will be well to

FIG. 211.—Procedure for the establishment of a Colonic Fistula on the left side. The pelvic loop of the colon has been exposed and connected by means of a continuous suture with the deepest stratum of the abdominal wall. The black dotted line represents the line of incision in the bowel and the purse-string suture which has been passed around this is intended to retain a Paul's glass tube introduced through the opening.

postpone opening the colon for one or two days, by which time the bowel will have become adherent to the abdominal wall. A delay of even a few hours will often seal off the peritoneal cavity to an extent sufficient to prevent leakage along the suture line and soiling of the peritoneum. As a rule, however, there is urgent necessity for evacuating the bowel, and certain toxæmia is a more present danger than questionable peritonitis; the latter, moreover, will only occur if the technique be faulty. Therefore the opening must be made as a rule without delay.

The best method for effecting this consists in introducing a seco-muscular purse-string suture of stout silk into the exposed piece of bowel as represented in Fig. 211

The centre of the area circumscribed by the suture is incised and a Paul's glass tube introduced and securely fixed within the bowel by tightening the sutures. This will remain *in situ* for two or three days; it then becomes loose and falls out.

Post-operative Details.—The patient must at once receive the treatment appropriate to his general condition. An enema of hot coffee, rectal or subcutaneous saline, may be indicated. The most pressing indication, however, is to obtain a free evacuation of the bowels. Eserine salicylate $\frac{1}{100}$ grain hypodermically, followed in fifteen minutes by an enema, will be found useful and in serious cases we have found pituitary extract undoubtedly beneficial.

The site of the fistula must be kept scrupulously clean, and the inevitable irritation consequent on faecal contact will be combated by suitable applications, such as zinc oxide ointment, vaseline, bismuth paste, or by the rubber solution or rubber dam suggested under "Gastrostomy."

TYPHLOSTOMY.—The operative procedure just described is sometimes performed upon the right side when it is decided to open the cæcum or to drain the commencement of the ascending colon.

Typhlostomy is strongly indicated for the relief of the abdominal distension which sometimes occurs as the result of a malignant stricture situated in the ascending or transverse segment of the colon. In some cases of this nature it is an essential preliminary measure to the subsequent resection of the growth.

When ulcerative colitis is present and intractable to the usual remedies typhlostomy may be indicated for the purpose of affording rest to the diseased colon.

The Operation. The abdominal tissues are divided after the method of McBurney, which has been fully described, and the aperture leading into the abdominal cavity is made sufficiently free to enable the cæcum to be drawn out without an undue degree of constriction. When possible the whole cæcum is drawn well out of the wound; the edges of the parietal peritoneum are seized with forceps and strongly everted in order to facilitate their approximation to the base of the protruding bowel with a continuous sero-muscular suture of catgut. A large amount of the cæcum will lie outside the wound, and if there is no immediate necessity for draining the bowel it may be left for a period varying from three to five days. The opening is most readily made with the thermo-cautery. A free protrusion of the cæcum and a large opening are necessary to ensure the complete evacuation of the faecal current. If the operation is performed in the presence of acute obstruction the most satisfactory plan will be to introduce a Paul's tube. Should the cæcum when exposed be tense and distended it may be emptied of gas with a trocar and cannula. As soon as it assumes the flaccid condition it is seized with forceps and drawn out of the wound. The protruding part is then clamped at its base and the trocar removed. A purse-string suture is passed so as to include an elliptical area, in the centre of which an incision is made sufficient to admit a tube. The suture is securely tied around the tube and the clamp removed. It is a wise precaution to suture the cæcum to the parietal peritoneum all round.

The method of closing an artificial aperture of this kind has been described in another section (p. 317).

Disadvantages attending Typhlostomy.—(1) The contents of the small intestine being liquid cause great irritation of the skin surrounding the cæcal fistula. (2) There may be a loss of nutrition owing to the escape of the intestinal contents and the resulting

diminution of absorption. The former is an inevitable consequence of this operation; as for the latter, it is not definitely accepted that exclusion of the large intestine determines faulty nutrition.

If it be practicable it would seem advisable to establish the fistulous opening in the lower part of the ascending colon rather than in the cæcum.

COLOSTOMY.

Indications for Colostomy. (1) Malignant disease in the colon or rectum. A permanent artificial anus is usually required in those cases which are incapable of being dealt with by radical measures. (2) Certain forms of stricture other than malignant resulting from ulceration and subsequent contraction such as may occur from syphilis. Under this heading may be grouped cases of stenosis due to pressure of tumours, such as sarcomata, originating outside the bowel or resulting from the pressure of the exudate in pelvic cellulitis. (3) Fistulous communications between the bladder and the rectum or between the bladder and the colon. (4) Certain inflammatory conditions involving the colon or rectum or both, such as dysenteric or tuberculous ulceration, diverticulitis, or colitis of the membranous or ulcerative form. (5) Certain cases of congenital malformation of the rectum and anus. (6) As a preliminary measure in certain cases of excision of malignant disease of the colon or rectum, more especially if the growth is associated with signs of obstruction. Here the artificial anus is only of temporary duration. (7) Cases of obstruction of the colon due to kinking or compression of the bowel by bands where the gut is greatly distended. The costo-colic ligament has been responsible for a kink in the region of the splenic flexure. When colostomy is performed for such conditions a lateral fæcal fistula results.

ASCENDING COLOSTOMY. Should it be considered necessary to perform colostomy, *i.e.*, to establish a genuine artificial anus on the right side, some little difficulty will be encountered in drawing the bowel forwards, unless, as occasionally happens, it is provided with a mesentery. With the usual anatomical arrangement the bowel may be mobilised by incising the peritoneum vertically along its outer aspect and beyond the line of peritoneal reflection from the colon to the parietes. The finger introduced through the aperture undermines the colon and enables it to be drawn forwards sufficiently to permit of a glass rod being introduced beneath it. The ends of the rod rest on the skin on each side of the wound and so the loop of bowel is suspended. A few sutures adapt the wound in the abdominal wall to the size of the protruding gut. In a few days when the colon is adherent to the parietal peritoneum the glass rod may be removed and the bowel opened.

INGUINAL OR ILIAC COLOSTOMY. In this operation the abdomen is opened in the left iliac region, the pelvic colon is identified, and that part which adjoins the iliac colon having been drawn out in the form of a loop sharply bent upon itself, is secured in the wound. The projecting loop is opened either immediately or after an interval of three or four days. Through the artificial anus so established all the bowel contents make their way to the surface.

The Abdominal Incision corresponds in its direction and extent to that employed for exposing the appendix on the right side and is made in a similar manner, viz., by splitting the muscles of the abdominal wall as recommended by McBurney. The

extent of the incision should not be greater than will permit of the bowel being drawn through the abdominal wall. A skin incision of about 2 inches usually suffices.

Search for the Colon. The pelvic colon, if distended, may immediately present in the wound, but frequently the parts which protrude are the great omentum and the coils of the small intestine, rendering it necessary to search for the large bowel. If the fingers are passed from without inwards along the floor of the iliac fossa they will

FIG. 262.—Left Iliac Colostomy. The abdomen has been opened by McBurney's muscle splitting incision at the outer side of the rectus muscle, and the pelvic loop of the colon has been drawn out. The method of fixing the latter in the wound is fully described in the text.

promptly come in contact with the iliac colon which is the only portion of fixed intestine in this region. Following this downwards towards the brim of the true pelvis, the beginning of the pelvic colon is secured and drawn through the abdominal wound. The taeniæ coli, the sacculations, and the appendices epiploicæ immediately show that it is the colon and not the small intestine that has been withdrawn. In some instances the selected loop of large bowel may have such a short mesentery that it may be impossible to bring it outside the abdomen. Such a condition may be congenital, but it may also result from inflammatory or malignant infiltration. This difficulty is overcome either by performing a transverse colostomy or by mobilising the bowel

by insinuating the fingers beneath it through an incision in the peritoneum of the iliac fossa at the outer side of the line of reflection.

Distension of the colon to a considerable degree may be present and further interfere with its delivery through the wound.

Method of fixing the Colon.—The loop of bowel having been drawn out through the abdominal wound, a small aperture is made in the mesocolon, care being taken in so doing not to wound any blood vessels running therein. Through the aperture a glass rod or some equally suitable support is passed, and the two ends of the rod are allowed to rest on the abdominal wall on each side of the wound. A suture of silkworm gut is introduced at each angle of the wound through the entire thickness of the abdominal wall and through the anterior longitudinal band of the colon. These sutures diminish the patency of the abdominal opening; they serve also to fix the bowel securely and prevent prolapse.

FIG. 213.—Left Iliac Colostomy. This figure represents the colon secured in the wound by the method described in the text as Ward's Stitch.

In the course of three or four days the bowel will have become firmly adherent to the parietes and the glass rod may be removed. Another efficient method of fixing the colon is performed as follows: The loop of bowel is withdrawn from the abdomen as before and a bloodless area of the mesocolon identified. A curved needle, threaded with thick silk or celluloid thread doubled, is introduced about ½ inch from one edge of the abdominal wound and opposite the middle point of the latter. It traverses the whole thickness of the abdominal wall from skin to peritoneum, passes through the mesocolon at the selected point, and is then carried through the abdominal wall on the other side of the wound from peritoneum to skin. Care must be taken to include the parietal peritoneum in the stitch. The needle is now passed in the reverse direction through the same opening in the mesocolon and does not traverse the abdominal wall again. The two ends of the thread are thus on one side of the abdominal wound and a loop of the thread on the other. A piece of rubber tubing of medium bore is passed through the loop on one side, and on the other the thread is drawn tight and knotted over a similar piece of tubing (Fig. 213). This is known as Ward's stitch and forms an excellent means of supporting the loop of bowel, while at the same time it exerts a moderate degree of lateral pressure.

Any appendices epiploicæ present on the protruding loop are ligatured at their attachment with fine catgut and removed.

Opening into the Colon.—If the bowel be distended and the need for opening it is urgent a purse-string suture is placed and a Paul's glass tube is introduced in the manner already described (p. 352).

If, however, the case is not urgent an interval of three or four days may be allowed to elapse before the lumen of the bowel is opened. This may be done in various ways viz., (*a*) incising the loop along its convexity or (*b*) excising a portion of the loop.

The protruding bowel is grasped and crushed by a powerful clamp. The latter is then removed and the portion of the loop distal to the site of the clamp excised by cutting through the crushed part. Bleeding vessels are secured and ligatured with catgut.

The After-treatment. A suitable truss or belt with a pneumatic pad must be

provided and the action of the bowels regulated. The distal segment of the intestine is washed out regularly so as to remove the decomposing discharges which tend to collect in its interior.

COMMENTS.

Difficulty in finding the Pelvic Colon. If the instructions given above be followed the pelvic colon can be identified readily. The transverse colon is sometimes mistaken for the pelvic, but this will not occur when it is remembered that if the former segment of the large bowel presents itself in the left iliac region, it will be as a relatively free coil, and its mesentery will not be fixed low down in the abdomen, as is always the case with the pelvic colon.

The Portion of the Loop selected for the Artificial Anus. In the procedure just described it will be noticed that the lowest portion of the colon that can be secured is chosen as the site of the artificial anus. By selecting this part of the colon its normal function of faecal reservoir is maintained and the patient is not troubled by continual leakage from the colostomy opening. There is said to be some danger of prolapse of the proximal segment when this method is adopted, and many surgeons draw down the colon and fix the highest portion in the wound. The annoyance caused by such a procedure is inevitable and definitely outweighs any theoretical danger of prolapse.

Fixing the Colon in the Wound. Too great traction should not be exerted on the colon when drawing it forward and fixing it to the wound lest the resulting tension should interfere with its vitality.

If the mesocolon is unusually short some difficulty will be experienced in bringing the bowel to the surface. The measures by which this difficulty is overcome are chiefly two: first, the mobilisation of the colon in the manner already described; second, the performance of a transverse colostomy.

If there be a growth at the centre of the loop formed by the pelvic colon the mesentery may be divided, the bowel drawn out, and a tube introduced into the proximal healthy segment. The protruding part with the growth is subsequently cut away.

Necessity of a Sharp Spur. When the loop is drawn out its two limbs should lie side by side in close contact like the barrels of a gun. This precaution helps to ensure the complete evacuation of the bowel at the site of the artificial anus.

Opening into the Colon. When the protruding part of the colon is of moderate dimensions it is only necessary to incise the loop along its convexity. This affords a free exit to the bowel contents and it is surprising how much the protrusion shrinks in the course of a fortnight. If, on the other hand, the protruding loop be bulky the greater part of it may be excised. In doing so it is better not to make the section flush with the cutaneous surface of the abdomen as a slight degree of protrusion is better calculated to direct the faecal current to the exterior and prevent a portion of it from finding its way into the lower segment.

TRANSVERSE COLOSTOMY. This procedure may be employed when the establishment of an artificial anus in the left iliac region is impossible, or it may be practised advisedly as a temporary measure preparatory to resection of a growth in the pelvic colon and as a means of relieving the obstruction brought about by the growth.

The Abdominal Incision is made midway between the middle line and the outer border of the rectus muscle, and is situated for the most part above the level of the umbilicus. The rectus sheath is divided, the muscle split vertically, and the abdomen opened in the usual way.

The Finding of the Transverse Colon and its Fixation in the Wound.—The great omentum is the most certain guide to this part of the colon. Should the great omentum render the delivery of the bowel difficult it may be detached from the latter to the necessary extent.

The method of fixing the loop in the wound resembles that already described in the operation of iliac colostomy

COMMENTS.

In this operation the presence of an excessive mesentery renders possible the establishment of an efficient artificial anus.

The opening into the bowel is readily supervised and the adjustment of a suitable truss is easier than in the case of an artificial anus in the iliac region. Moreover, the split rectus muscle forms a fairly efficient sphincter. Should it be necessary to close the opening later this can be done with greater facility than would be possible were the pelvic colon involved.

LUMBAR COLOSTOMY.—Colostomy by the lumbar route is practically never performed. At the present day it might possibly be indicated when an operation as a substitute for typhlostomy on the right side is required.

The reasons for not adopting lumbar colostomy are chiefly the following: (*a*) the depth of the colon from the surface in this region; (*b*) the difficulty in finding the colon; (*c*) the occasional presence of a mesocolon; (*d*) the difficulty in supervising an artificial anus in the lumbar region.

APPENDICOSTOMY.—This operation, first described by Dr. Weir, of New York, consists in securing the appendix between the margins of an abdominal wound, opening it by cutting away its distal extremity, and so rendering its lumen available for drainage purposes or the introduction of fluids into the colon.

Indications. (1) The introduction of fluids in certain cases of colitis and dysentery; (2) for drainage of the cæcum in cases of obstruction occurring in the large bowel; (3) for the administration of fluids in certain cases of chronic constipation; (4) to relieve intestinal distension; (5) for lavage of the excluded colon after ileo-sigmoidostomy; and (6) for the administration of saline solution after any severe abdominal operation.

The Operation. *The Abdominal Incision.* This resembles the incision usually made for exposing the appendix by McBurney's method.

Fixation of the Appendix in the Wound. If the appendix be movable no obstacle is offered to its fixation, but if it be fixed by adhesions it may be difficult or impossible to free it to the necessary extent without compromising its blood supply. If the meso-appendix has to be divided to admit of withdrawal it is ligatured in such a fashion that the artery to the appendix is uninjured and is not included in the ligature. If the need for opening the appendix be not pressing it may be secured *in situ* by means

of two safety pins passed through the serous and muscular coats, the abdominal wound being closed beneath the pins. The appendix is cut across after twenty-four or forty-eight hours about ½ inch beyond the level of the skin, but if necessary the section may be performed immediately.

If in the course of a laparotomy the cæcum and intestines be found greatly distended the appendix may be withdrawn through a stab wound made from within outwards in the abdominal wall and opened in order to allow liquid fæces and gas to escape (Keetley).

An appendix fixed in the manner described may have its lumen subsequently dilated by forceps or bougies. This dilatation, however, must be carefully performed, as any trauma to the mucous membrane may produce subsequent cicatrisation and occlusion of the lumen.

COMMENTS.

Appendicostomy for Colitis and Dysentery may be said to possess the following advantages :—(*a*) The fistula does not cause trouble from leakage. (*b*) It may be readily closed when occasion arises. (*c*) Irrigation may be carried out as easily as when the cæcum has been opened. It is probable that the quantity of the fluid used is of more importance than its nature. The irrigating fluids most commonly employed are normal saline solution, quinine solution, and weak solutions of nitrate of silver and potassium permanganate.

Appendicostomy in Typhoid Fever.—It has been found possible to introduce a catheter into the ileum through the lumen of the appendix and the ileo-cæcal aperture. It has therefore been suggested that medicating fluids might be introduced into the diseased ileum in cases of typhoid fever. Apart from the intrinsic difficulty of passing the tube, its introduction into a segment of bowel weakened by disease would appear to be accompanied by dangers to which there are no compensatory advantages.

Appendicostomy for Ilio-cæcal Intussusception and Intestinal Obstruction. After reduction of an ileo-cæcal intussusception appendicostomy has been performed with a view to fix the bowel and prevent recurrence, and also for the relief of gaseous distension and for the administration of aperients (Keetley).

Appendicostomy has been suggested as a substitute for typhlostomy, but it cannot be regarded as satisfactory, seeing that the small aperture provided is totally inadequate to ensure the complete deviation of the fæcal current.

ENTERO-ANASTOMOSIS IN CASES OF MALIGNANT DISEASE OF THE COLON.—This procedure has been performed mainly for the purpose of diverting the bowel contents from a segment along which the natural passage has been obstructed or with a view to promote the healing of a fæcal fistula.

The fact remains, however, that even in the event of a free entero-anastomosis it usually happens that the fæcal current still tends to a large extent to pass by the original route, with the result that if the short circuiting has been performed to overcome obstruction of the stenosing type the short-circuited loop of bowel may become distended with fæcal matter. To overcome this latter objection the upper loop of bowel may be constricted by suture below the anastomosis.

The following are the chief conditions for which a short-circuiting operation may be performed in cases of malignant disease of the large bowel :—

1. Obstruction of the bowel caused by a growth unsuited for a radical operation. A good example is afforded by a growth in the cæcum or in the adjoining part of the ascending colon. The ileum may then be anastomosed with the transverse colon. Should the short-circuited piece of bowel become distended it may be treated by establishing a fæcal fistula or performing an appendicostomy.

2. As a preliminary measure in certain cases of resection of intestine it may serve as a substitute for a preliminary colostomy, but as a rule the latter operation will be much the safer, owing to the great risk attending an anastomosis in the presence of distended bowel with highly virulent contents. If an anastomosis is employed it should be reserved for cases in which obstruction symptoms are not obvious or are at least of a very chronic character.

EXCLUSION OF THE INTESTINE.—Two main varieties of exclusion are practised, viz., (*a*) unilateral, and (*b*) bilateral.

1. Unilateral Exclusion.—This operation resembles a short-circuiting operation, with this difference, however, that the proximal limb of the short-circuited loop is interrupted just beyond the anastomosis. It is mainly indicated in the following :—

(1) Certain inflammatory conditions attended by fistulous formation in which it is necessary to divert the fæcal current in order to allow the fistula to heal ; such a state of affairs is sometimes met with in the cæcal region, where a large inflammatory tumour may exist with suppuration and fistula. In cases of tuberculous intestinal fistulæ a unilateral exclusion may be considered advisable as a means of bringing about improvement in the area of primary disease.

(2) Certain cases in which fistulous communications have been established between the bowel and the other viscera within the abdomen or pelvis.

(3) In certain cases of chronic constipation a unilateral exclusion has been proposed by Sir Arbuthnot Lane. An objectionable result of the procedure is the tendency which exists for distension to occur in the excluded segment. Lane's operation consists in the establishment of an ileo-sigmoidal anastomosis.

The Operation.—The procedure consists of two stages, viz., the division of the afferent segment of the bowel and the immediate closure of its two ends by suture followed by an anastomosis between the afferent bowel near its closed extremity and the distal segment of the bowel at the selected site, or the open end of the proximal bowel segment may be anastomosed with the side of the distal segment (end-to-side anastomosis). The methods employed for effecting the closure of divided intestine and performing an intestinal anastomosis have been already described.

2. Bilateral Exclusion.—In this procedure the continuity of the bowel is interrupted by a double section, one on the proximal and another on the distal side of the segment to be excluded. The isolation of a loop of intestine in this way and the closure of its two ends is attended by considerable risk, owing to the inevitable collection within it of the natural bowel secretion and gas, and possibly the pathological products of ulceration as well. The occluded and distended gut may rupture, with resulting peritoneal infection, but quite apart from this the individual will suffer from the effects of auto-intoxication and infection. Alternative procedures consist in leaving one end of the excluded segment open and the other closed, or both ends may be left open and connected with the surface of the abdominal wall.

THE RECTUM.

OPERATIONS FOR RECTAL CARCINOMA.

Before considering the various operative measures which are performed for the removal of cancer of the rectum it will be necessary to consider some points bearing upon the normal anatomy of the part and the pathology of the disease.

ANATOMY.—The part of the bowel included under the term "rectum" consists of an upper segment, the rectum proper, and a lower segment, the anal canal. The rectum proper extends from the termination of the pelvic colon in front of the body of the third sacral vertebra to the level at which the bowel is compressed laterally between the levatores ani muscles; here the rectum passes into the sphincteric passage known as the anal canal.

The upper part of the rectum in the male lies within the recto-vesical pouch, and in the female within the recto-vaginal or the pouch of Douglas. In this situation it is invested by peritoneum in front and on each side. Behind it is separated from the sacrum by some connective and fatty tissue containing the superior hæmorrhoidal (superior rectal) and middle sacral vessels and by the rectal layer of pelvic fascia.

The lower portion of the rectum proper is extraperitoneal. Its connection with surrounding parts is most intimate in front, where it lies in close relationship with the bladder and prostate in the male and with the vagina in the female.

This part of the rectum does not usually present a uniform calibre, but is frequently dilated in its lower segment, constituting what is sometimes termed the rectal ampulla, or the suprasphincteric segment of the rectum.

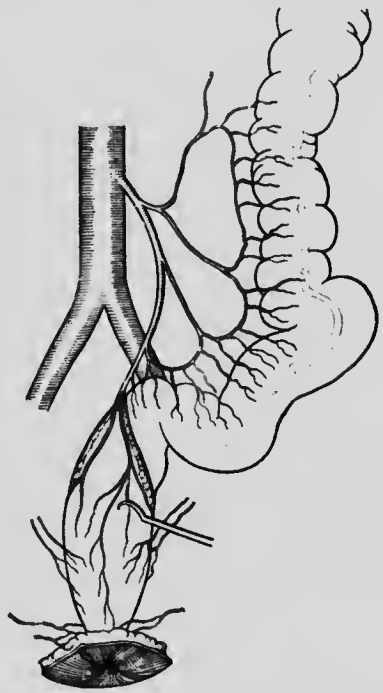

FIG. 214.—Diagrammatic representation of the arteries supplying the rectum, viz., the superior, middle and inferior hæmorrhoidal. Note the point at which the lowest sigmoid branch is given off by the inferior mesenteric artery. This has been termed by Davis "the critical point," because unless the mesenteric trunk is divided above that level blood will not travel from above downwards into the superior hæmorrhoidal artery, in other words, the only direct communication between the sigmoid and hæmorrhoidal vessels is at the site of origin of the lowest sigmoid branch. (See p. 333.)

The Blood Vessels.—The rectum derives its blood supply from the three hæmorrhoidal arteries and from the middle sacral artery (Fig. 214). The superior hæmorrhoidal artery descends in the root of the pelvic mesocolon until it reaches the junction of the pelvic colon and the rectum, where it divides into two branches which run downwards and forwards around the sides of the gut. The right branch lies on a slightly posterior plane to the left. The anastomosis between the

lower sigmoid arteries and the superior hæmorrhoidal has been described above (p. 333).

The middle hæmorrhoidal artery usually springs on each side from the anterior division of the internal iliac artery; it descends on the side wall of the lower part of the rectum, to which it is distributed by means of four or five small branches. The middle hæmorrhoidal trunks are readily found just above the levator ani muscle, where they lie one on each side in close relationship to the wall of the rectum.

The inferior hæmorrhoidal arteries, usually two or three on each side, arise from the internal pudic arteries and pass inwards and downwards through the ischio-rectal fossa to be distributed to the anal canal.

A few small branches from the middle sacral artery pass to the back of the rectum.

Fig. 215.—Carcinoma of the rectum of the tuberous type removed by trans-sacral resection with preservation of normal sphincteric control. In this case the growth had developed mainly in the direction of the lumen of the bowel, and but to a slight extent in that of the perirectal tissues.

Lymphatic Vessels and Glands.—The lymphatic vessels from that portion of the anal canal which lies below the white line, as well as the lymphatics of the skin around the anus, pass to the inguinal glands.

Those vessels, however, which originate in the mucous membrane of the anal canal, pass upwards and, joining with the lymphatics from the lower portion of the rectum, form one or two lymphatic trunks which pass along the middle hæmorrhoidal artery to a gland which lies on the latter about half-way between its origin and the rectum. From this gland efferent vessels pass to a gland at the origin of the middle hæmorrhoidal artery, to one of the external iliac glands, and to one of the glands of the lateral sacral group (Poirier and Cuneo).

Owing to the free submucous intercommunication of the lymphatics of the anal canal and the rectum some of the lymph from the former passes upwards to the glands situated along the course of the superior hæmorrhoidal vessels. These glands also receive lymph from the rectum proper and are termed by Gerota the ano-rectal glands. The efferents of this group pass upwards along the superior hæmorrhoidal vessels and drain into the glands of the inferior mesenteric main group (see p. 334).

From these considerations it will be seen that the lymphatic glands which may be affected in malignant disease of the anal canal are—(1) the inguinal glands; (2) the gland on the middle hæmorrhoidal artery and those in connection with it, viz., the external iliac group, the lateral sacral, and the glands at the bifurcation of the common iliac artery; (3) the ano-rectal glands and the inferior mesenteric main group.

The lymphatics of the lower portion of the rectum proper pass chiefly to the gland

on the middle hæmorrhoidal artery and to those in connection with it, whilst those from the upper portion drain into the ano-rectal glands.

The spread of cancer by the lymphatics will therefore affect practically the same glandular groups whether the primary growth be in the rectum or in the anal canal. The removal of possibly infected glands involves, therefore, not only a wide dissection of the pelvis, but also a high division of the gut itself.

PATHOLOGY.—The following are the more frequent types of cancer met with in the rectum: (*a*) an exuberant or adenomatous type, in which there is a considerable mass of the growth within the bowel which tends to develop rapidly *in situ* and to be followed by metastases in the glands and liver; (*b*) a slow-growing atrophic form, in which the tumour development is not marked, but in which there is a great tendency to stenosis, a hard ring stricture being produced; (*c*) colloid cancer, in which the examining finger reveals an ulcer with a hard edge, surrounded with an area of dense infiltration. The growth may involve a wide area of the bowel wall and spread either circumferentially or in a longitudinal direction.

Malignant disease may have its point of origin at the beginning of the rectum, within the ampulla, or in the anal canal. The anal canal may be involved by extension from the ampulla, or the latter may be affected secondarily to a growth in the former.

FIG. 216.—Carcinoma involving the upper part of the rectum removed by trans-sacral resection. The growth involved the entire circumference of the bowel but without causing a marked degree of stenosis.

Modes of Extension of Rectal Cancer.—(*a*) **Progressive Local Extension into the Surrounding Tissues.**—This involvement of surrounding structures is the most common factor in rendering a case inoperable. Moreover, when recurrence takes place after operation it is as a rule locally. (*b*) **Lymphatic Extensions.**—The mass of clinical and operative evidence goes to show that when the lymphatic glands become affected the disease has reached a late stage and is already inoperable from local extension or from metastatic growths in the liver. It is unusual to find recurrence of cancer in the lymphatic glands after the primary growth has been removed. Sampson Handley has shown, however, that cancer cells may permeate along the submucous lymphatics for a considerable distance from the original growth, and on this account he advocates wide resection of the bowel. (*c*) **By the Portal Blood Vessels.**—Metastases occur frequently in the liver and at a relatively early period. It is not uncommon to find the growth perfectly operable as far as local extension and lymphatic involvement are concerned, but inoperable by reason of the presence of palpable deposits in the liver.

Operative Measures.—In a large percentage of individuals who apply for surgical

treatment the disease is found to have advanced too far to permit of its satisfactory removal, and in such cases a colostomy is usually indicated. Too often excessive reliance on the statements made by the patient determines a diagnosis of hæmorrhoids, and through neglect to make a digital examination when piles are present a cancer of the rectum may be overlooked. Operative results cannot be favourable when early diagnosis is neglected.

The radical measures which are employed in the treatment of rectal cancer have as their object the complete removal of the disease and the re-establishment of normal sphincteric control.

In some cases the sphincteric muscular apparatus must be sacrificed. When, for instance, the disease is situated low down within or close to the anal canal it is

FIG. 217.—Carcinoma of the Rectum, removed by trans-sacral resection. This specimen represents a soft adenomatous form of growth with raised and overhanging margins.

necessary to cut well wide of the tangible or visible limits of the growth, as extension of the latter is very liable to take place along the muscular and submucous planes of the gut. This wide local resection is essential in every case, no matter at what level the disease is situated.

The radical operation aims at the removal of obviously and probably affected lymphatic glands in addition to the extirpation of the primary growth. According to the facts in regard to lymphatic drainage of the rectum which have been stated above, the lymphatic area that should be removed in rectal incision comprises—(*a*) the inguinal glands in ano-rectal cancer; (*b*) the glands in relation to the middle hæmorrhoidal artery; and (*c*) the ano-rectal glands along the superior hæmorrhoidal artery in cancer of the rectum proper or of the anal canal.

It must be acknowledged that *a priori* anatomical reasoning with regard to the dissemination of rectal cancer by the lymphatics has not been substantiated by clinical or operative experience. It cannot be denied that a limited resection of the growth has yielded and continues to yield a considerable percentage of cures as far as local recurrence and lymphatic metastases are concerned. This may be accounted for by the

fact that rectal cancer usually involves the glands at a relatively late stage in the course of the disease, or in some cases does not spread to the glands at all. Wide local extension and metastatic growths in the liver and not lymphatic involvement are the usual factors which render a rectal cancer inoperable. Furthermore, enlargement of glands does not necessarily indicate cancerous involvement, for it may be altogether due to septic infection. On the other hand absence of enlargement does not absolutely negative the presence of metastatic deposits.

The modern radical operation rests entirely on the supposition that we give the patient a better chance of permanent cure by removing the lymphatic area, but in the present state of our knowledge of lymphatic involvement in rectal cancer it is debatable whether the intrinsic risk of the radical operation does not outweigh the speculative danger of leaving some of the area of lymphatic drainage.

With increasing improvement in technique, however, and in the hands of those having experience in rectal surgery extensive resection must have a decreasing mortality, and it appears to harmonise with the results of anatomical and pathological investigation.

Fig. 218.—Carcinoma of the Rectum, removed by trans-sacral resection. The growth in this case was of the hard, tuberous variety; it had extended completely around the bowel with marked resulting stenosis. The rectum at the seat of disease was surrounded by a hard mass of fibro-fatty tissue.

Mobilisation of the Rectum and the Adjoining Segment of the Colon is a necessary and very important step in the performance of the more extensive operations for the removal of rectal cancer.

The rectum must be separated from the parts with which it is in direct relationship within the pelvis so as to render possible a free excision of the diseased zone. In order to restore normal sphincteric control the pelvic colon must be mobilised sufficiently to enable it to be brought down to the level of the anus and retained there without tension.

Free mobilisation of the rectum and colon also facilitates removal of the hæmorrhoidal lymphatics. The manner in which this mobilisation is effected has been indicated already in the description of resection of malignant growths in the pelvic colon (p. 338). The incision through the peritoneum along the outer side of the descending colon, reaching if necessary to the splenic flexure, will give great freedom of movement to this portion of the gut, but the chief impediment to bringing the lower portion of the pelvic colon down to the anus is the superior hæmorrhoidal artery. This vessel must be divided, and the site of its division must be carefully selected. Sudeck, Hartmann, and others have shown that there is practically no anastomosis between the lowest sigmoid arterial loop and the terminal portion of the superior hæmorrhoidal artery, so that ligature of the latter below the point at which it is joined by the lowest sigmoid loop will deprive a portion of the gut of its blood supply and jeopardise its vitality.

The superior hæmorrhoidal artery must therefore be divided between ligatures above the last anastomotic loop, which is just below the promontory of the sacrum. Reference to Fig. 214 will render this step obvious.

The method of operation to be adopted will depend upon the site and extent of the cancer, and for this reason it will be convenient to consider the operative measures suitable for cancer occurring in the following situations :—

1. Cancer at or close to the sphincteric zone, viz., anal and ano-rectal growths. Squamous epithelioma of the anus is rare ; according to Tuttle it occurs in about 6 per cent. of cases.

2. Cancer in the supra-sphincteric segment of the rectum but below the recto-vesical or recto-vaginal reflection of the peritoneum. Cancer would appear to involve this portion of the rectum in about 25 per cent. of cases.

3. Cancer at the commencement of the rectum and extending upwards in some cases so as to involve the terminal portion of the pelvic colon. This appears to be the most frequent site for rectal cancer, occuring as it does in about 65 per cent.

PERINEAL EXCISION OR AMPUTATION OF THE RECTUM.

THE OPERATIVE TREATMENT OF ANO-RECTAL CANCER.—The parts removed in this operation include the lower segment of the rectum together with the anal canal, its associated muscles, and the surrounding cellular tissues. The hæmorrhoidal lymphatic glands and those of the lateral sacral chain which lie behind the rectum will also be removed. If the squamous epithelium of the anal orifice be encroached upon by the growth the inguinal glands on one or both sides must be removed in addition. This procedure is sometimes termed *amputation* of the rectum, in contradistinction to *resection* in which a segment of the bowel is excised and the continuity of the passage subsequently re-established.

Preliminary Measures.—The more important of these consist in getting the bowels thoroughly cleared. Castor oil answers very well for this purpose and may be given on two or three occasions during the week immediately preceding the operation. No aperient, however, should be given within the forty-eight hours before the latter as it is of importance that the bowel should be at rest at this time ; besides, the infectivity of the bowel contents is increased temporarily by aperients. Salicylate of bismuth seems to be useful in diminishing the virulency of the intestinal contents it may be given in 15-grain doses three times daily for a few days beforehand. Opium is administered the day before operation in order to quiet the bowel and diminish the risk of fæcal contamination. Pil. saponis co. gr. 5 or pil. plumbi cum opio gr. 5 are excellent for this purpose ; two or three pills may be given altogether. It is advisable to administer an enema on the morning of the operation.

Such diet is provided as will leave the least possible residue in the intestinal tract.

Some surgeons favour the establishment of an artificial anus in the iliac region ten or twelve days before undertaking the major operation. The chief indication for this procedure is difficulty in effecting a thorough clearance of the bowel owing to the obstructive character of the growth.

The Operation.—*Position of the Patient, etc.*—The patient is placed in the lithotomy position with the buttocks well elevated. A sound is passed into the urethra and held in position by an assistant. A thorough cleansing of the interior of the rectum

and the external parts is carried out. If the anal integument is free a purse-string suture of stout silk is passed round the orifice to occlude the bowel. The ends of the suture are left long and enable traction to be exerted on the bowel subsequently.

The Cutaneous Incision and Exposure of the Rectum from behind.—The incision in the skin surrounds the anus and follows the middle line in front as far as the root of the scrotum, and behind to a point corresponding to the base of the coccyx. The superficial tissues are progressively divided throughout the entire extent of the incision. It is usually wise to excise the coccyx as more room is obtained for the subsequent manipulations. The section is now carried more deeply through the ano-coccygeal raphé between the levatores ani muscles and through the posterior fibres of the external sphincter muscle and the pelvic fascia until the rectum is exposed.

Division of the Levatores Ani Muscles.—The lateral portions of the superficial incision have already opened up the ischio-rectal fossa and exposed the lower or perineal aspect of the levator muscles. On introducing the finger into the posterior part of the wound through the divided ano-coccygeal raphé the rectum, in the absence of adhesions or malignant infiltration, is easily cleared on its posterior and lateral aspects, more especially when the coccyx has been removed.

The finger is passed through the wound in the ano-coccygeal raphé to gain the pelvic aspect of these muscles. Strong scissors are taken: one blade is placed deep in the wound just behind the anus and in the interval between the rectum and the levator ani muscle, on the pelvic surface of the latter; the other blade lies in the ischio-rectal fossa. The bridge of tissue between the blades is now cut and a similar section is made upon the opposite side. These lateral incisions are extended towards the middle line in front and detach the levator muscles from the rectum. A temporary plug of sterile muslin is placed in the wound cavity behind the rectum, and the surgeon proceeds to separate the latter in front.

Detachment of the Rectum in front.—The anterior portion of the incision is deepened in the interval between the rectum and the bulb, the surgeon keeping close to the latter so as to avoid wounding the bowel. The fibres of the recto-urethralis muscle between the rectum and the membranous urethra are divided and the interval between the rectum and the prostate is exposed. During this procedure the tissues must be divided close to the urethra, the position of which is recognised by the sound in its interior, and care is taken not to bend the rectum forcibly backwards, as this would result in a sharp kink and would increase the risk of wounding it.

Division of the Lateral Attachments of the Rectum.—The structures which hold the rectum on each side consist of the anterior fasciculi of the levator muscles and the middle hæmorrhoidal vessels together with the connective tissue by which these structures are surrounded. The tissues are put on the stretch by drawing the rectum backwards and are divided between clip forceps placed close to the prostate. The rectum is now quite free in front and laterally and can be drawn backwards.

Detachment of the Rectum behind and opening into the Peritoneal Cavity.—The posterior aspect of the rectum is easily detached from the front of the sacrum by means of the finger as far upwards as the promontory. The retrorectal glands and cellular tissues are displaced forwards along with the bowel.

The rectum is now displaced backwards in order to expose the peritoneal *cul de sac*, which occupies the bottom of the wound in front. The membrane is seized with forceps and divided transversely.

Division of the Mesorectum.—Although the rectum can now be drawn down to a considerable extent, yet it will be found that its mobility must be further increased by the judicious division of the mesorectum at its posterior aspect. The rectum

is therefore drawn first to one side and then to the other to render the peritoneum tense. The latter is seized with forceps, and the transverse incision already made is continued backwards by successive snips of the scissors between the forceps and the bowel as far as the sacrum.

The rectum is now suspended from the posterior wall of the pelvis only by its mesentery. In order to avoid cutting the superior hæmorrhoidal artery below its junction with the lowest sigmoid artery care should be taken to divide the meso-rectum close to the sacrum rather than in the immediate neighbourhood of the rectum. All forceps are replaced by ligatures, and before proceeding further the surgeon ascertains if the mobilisation of the rectum will suffice to enable it to be divided at a safe distance above the site of disease and at the same time to be attached to the perineal integument by sutures without an undesirable degree of tension.

Amputation of the Rectum and Suture of the Perineal Wound. The rectum is drawn down and the anterior aspect of the colon is connected by catgut sutures with the peritoneum of the recto-vesical pouch.

The levator muscles are approximated by a few deep sutures in front of the bowel, and in this way the great depth of the perineal wound is reduced.

The rectum is clamped and divided at least 1 inch above the disease, and at the same time the precaution is taken of allowing the proximal cut extremity to project a little beyond the cutaneous margins of the wound.

All bleeding vessels are secured by ligature. The projecting segment of the rectum is fixed by sutures as nearly as possible at the normal site of the anus; this is better than to draw the bowel back to the space left by the removal of the coccyx. The sutures should be passed deeply through all the perineal structures, for if they only engage the skin they tend to cut out too quickly. Silkworm gut or thread is better than catgut for this purpose, as the latter is apt to undergo too rapid absorption. Two drainage tubes are introduced, one in front of and one behind the rectum. Finally the margins of the cutaneous wound are carefully approximated.

COMMENTS.

Precautions to ensure Asepsis.—If the bowel be carefully washed out with an antiseptic solution as soon as the patient has been anæsthetised and the anus firmly closed by a purse-string suture, there is little risk of subsequent contamination. It is sometimes wise to place a gauze plug in the rectum before closing the anus, in order to render the former more easily recognised and diminish the risk of its being wounded. No large plug should be employed, for it necessarily leaves less space for the subsequent manipulations. It matters little by what means the anus is closed so long as no communication is left between the inside of the rectum and the wound. A purse-string suture is the simplest method, but in those cases in which the growth involves the anal canal it is easier to make an elliptical incision around the anus and suture the two flaps of skin thus outlined over the aperture. Again, the mucous membrane of the anal canal may be separated from the sphincter muscles and tied securely, thus occluding the bowel. It is only by removing the rectum as a closed sac that it will be possible to ensure true asepsis. All gloves and instruments used in closing the bowel should be discarded before the operation proceeds. Some years ago we suggested scraping foul and exuberant growths with a flushing curette as an immediate preliminary to operation. This proceeding certainly diminishes the danger of infection when the rectum is accidentally opened. The bleeding is trivial and soon stops.

Avoidance of Tension on the Sutures.—When freeing the rectum from its surroundings care should be taken not to strip it to such an extent as to compromise its vitality. It is of great importance also to bring the bowel down to the level of the anus without traction. The mesorectum must be divided close to the sacrum to an extent sufficient to allow the proximal end of the gut to protrude uncontrolled slightly beyond the anal site, otherwise tension on the sutures will ensue.

A Sacral or Coccygeal Anus.—If it be found impossible to obtain sufficient mobilisation the rectum may be allowed to fall backwards to the site of the coccyx and a coccygeal anus established. In some cases even the formation of a sacral anus is indicated.

Loss of Control over the Bowel.—Fæcal incontinence is inevitable after this operation, and all attempts to obviate the inconvenience resulting from it have been unsatisfactory.

Post-operative Asepsis.—It is no less important to preserve asepsis after the operation as well as during its performance. To this end it would be desirable to temporarily occlude the bowel by applying a constricting ligature to the protruding rectum and allowing the latter to remain closed for twenty-four or forty-eight hours. Such occlusion, however, may give the patient great discomfort from flatulence, and it is therefore wiser to adopt an alternative plan. A stout rubber tube is tied into the bowel and the latter securely closed round it. The outer end of the tube is allowed to protrude beyond the dressings. By this means there is a free exit for the escape of gas and the bowels may be allowed to move at an earlier date without risk of wound contamination.

Involvement of the Vagina.—In the female the perineal operation may be carried out in the manner just described without any necessity of encroaching upon the vagina. If the latter is invaded, however, by the growth a partial resection of the vaginal wall will be necessary. In such cases the vaginal method of operation may be undertaken with advantage.

PERINEAL EXCISION OF THE RECTUM BY THE DIEFFENBACH-REHN METHOD.—This method is applicable to cases in which the growth occupies the rectum [illegible]per and in which the sphincteric apparatus may be preserved.

The [illegible]erior Perineal Section.—A median longitudinal incision is made in front of the anus; it extends deeply between the rectum and the bulb of the urethra till the recto-urethralis muscle is divided. The rectum is now easily detached from the prostate, bladder, and seminal vesicles up to the peritoneal reflection. This part of the procedure having been accomplished, the wound is plugged with a sterile muslin swab.

The Posterior Perineal Section.—A median longitudinal incision is carried backwards from behind the anus to the tip of the coccyx and beside the latter to its base. The ano-coccygeal raphé and the overlying pelvic fascia are incised and the rectum exposed. The finger is passed through the depth of the wound behind the rectum and proceeds to detach the bowel from its surroundings behind and on each side.

If more room appears necessary the coccyx and perhaps a piece of the sacrum may be excised. The wound is then plugged with gauze.

Division of the Sphincters and the Perirectal Dissection.—The median incisions

in front of and behind the anus are extended respectively forwards and backwards through the external and internal sphincter muscles. An incision is carried circularly through the cutaneous margin, and the mucous membrane of the anal canal is carefully detached all round and up to a point above the level of the internal sphincter. The wound margins, including the sphincter muscles, thus carefully preserved are drawn apart.

A ligature or purse-string suture should be passed round the tube formed by the anal mucous membrane so as to occlude the bowel. A circular incision through all the coats of the rectum with the exception of the separated mucous coat is made just above the upper edge of the sphincter muscle, that is, above the levatores ani muscles. The finger can now be passed above the latter to continue the further detachment of the rectum from its surroundings until a point well above the disease is reached.

The rectum is now free in front and behind and is only attached laterally by the middle hæmorrhoidal arteries, which can be easily felt as they pass inwards to the bowel. These vessels are ligatured and divided on each side.

If the detachment thus carried out does not allow the growth to be drawn well outside the anus the whole wound should be carefully and thoroughly washed out with some mild antiseptic lotion and the peritoneum opened in front. Should further mobilisation be necessary the surgeon must proceed to divide the mesorectum in the fashion described above, due precaution being taken to determine the site of ligature of the superior hæmorrhoidal artery (p. 333).

Resection of the Growth followed by Fixation of the Upper Healthy Bowel Segment at the Anal Site.—When sufficiently mobilised the bowel should descend until the section can be made a full inch, if not more, beyond the level of the anus in order to avoid the risk of subsequent retraction.

When the level of the line of section has been determined the opening in the recto-vesical fold of the peritoneum should be closed by suturing that membrane to the anterior surface of the pelvic colon.

A pair of intestinal clamps is applied above the line of section and the rectum divided. The proximal end of the latter is fixed by sutures to the skin round the anus, and the deeper tissues are approximated by interrupted sutures of catgut. The sphincter muscles must be carefully reunited by a series of interrupted sutures, as prompt and accurate union is essential for the restoration of sphincteric action.

Two drainage tubes are introduced, one behind and one in front of the anus.

COMMENTS.

1. As the whole object of this method is the preservation of the sphincters with intact nerve supply, primary healing of these muscles is essential, otherwise permanent loss of control will result. The necessity for rigid asepsis is therefore obvious.

2. A modification of this operation has been described by Sir Charles Ball (Diseases of the Rectum) and is carried out on somewhat similar lines.

EXCISION OF THE RECTUM BY THE VAGINAL ROUTE.—Free access is afforded to the rectum by an incision through the posterior wall of the vagina, and the vaginal route is sometimes used even when its greatest indication, namely, involvement of the vaginal wall by the growth, is not present. With the patient in the lithotomy position the cervix uteri is pulled down and the peritoneum of the pouch of Douglas opened. A longitudinal incision is made along the whole length of the posterior vaginal wall and two flaps of the latter are reflected from the rectum. The rectum

is freed from its surroundings down to the upper end of the anal canal and divided below the level of the disease. Further traction brings the bowel down to a point well above the growth, whereupon another section is made. The end of the upper segment is now sutured to the intact anal canal. Murphy, of Chicago, divides the anal canal longitudinally in the middle line before resecting the gut and subsequently sutures it.

The flaps of the vaginal wall are then sutured in position and so cover in the sutures in the bowel.

THE TRANS-SACRAL OPERATION FOR RECTAL CANCER.

The Preliminary Measures in this procedure are similar to those described in connection with perineal excision of the rectum.

Stages of the Operation. — *The Superficial Incision.* The patient is placed on the left side with the buttocks projecting slightly beyond the edge of the table and the

FIG. 219. —Trans-sacral Resection of the Rectum. The patient lies upon the left side, with the lower limbs well drawn up. The anus has been occluded by means of a purse-string suture. A median incision has been made through the superficial tissues from a point over the middle of the sacrum to within ¾ inch of the anus. The site selected for the division of the sacrum is represented by a black line.

knees well drawn up. The pelvis should be elevated by means of an air-cushion placed under the left trochanter.

The cutaneous incision is made exactly in the middle line and extends from a point an inch beyond the posterior margin of the anus to the middle of the sacrum. It is deepened down to the bone. The tissues are now dissected off this aspect of the bone and the edges of the wound strongly retracted. The coccyx and the lower part of the sacrum are thus thoroughly exposed.

Division of the Sacrum.—By moving the tip of the coccyx backwards and forwards the position of the sacro-coccygeal articulation is readily perceived provided that ankylosis has not taken place. If the scalpel be drawn transversely across the sacrum about ¾ inch higher up it will indicate the level at which the sacrum should be divided (Fig. 219). The tissues which are attached to the bone below this plane are divided on each side. The osseous section is made with an Adam's saw and the bone removed. Any bleeding from the middle or lateral sacral arteries can be controlled by applying forceps to these vessels.

Exposure of the Rectum.—The rectal layer of the pelvic fascia is next identified, picked up, and divided between forceps. This incision is extended downwards for a short distance into the ano-coccygeal raphé between the levatores ani muscles.

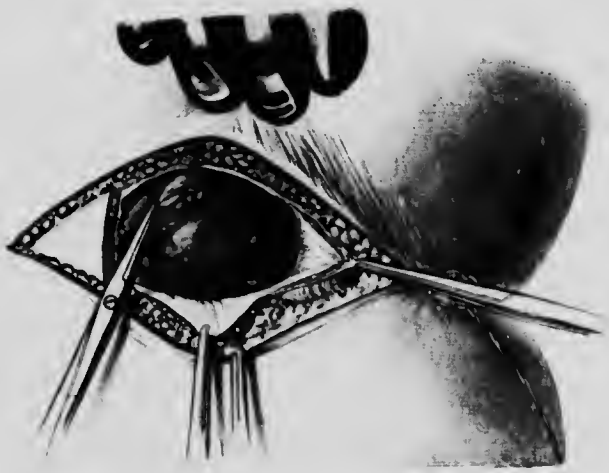

Fig. 220.—Trans-sacral Resection of the Rectum. The coccyx and about an inch of the sacrum have been removed, and the rectal layer of the pelvic fascia divided. The posterior aspect of the rectum has been exposed, and the loose fatty tissue at the side of the rectum high up has been seized with forceps, and is about to be divided in order to reach the peritoneum and open into the pelvic cavity.

The retrorectal fatty tissue now exposed tends to obscure the position of the rectum. By a process of blunt dissection upwards on each side of the bowel through the perirectal fatty tissue the peritoneal reflection is reached. This membrane is divided between catch forceps just below the divided sacrum and about ½ inch to the right of the bowel (Fig. 220). The right index finger is introduced into the pelvic cavity through the peritoneal aperture and made to project on the opposite side of the bowel, where it can be cut down upon and pushed through. A strip of gauze is then passed round the rectum to serve as a traction loop (Fig. 221).

Mobilisation of the Rectum and Pelvic Colon.—Mobilisation of the bowel is accomplished by progressive division of the mesentery of the pelvic colon and of the peritoneal reflection on each side. The section of the pelvic mesocolon should be made close to the sacrum in order that all the glands and loose tissue between the folds of the mesentery may be removed with the gut. A loop consisting of the upper part of the rectum and the lower part of the colon can now be drawn out into the wound, but to

permit of the bowel section being made at a safe distance above the growth the pelvic colon must be withdrawn to a still greater extent from the pelvis. This necessitates the division of the superior hæmorrhoidal artery, which may be felt as a definite cord passing from the promontory of the sacrum to the upper part of the rectum and limiting the further descent of the latter. A curved aneurysm needle threaded with catgut is passed round this artery under the guidance of the left index finger at as high a point as possible so as to tie the vessel above the junction of the last sigmoidal artery (see p. 333). Another ligature is passed in a similar fashion ½ inch below the first and tied. The artery is divided between the two ligatures. A large part of the pelvic colon can now be drawn freely out of the wound.

The Resection.—The upper and lower limits of the growth are ascertained by

FIG. 221.—Trans-sacral Resection of the Rectum. The pelvic cavity having been opened by dissecting deeply at the right side of the rectum, the left index finger of the surgeon has been passed into the opening and around the bowel to its opposite lateral margin, where it has been cut down upon and pushed through. This step greatly facilitates the subsequent steps of the operation, as a strip of muslin can be passed around the rectum and traction exerted while it is being mobilised preliminary to its division.

palpation. A ligature of stout silk is applied well above its tangible margin and tied as tightly as possible. It is always well to allow 3 or 4 inches or even more of the gut to intervene between this ligature and the edge of the growth so as to minimise the chance of local recurrence. The free mobilisation which high division of the superior hæmorrhoidal artery affords renders a wide resection as easy and safe as one of a more limited extent. Another ligature is similarly applied still higher up, whereupon the bowel is cut across between the two, carefully wiped dry, and disinfected with pure carbolic acid or with the actual cautery.

The separation of the diseased segment is next proceeded with. The end of the distal segment of the bowel is drawn down, and the surgeon separates the gut from its connection with the bladder and prostate in the male, the vagina in the female, by a process of blunt dissection. When this has been accomplished the rectum is free in front and behind, but laterally it is held in place by the middle hæmorrhoidal vessels,

which constitute the so-called "lateral ligaments" of the rectum. These are rendered tense and obvious by withdrawing the gut as far as possible through the wound. An aneurysm needle threaded with catgut is passed round the middle hæmorrhoidal vessels on each side and these are ligatured and divided. By cutting through the peri-rectal tissues on each side with blunt-pointed scissors the rectum is separated from its connections down to the beginning of the anal canal (Fig. 222).

Drawing down the Upper Segment and its Fixation at the Anus.—At this stage of the procedure two alternatives present themselves: (1) the rectum may be doubly ligatured below the disease and the cancerous segment removed, after which the remaining healthy mucous membrane of the anal canal is everted through the anus, or (2) the entire cancerous segment of the rectum may be turned inside out by passing a forceps through

Fig. 222.—Trans-sacral Resection of the Rectum. The loop of the rectum represented in Fig. 221, having been sufficiently mobilised, has been doubly ligatured and cut across well above the growth. A piece of sterile muslin has been introduced into the pelvic cavity. The cancer bearing segment of the rectum is being separated from its surroundings and the method of dividing its lateral attachments is represented in the figure by an aneurysm needle carrying a ligature of catgut.

the anus and catching the gut above the disease. It is possible to invaginate the rectum through the anus in this manner when the growth is not of a bulky nature, and it is a step which is certainly to be recommended, as it enables one to inspect thoroughly the diseased area and make the lower section with ease and precision (Fig. 228).

The upper segment of the bowel is now drawn down, and the surgeon satisfies himself that it has sufficient mobility to be brought beyond the level of the anus without tension. The anterior or serous surface of the bowel is sutured to the divided peritoneum of the recto-vesical or recto-vaginal pouch by interrupted sutures of catgut. The next step consists in drawing down the end of the upper segment through the anus and connecting it to the everted lower segment by a series of interrupted sutures. A useful precaution at this stage is to connect the ligatured extremity of the gut to the skin in the vicinity of the anus by a temporary suture. The free ends of the occluding suture may be employed for this purpose. This prevents the parts from slipping

back and receding within the anal aperture. As an alternative to this method, which necessarily keeps the bowel occluded for some days, a short piece of glass tubing or one of rigid rubber may be tied in for the purpose of permitting gases to escape and preventing contamination of the wound for at least forty-eight hours after operation.

Closure of the Sacral Wound; Drainage.—A few deep sutures of catgut are introduced through the musculature of the pelvic diaphragm and the rectal wall. These sutures serve to take the strain off those already introduced at the anus and help to prevent the bowel slipping back. Finally the greater part of the wound is closed with silkworm gut and a couple of strips of iodoform gauze are introduced for drainage

FIG. 223.—Trans-sacral Resection of the Rectum. The lower or cancer bearing segment has been fully detached from its surroundings and drawn downwards. The upper segment has been mobilised to a sufficient extent to permit of its being drawn down to and if necessary, out through the anal aperture after the cancerous segment has been resected. Note how the cut margin of the peritoneum of the recto-vesical pouch has been connected by suture with the anterior aspect of the pelvic colon in order to shut off the pelvic cavity from the sacral wound.

purposes, as there is likely to be a considerable amount of oozing after the patient recovers from the anæsthetic. The gauze is removed after forty-eight hours and a fresh plug introduced.

Post-operative Measures.—As it is desirable to keep the bowels constipated for some days after the operation the administration of opium is continued. Pil. plumbi cum opio answers very well for this purpose. If the occluding ligature has been left on the protruding segment of gut the latter is inspected from time to time to see if there is any evidence of gaseous or fæcal accumulation above the ligature. If the bowel seems distended and if the patient is troubled with flatulence a puncture may be made and the gas allowed to escape. As a rule there is no need to remove the ligature until the third or fourth day. By this time the opposing peritoneal surfaces have quite acquired adhesions, the pelvic cavity is sealed up, and the protruding bowel has become securely anchored in its new site.

If after the removal or spontaneous separation of the ligature the parts do not recede

gradually within the grasp of the sphincter they may be trimmed with scissors and al bleeding points ligatured with catgut. This, however, is seldom necessary. A the end of a week or ten days the bowels are made to act freely with castor oil.

When a tube has been tied into the protruding gut the patient is usually mor comfortable, and the bowels may be allowed to move at an earlier date. Rigid loca cleanliness is of course all-important.

COMMENTS.

1. Resection followed by junction of the upper with the lower segment without invagination of the latter through the rectum is not a satisfactory operation, for it is extremely difficult to avoid subsequent leakage, owing mainly to the absence of a complete peritoneal covering on the lower segment. Several cases of severe cellulitis have occurred after its performance, and intractable fistulæ have not been uncommon. If this method be followed a preliminary colostomy will be advisable in order to prevent fæcal contamination and the distension due to the passage of scybalæ after operation. The colostomy opening can be closed when definite and permanent union of the bowel has taken place.

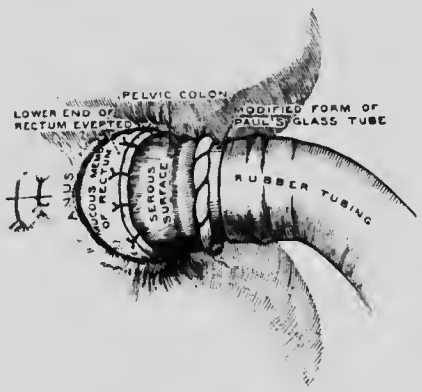

FIG. 224.—Trans-sacral Resection of the Rectum. The cancerous segment has been resected, and the mucous membrane of the anal canal having been everted, the pelvic colon has been drawn down and out through the anal orifice. A few points of interrupted suture are represented, connecting the raw tissues of the anal mucous membrane with the serous surface of the colon. A glass tube has been introduced into the distal extremity of the colon, and securely fixed by a purse-string suture. A piece of rubber tubing leads from the glass tube to a suitable receptacle.

2. In order to obtain quicker and more extensive union between the upper segment and the lower the mucous membrane may be completely removed from the latter and the upper segment sutured at the level of the muco-cutaneous junction. Adhesions rapidly form, and the line of suture is advantageously placed at the anal aperture instead of at a higher level within the bowel.

3. The great majority of deaths following this operation has been due to sepsis. If the technique outlined above be followed and the diseased segment removed as a closed sac or by evagination the danger of septic infection will be greatly diminished.

4. The key to a successful sacral or coccygeal resection of the rectum lies in opening into the cavity of the peritoneum at an early stage of the operation. By so doing the succeeding stages are rendered much easier.

5. In some cases the surgeon may find that the colon cannot be brought down far enough to be fixed at the anus without tension. In such a contingency the proximal segment may be fixed in the sacral wound. If, however, the peritoneum is freely opened and the superior hæmorrhoidal artery divided with due regard to the anastomotic circulation, the necessity for this will rarely occur.

THE COMBINED PERINEO-ABDOMINAL OR SACRO-ABDOMINAL OPERATION.

The Combined Method of operation is best adapted for cancers situated at the commencement of the rectum or in the lower part of the pelvic colon. It affords ready access to and renders possible a thorough investigation of the seat of disease. It can be ascertained whether the growth is circumscribed or whether it has spread to an extent incompatible with its successful removal, and at the same time the surgeon can investigate the condition of the hæmorrhoidal lymphatic glands and can observe if the liver is involved by metastatic deposits. Not a few rectal cancers have been removed by the perineal route in patients with extensive involvement of the liver. Again, it is only by adopting the abdominal route that one can draw down the bowel to the anus with a confident feeling that it retains an efficient blood supply.

The method of carrying out the combined operation in cases of cancer low down in the pelvic colon has already been described (p. 344). The process of mobilising the pelvic colon and the rectum is approximately the same in all cases, but the method of dealing with the upper healthy segment of the bowel will necessarily vary with the requirements of individual cases. The choice may be said to lie between the establishment of an artificial anus in the left iliac fossa and the restoration of the normal continuity of the bowel by drawing down the stump of the colon to or through the anal aperture and its fixation at this site.

The following procedure may be adopted in cases in which it is decided to terminate the operation with a colostomy.

Stages of the Operation.—The Abdominal Stage.—The patient is placed in the Trendelenburg position and a free median incision is made between the symphysis pubis and the umbilicus. The liver is first examined, and then the condition of the affected segment of the bowel and of its mesentery is carefully investigated in order to determine the local extent of the disease and the presence or absence of glandular involvement. Nodules in the peritoneum must always be sought for. Assuming that the indications for the radical operation are favourable, the surgeon proceeds to mobilise and divide the loop of pelvic colon.

Division and Mobilisation of the Colon with the Upper Part of the Rectum.—A self-retaining retractor is placed in the wound and free exposure ensured. The coils of the small intestine are carefully packed away and prevented from passing down into the pelvis by large thick abdominal wipes soaked in hot saline solution. Several long strips of gauze rinsed out of the same solution are inserted all round the area included in the intra-abdominal manipulations.

The pelvic colon is drawn out from the wound, emptied by finger pressure, and clamped in two places about 3 inches apart and well away from the diseased zone. As there is no question of bringing the proximal end down to the anus in this case, there is no advantage in leaving much of the pelvic colon. Miles divides the gut at the point between the distribution of the upper and middle sigmoid arteries. It is always wise to examine the mesocolon by transmitted light and place the level of the section about ½ inch distal to a definite sigmoid artery. Two purse-string sutures are now passed in a circumferential direction round the bowel and through its mesentery. These sutures lie between the clamps and about ½ inch from the latter respectively (Fig. 225). They pass only through the serous and muscular coats of the bowel. The bowel is divided midway between the sutures with scissors or the thermo-cautery and the section is prolonged for a short distance into the mesentery,

bleeding vessels being secured by forceps. The exposed mucous membrane is carefully wiped dry. Each aperture is next closed by a penetrating continuous suture, where upon the closed stump is invaginated, as shown in Fig. 226, and the purse-string suture previously introduced is drawn tight.

Fig. 225.—The combined Abdominal and Perineal Operation for Rectal Cancer. The abdomen has been opened by a left paramedian incision, the operating table being inclined in the Trendelenburg position. The coils of the small intestine have been pushed aside and muslin compresses packed around the pelvic loop of the colon. This latter has been seized with two clamps placed about two inches apart. Two circumferential purse-string sutures have been passed around the segment of the bowel which intervenes between the clamps, each suture being about ½ inch from its respective clamp. These sutures traverse the serous and muscular layers, but do not enter the lumen of the bowel.

The upper segment is replaced temporarily within the abdomen, and the isolation of the lower or rectal segment is undertaken in the following manner:—

The incision on the mesocolon is prolonged backwards to its parietal attachment and the superior hæmorrhoidal artery divided between ligatures.

The peritoneum of the mesocolon is divided in a downward direction on each side

close to its parietal attachment and carefully detached from the subjacent parts in an outward direction towards the iliac vessels. These incisions are joined by another passing in a curved direction between the rectum and the bladder in the male, or through the pouch of Douglas in the female. The diseased bowel is now drawn forwards

FIG. 226.—The combined Abdominal and Perineal Operation for Rec Cancer. The loop of bowel represented in Fig. 225 has been divided midway be n the clamps, and the section has been prolonged for a short distance into the r c meso-colon. The open extremity of each piece of intestine has been occluded y a continuous penetrating suture similar to that represented in Fig. 189, p. 314. The occluded extremity of the proximal segment has been invaginated by first depressing it and then drawing the purse-string suture tight. The end of the distal segment is being depressed preliminary to completing its invagination by tightening the purse-string suture.

and together with the cellular and lymphatic tissues of the mesentery is detached from the pelvic wall. This part of the procedure is most effectively accomplished by means of dry sponging. The front of the sacrum is then laid bare and the middle sacral artery may be ligatured and divided: further isolation of the bowel is effected in the coccygeal region. In separating the rectum from its connections in front it

is important to strike the proper plane of cleavage between it and the bladder. The best method of accomplishing this is to define accurately the position of the seminal vesicles and vasa deferentia and to keep close to these structures until the posterior surface of the prostate is reached. The rectum is now free both in front and behind,

FIG. 227.—The Combined Abdominal and Perineal Operation for Rectal Cancer. This figure represents a stage in the process of removal of the lower part of the pelvic loop of the colon and the rectum. The pelvic meso-colon has been divided back to its parietal attachment, and the superior hæmorrhoidal vessels have been cut across between ligatures. The peritoneum forming the respective right and left layers of the pelvic meso-colon has been divided, and the bowel with its mesentery raised from the concavity of the sacrum.

but laterally the middle hæmorrhoidal vessels can be felt passing inwards from the internal iliac artery and fixing the bowel on each side. An aneurysm needle is passed round these vessels and they are ligatured and divided.

The Colostomy.—A small opening is made in the left iliac region of the abdominal wall, and through it the stump of the colon is drawn out and secured by sutures.

The distal segment of the bowel is then packed down to the bottom of the pelvis, and if feasible the lateral cut margins of the pelvic peritoneum are brought together and sutured over it in front of the sacrum.

Closure of the Abdominal Wound. This is accomplished in the usual manner by sutures of catgut and silkworm gut.

2. The Perineal or Sacral Stage of the Operation.—The patient is now placed in the lithotomy position or on the left side, according to whether the perineal or sacral route is chosen. The site of the incision and the surrounding area are disinfected with tincture of iodine, the anus being occluded by a purse-string suture.

Exposure of the Rectum.—The method by which this step is accomplished has been described in connection with the perineal and sacral operations. The stump of the rectum already mobilised from above is drawn out through the perineal wound and its further separation effected. If the middle hæmorrhoidal vessels have not been divided they are now ligatured. The lower extremity of the rectum, including the sphincters, is detached from its surroundings and the entire rectal segment removed. Any compresses which may have been packed into the perineal space from above are also taken away.

Drainage and Closure of the Perineal Wound.—A large rubber tube surrounded by gauze is introduced into the posterior part of the wound, and the latter is closed by sutures except where the drain emerges.

The Colostomy Aperture.—The stump of the colon already fixed in the iliac region is maintained closed for two or three days. In exceptional cases, however, it may be opened at the conclusion of the operation, but if so a Paul's tube ought to be tied in in order to conduct away the contents of the bowel without risk of contamination of the wound.

THE COMBINED OPERATION FOLLOWED BY RESTORATION OF THE NATURAL ANAL OUTLET.—This procedure resembles in many respects the operation just described. Accordingly only those details will be alluded to in which the technique presents material differences.

1. The Abdominal Stage.—The abdomen is opened and the preliminary investigation is conducted as before.

Mobilisation of the Colon and Ligature of the Superior Hæmorrhoidal Artery.—Mobilisation of the colon is accomplished by the method described in a previous section for extirpation of cancer low down in the pelvic colon. The peritoneum is divided along the outer side of the iliac and descending segments of the colon, and the latter is raised with its blood vessels from the iliac fossa and carefully separated from the posterior abdominal wall towards the middle line. Care must be exercised in order to avoid injuring the spermatic or ovarian vessels, as the case may be, and to preserve the ureter intact. The latter adheres to the peritoneum and is usually raised along with it. The incision in the peritoneum is further extended downwards into the pelvis beside the pelvic mesocolon to the left pararectal fossa, and it may be carried further upwards also if deemed necessary.

The inferior mesenteric vessels are exposed retroperitoneally on drawing the colon with its mesentery over towards the right side, and the branches passing to the bowel as well as the arches which they form with each other can usually be easily recognised. The point at which the lowest sigmoid loop joins the superior hæmorrhoidal artery is determined, and the latter is doubly ligated and divided above the junction. An

incision is now made through the peritoneum constituting the right leaf of the meso-colon close to its parietal attachment. It extends from the promontory of the sacrum to the right pararectal fossa. Another incision connects this across the recto-vesical or recto-vaginal pouch to that already made.

From the point of ligature of the inferior mesenteric artery an incision is now carried obliquely downwards to the level at which it has been determined to divide the bowel. This incision must be made with care, for it is essential to leave the arterial arches and the terminal branches of the superior hæmorrhoidal artery intact. It is therefore necessary to leave the cut mesosigmoid containing the vessels attached to the freed loop. By a process of dry sponging the pelvic colon and rectum, together with the portion of mesentery included between the incisions and the presacral connective

FIG. 228.—Trans-sacral Resection of the Rectum. This figure represents a method of dealing with the lower cancerous segment when the mass of growth is not of a bulky character. A pair of forceps is introduced through the anus, and passed up to the ligatured extremity of the rectum where it is made to grasp the mucous membrane and draw it down and out through the anus, the entire segment being thus turned inside out. When this manœuvre can be accomplished, it enables the section of this lower rectal segment to be made with ease and precision and with the minimum of risk of septic infection of the wound.

tissue, are detached from the front of the sacrum and left pelvic wall and drawn forwards. The rectum is freed from its surroundings as in the previous operation. One or more compresses of gauze are then pushed down behind it, to be removed later through the perineal wound.

The surgeon now satisfies himself that the bowel will descend to the required extent and the abdominal wound is closed.

2. The Perineal Stage of the Operation.—The rectum is exposed as already described in the perineal and sacral operations and the loop is drawn out through the wound. The site of the upper section is determined and the bowel is divided between ligatures well above the growth.

The end of the upper segment may be anchored temporarily by its occluding ligature to the skin of the buttock. The lower segment is carefully dissected away from its surroundings, the perirectal tissues being divided as far as possible from

the growth, especially at the level of the latter, in order to avoid the possibility of leaving any affected parts behind.

The rectum having been rendered quite free down to its junction with the anal canal may be dealt with in one or other of two ways:—(1) If the growth is not very bulky the rectum may be turned inside out like the sleeve of a coat (Fig. 228); it is then cleansed and a circular section made through the protruding cylinder about 1 inch away from the anus, after which the upper segment is then drawn down through the everted anal cylinder, and these two are connected by a series of interrupted sutures as represented in Fig. 224. The upper segment, still occluded by a ligature, may be retained outside the anal orifice by connecting the ligature with the perineal skin for twenty-four or forty-eight hours, after which the ligature is cut and the parts allowed to recede within the anus. (2) The rectum having been drawn out through the perineal wound is clamped or ligatured in two places in its lower or ampullary segment; it is then divided between the clamps and the diseased part removed. The anal segment having been cleansed is turned inside out, and the remaining steps of the operation are completed as before.

The perineal wound is drained by means of a stout rubber tube surrounded by gauze, and for the remainder of its extent it is closed by interrupted sutures of silk-worm gut.

Fig. 224.—The Operative Treatment of Hæmorrhoids by Ligature and Excision. A large hæmorrhoid on the right side of the anal aperture has been dissected up with careful definition and preservation of the external sphincter. A ligature of strong plaited silk has been passed from one extremity of the wound to the other, taking up successive pieces of the subcutaneous tissue immediately adjoining the cut margin of the perianal integument. Opposite the centre of this cut margin the ligature has been drawn out in the form of a loop.

THE OPERATIVE TREATMENT OF HÆMORRHOIDS.

LIGATURE AND EXCISION.—Preliminary Measures.—The bowel should be well cleared in all cases before undertaking operative measures for hæmorrhoids. Castor oil is very useful for this purpose, and 1 ounce may be taken the last night but one preceding the operation. It is better not to postpone its administration until the night before lest the surgeon should be hampered by the liquid contents of the rectum escaping during the performance of the operation. An enema will be administered and the rectum thoroughly washed out on the morning of the operation. With individuals who suffer from constipation it will be wise to take additional precautions to ensure that the bowel is well emptied, as the ordinary dosage may prove totally inadequate. We prefer to operate with the buttocks in the lithotomy position, as it affords better access than when the individual lies on the side.

The anus and the surrounding integument are cleansed and disinfected. The feet and legs are encased in sterilised slip-on drawers which include the feet, and the buttocks likewise are covered by sterilised sheeting held in position by towel clips or ordinary hæmostatic forceps. The anus and a small area of the surrounding skin will alone be exposed to view.

The protrusion of the piles and the manipulations attending their removal are facilitated by dilating the anus to a moderate extent. The two thumbs introduced within the bowel first dilate in the transverse and subsequently in the antero-posterior direction. The dilatation should be carried out slowly and steadily and not in a jerky or forcible manner, the object being merely to bring the piles well into view and enable them to be seized and drawn down readily through the anal orifice.

A case suitable for ligature and excision is one in which it is possible to recognise certain distinct pile tumours with intervening deep sulci. From three to five of these tumours are frequently present.

The Operation.—The individual piles having been defined are seized with forceps and made to protrude through the anal orifice. A pile at one side is first dealt with. The retaining forceps are drawn upon by the surgeon, and while the protruding mass is made tense an incision is made with scalpel or stout scissors through the integument of the everted anal canal and extended through the subcutaneous tissues until the margin of the external sphincter is exposed (Fig. 229). The muscle edge is defined, and by a few additional snips the pile is isolated and drawn down sufficiently to permit of the ligature being placed in healthy mucous membrane. Should any vessels spout they will be seized with hæmostatic forceps. A curved needle threaded with strong silk, No. 8 size, is now passed through the subcutaneous tissue immediately subjacent to the anal integument which has been raised and held aside. The needle is passed in such a way as to take up successive pieces of tissue, and it carries the ligature from one angle of the wound to the other; it is then unthreaded and laid aside. Opposite to the mid-point of the wound a visible portion of the thread is seized with forceps and drawn out so as to form a loop as represented in Fig. 229. A sinus forceps directed from the mucous aspect of the hæmorrhoidal tumour is made to transfix it high up in healthy tissue, its blades are opened, the loop of ligature seized and drawn through (Fig. 230). The loop is divided with scissors, but before doing so it is twisted so that its two limbs interlock, and the resulting ligatures are drawn respectively upwards and downwards. Each of these is now tied, and while this is being done the pile mass is drawn down, but as soon as the ends of the ligature are drawn tight the traction on the mass is discontinued and the second knot made. The ligature should be applied as tightly as possible so as to strangulate the pedicle and prevent any possibility of slipping subsequently (Fig. 231).

Fig. 230. The Operative Treatment of Hæmorrhoids by Ligature and Excision. This figure represents a further stage of the procedure represented in Fig. 229. The projecting loop of ligature has been seized by sinus forceps thrust through the healthy, rectal mucous membrane above the level of the hæmorrhoidal mass. The loop is about to be drawn through and divided. In this way two ligatures are formed by means of which the base of the hæmorrhoid is ligatured in two sections.

The second ligature is now tied in the same manner, and finally the main mass of the pile is detached with scissors and the free ends of the ligatures are cut short (Fig. 232).

The process of ligature will be facilitated by crushing the base of the detached pile

so as to diminish its bulk, but this is not necessary. A ligature passed and tied as described meets all the requirements of the case.

The remaining piles are now dealt with in similar fashion, and when the operation has been completed the ligatured stumps are gently pressed backwards within the anal orifice. The aperture should readily admit the finger; if not, the ligatures

FIG. 231.—The Operative Treatment of Hæmorrhoids by Ligature and Excision. This figure represents a further stage of the procedure represented in Figs. 229 and 230. The loop of ligature which has been drawn through the hæmorrhoid at its base has been divided and two independent ligatures formed. These have been made to interlock and the lower ligature has been securely tied. The free ends of the upper ligature are being held preparatory to completing the strangulation of the hæmorrhoidal mass.

will have been improperly applied and a certain degree of stenosis produced; this may remain as a permanent condition after healing has taken place.

EXCISION AND SUTURE.—This method of operation for piles is one which we regard with great favour. It is applicable to the same type of case as that described in connection with the previous operation. The technique which we employ is that recommended by Mr. A. B. Mitchell, F.R.C.S.I.

The preliminary measures, including the dilatation of the anus and the drawing down of the pile masses, are carried out as in the preceding operation.

The procedure is performed in the following manner: Having seized the pi
and drawn it down fully so as to put it on the stretch, it is grasped at its base wit
narrow-bladed forceps; those of Kocher employed for hæmostatic purposes are ver
suitable. The blades are applied in such a way that the long axis of the instrumer
occupies the same direction as that of the anal canal (Fig. 233).

The main mass of the pile which projects beyond the blades of the forceps is no
cut away and the sutures are introduced before the blades of the instrument are relaxe
A continuous suture of catgut is passed with a fully curved needle (Fig. 234). The fol

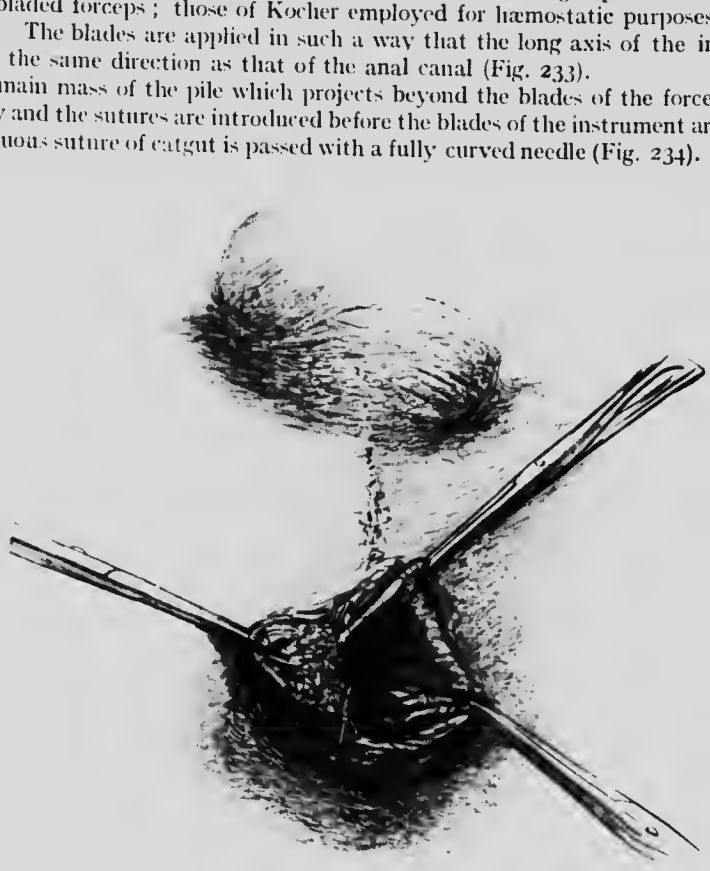

Fig. 232.—The Operative Treatment of Hæmorrhoids by Ligature and Excision. This figure represents the completion of the operation. The ligatured mass has been excised. The preceding stages of the operation are represented in Figs. 228, 229, 230, and 231.

of mucous membrane held by the tips of the blades is first underrun and securely
ligatured as it contains the chief vessels, and starting from this point, the sutures are
passed in a continuous fashion beneath the blades of the forceps until the entire mass
of tissue grasped by these has been underrun (Fig. 234). The final step consists in
relaxing the blades of the forceps and withdrawing them from the grasp of the suture
loops. These are immediately tightened by drawing the thread taut and knotting it
(Fig. 235). If any oozing should now take place one or more additional loops of suture
are passed beneath the bleeding vessels before the thread is cut. As a rule hæmostasis
is quite satisfactory.

The remaining piles are treated in like manner, and care is taken not to remove

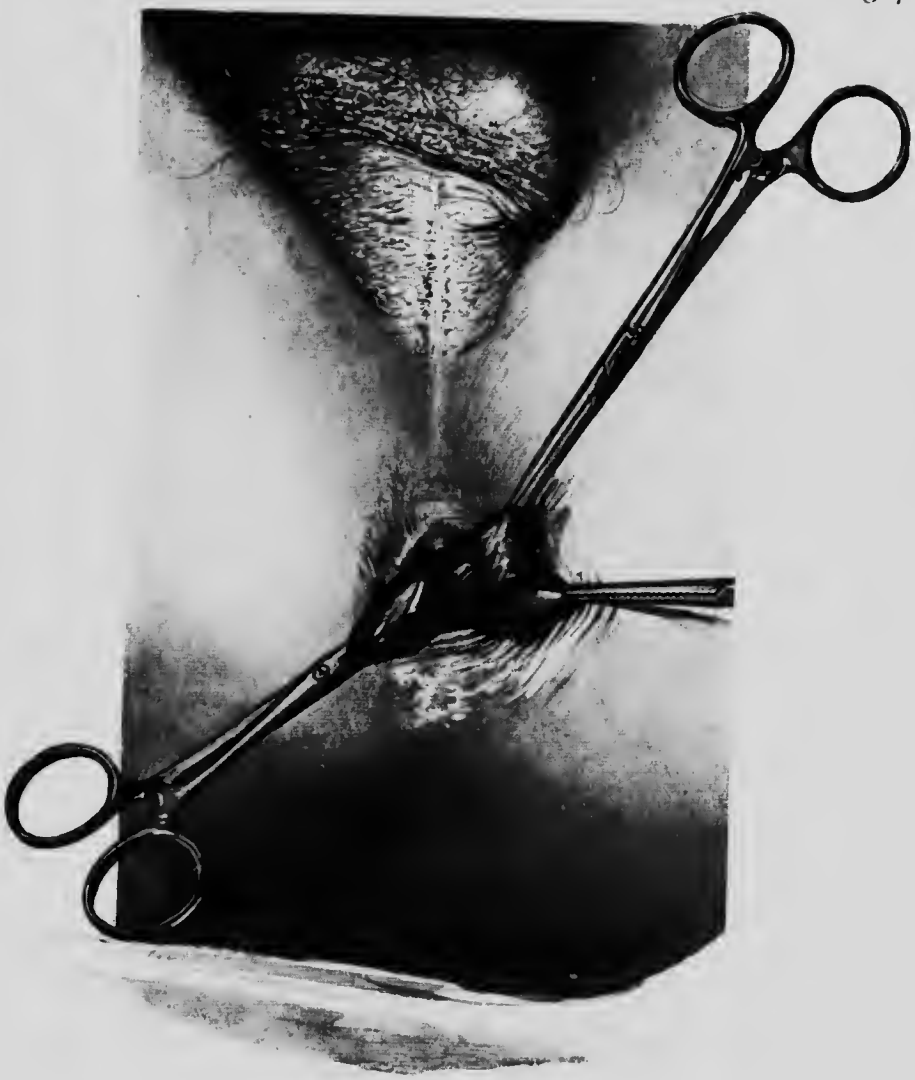

FIG. 233.—The Operative Treatment of Hæmorrhoids by Excision and Suture—Mitchell's Operation. The anus having been moderately and gently dilated, the individual hæmorrhoids have been seized and drawn down. One large hæmorrhoid at the right side of the anus has been grasped by a pair of Kocher's hæmostatic forceps, the blades of the latter having been introduced in the direction of the long axis of the anal canal.

so much of the anal mucous membrane as to cause an undesirable degree of stenosis of the orifice.

CIRCULAR RESECTION OF THE PILE-BEARING AREA: WHITEHEAD'S OPERATION.—This operation is well adapted to certain cases in which the

hæmorrhoidal development is pronounced. The entire ring of mucous membrane is involved, and a frequent complaint is that individuals so affected are troubled with the constant tendency of the pile-bearing area to prolapse. When the anus is moderately dilated under anæsthesia for the purpose of investigating the condition of the mucous membrane the swollen mass is at once obvious and tends to prolapse through the anal aperture; indeed it frequently happens that when the patient is placed in the lithotomy position the hæmorrhoidal zone of mucous membrane protrudes

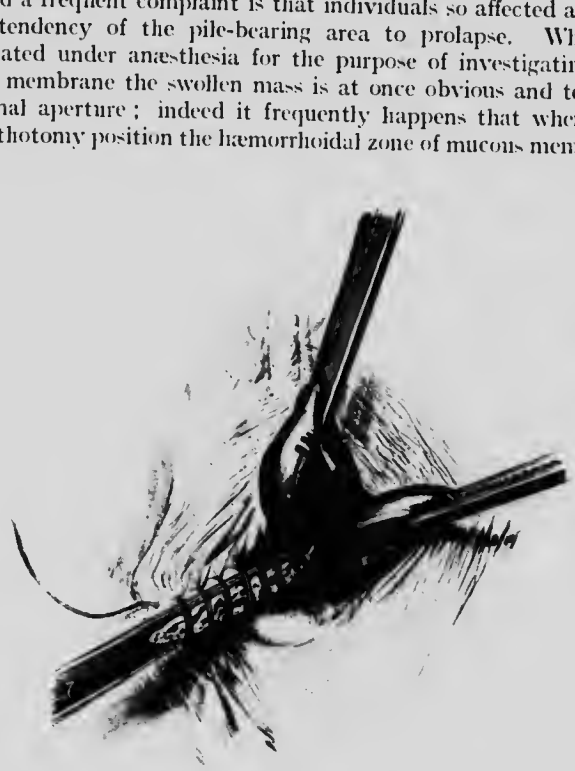

FIG. 234.—The Operative Treatment of Hæmorrhoids by Excision and Suture—Mitchell's Operation. This figure represents a stage of the procedure represented by Fig. 233. The hæmorrhoid has been excised and a continuous suture has been passed with a view to connect together the cut margins of the resulting wound and control the divided blood-vessels. The suture has been passed while the tissues are still held in the grasp of the forceps. With the suture in position, the blades of the forceps are relaxed and the instrument removed, whereupon the free end of the suture is drawn tight and knotted.

spontaneously and appears as an enormous hypertrophied roll of a purple or black colour extending completely around the anus, and if the finger be introduced within the orifice it will be noted that the tonicity of the sphincters is somewhat feeble and the canal distinctly patulous. This type of case is particularly suited for circular resection owing to the laxity of the mucous membrane and the facility with which it tends to prolapse. When the swollen hæmorrhoidal segment has been removed it is easy to draw down the healthy mucous membrane and connect it with sutures to the anal integument without any resulting tension.

The Operation.—The usual preliminaries having been attended to and the patient placed in the lithotomy position, the operation is carried out as follows: The mas-

of piles, if not already protruding, is drawn down and wiped dry. The resection is commenced by making an incision on one side from the anterior to the posterior commissure of the anus through the everted integumentary portion of the anal canal. By a few rapid snips of scissors or with a scalpel the subcutaneous tissues are divided along the same line, obvious spouting vessels are secured with hæmostatic forceps, and the margin of the external sphincter muscle is defined. With the handle of the scalpel or a suitable blunt dissector the sphincter is pushed away from the hæmorrhoidal mass, and by drawing this down the healthy mucous membrane is made to descend to the level of the anal orifice. Three mattress sutures of catgut are now intro-

FIG. 235.—Mitchell's Operation for Excision of Hæmorrhoids followed by Suture. This figure represents the final stage of the procedure illustrated by Figs. 233 and 234. The hæmorrhoid grasped by forceps has been excised. The continuous suture of catgut passed with the forceps still *in situ* has been drawn tight. In this way the wound margins are brought together and hæmostasis is effected. The remaining hæmorrhoids are treated in a similar manner.

duced in the manner represented in Fig. 236, one opposite each commissure and one midway between. Each suture enters the skin about ½ inch from its cut margin, and is made to enter the bowel about the same distance above the proposed line of section. From within the bowel it is made to return to the skin so that its two free ends come to lie close together and a loop is left within the bowel. When these three sutures are drawn upon and knotted the healthy segment of the rectal mucous membrane above the hæmorrhoidal zone is made to descend, and when the resection of the latter has been effected the cut margins of the skin and mucous membrane can be connected by suture and the danger of subsequent traction upon the line of junction will be greatly diminished.

The resection of the hæmorrhoidal mass is best accomplished by making two vertical

cuts through it one opposite each commissure to a point about ½ inch from the respectiv mattress sutures. The circular section is then commenced and is carried around i healthy tissue (Fig. 237). A good plan is to cut a small piece and immediately connec the rectal mucous membrane with the skin. By repeating this procedure upon th opposite side the hæmorrhoidal mass is progressively detached and set free. Th prompt introduction of the sutures helps to diminish hæmorrhage, and there is les

FIG. 236.—Whitehead's Operation for Hæmorrhoids by Circular Resection. By a careful process of dis-section the hæmorrhoidal mass has been dissected free of the anal sphincter on the left side, three deep mattress sutures have been passed respectively in front, behind and at the side of the anus. The loop of each suture lies within the lumen of the bowel above the diseased zone, and the free ends emerge from the skin about half an inch from its cut margin. By drawing these sutures tight and knotting them the healthy mucous membrane is made to descend, and the chief hæmorrhoidal vessels are controlled at the same time.

FIG. 237.—Whitehead's Operation for Hæmorrhoids completed. The four deep, supporting mattress sutures have been tied; the hæmorrhoidal mass has been resected and the cut margin of the rectal mucous membrane has been connected with that of the anal integument by means of several interrupted sutures of catgut.

risk of the cut mucous membrane receding and causing trouble than if the whole pile mass were cut away first and the suturing carried out afterwards.

Post-operative Measures.—For two or three days the diet should be restricted and consist of easily digested foods of a light kind. A purgative will be administered on the third or fourth day following the operation, and, as a rule, castor oil is to be recommended, as it acts satisfactorily and occasions but little pain. Should the first evacuation of the bowels be attended by suffering, a ready means of relief consists in the hot hip bath, which rapidly assuages the pain and relaxes the spasm of the sphincters. The addition to the bath of a little cyllin is to be recommended, and if one be taken each day for about a week the healing process will be hastened and the comfort of the patient promoted to a very marked extent. As a local application hazeline cream is very soothing; lano-cylin ointment too is very useful.

THE LIVER AND THE BILIARY PASSAGES.

ANATOMY.—The highest point of the right lobe of the liver lies beneath the right cupola of the diaphragm on a level with the upper margin of the fifth rib about 1 inch internal to the mammary line and about ½ inch below the right nipple. The left lobe does not reach quite so high, as it fails to reach the deepest part of the left cupola; its upper limit corresponds approximately with the upper border of the sixth rib in the mammary line, or about 1 inch below the left nipple. The upper border of the liver descends slightly between these points, and in the middle line it passes just above the junction of the middle segment of the sternum with the xiphoid cartilage.

The lower border of the liver as it is traced from right to left follows at first the costal arch as far as the tip of the ninth costal cartilage. It may, however, with the erect posture descend fully an inch below the ribs. From the ninth costal cartilage the line crosses the epigastrium obliquely with a slight downward convexity and reaches the tip of the eighth costal cartilage on the left side. From this it is continued outwards to meet the upper and outer limit of the left lobe already determined. In the middle line the lower border of the liver lies approximately midway between the base of the ensiform cartilage and the umbilicus. On the right side the liver outline will correspond with a curved line passing from the point which marks the upper limit of the right lobe to another situated 1 inch below the tip of the tenth costal cartilage.

The area in the epigastrium where the liver is in relation to the anterior abdominal parietes is one of considerable importance. It is here that incisions are frequently made to reach the liver or biliary passages, and it is here that the liver is most accessible to palpation, especially when enlarged and when its consistency is increased in certain forms of disease. It is to be noted that its lower margin rises and falls with respiration, and this is a useful diagnostic sign in some cases of obscure abdominal tumours.

When the gall-bladder is enlarged the outline of the fundus can sometimes be made out distinctly, especially when the abdominal parietes are thin. The liver assumes an abnormally low level when it is enlarged from any cause or in consequence of tight lacing; when the diaphragm is depressed by a pneumothorax, mediastinal tumours, a large pleural effusion, or emphysema of the lungs, or if it is paralysed.

The upper limit of the liver may reach an abnormally high level in cases of abscess or hydatid cyst involving mainly the convexity of the right lobe; it may do so also following shrinkage of the lung, as occurs in phthisis, or after the evacuation of certain forms of empyema. As it lies beneath the diaphragm the liver is overlapped by the lower margin of the right lung and by the costo-diaphragmatic pleural recess. The relationship maintained by the latter is fairly constant, as the line of pleural reflection between the diaphragm and chest wall is not subject to any considerable degree of variability. The relation of the lung, however, is very variable: it alters during respiration, as its thin edge advances and recedes within the pleural recess. When the liver enlarges in an upward direction the base of the lung rises with the diaphragm, but the depth of the pleural recess is practically unchanged. This fact is one of very great importance in the surgery of the liver (hepatotomy). It frequently happens that the most direct route to reach an abscess or hydatid cyst in the right lobe is by way of the thorax. In such cases the lung is displaced upwards for a considerable distance out of the costo-diaphragmatic recess and the diaphragm lies in contact with the thoracic wall over an abnormally extensive area. To reach the liver through the diaphragm the pleural recess is of necessity opened, hence the name *transpleural hepatotomy* which has been given to this operation.

The Fundus of the Gall-bladder comes into relationship with the anterior abdominal wall at a point corresponding with the anterior extremity of the ninth costal cartilage. This point is usually indicated on the surface by a slight depression where the right semilunar line reaches the costal margin.

The Deep Relationships of the Liver. The structures which lie beneath the liver are brought into view by gently raising its lower sharp margin after the organ has been

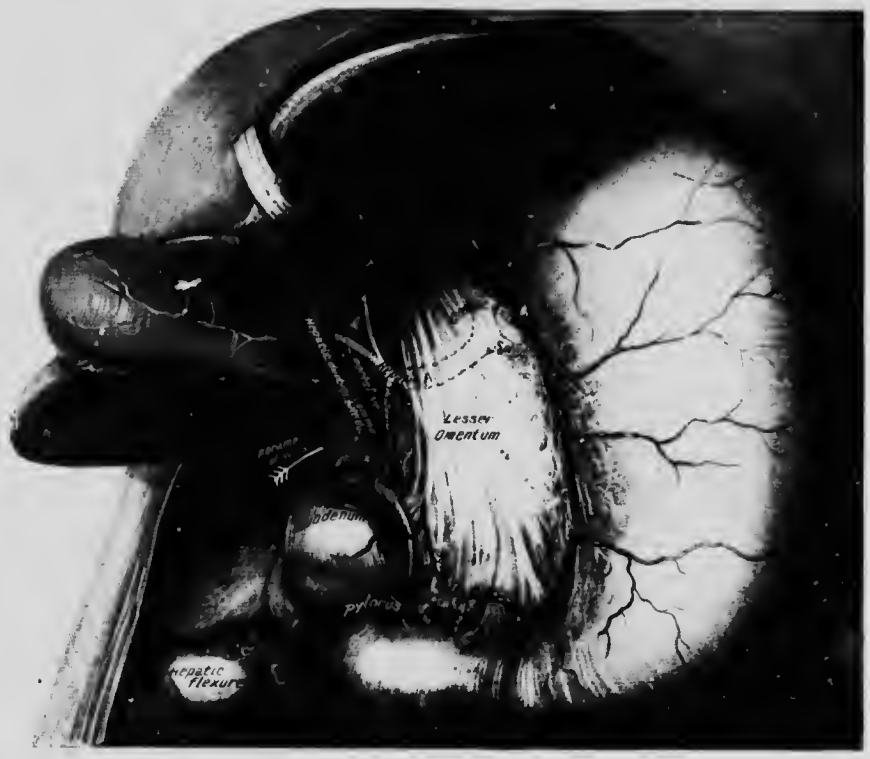

FIG. 238.—The deep relations of the liver and the chief structures in relationship to the common bile duct. The right and left hepatic ducts unite to form the hepatic duct proper, and this is joined lower down by the cystic duct, the junction of these two forming the common bile duct. This latter is seen in its supraduodenal stage in front of the foramen of Winslow.

exposed by a suitable abdominal incision. If the hand be passed backwards deeply beneath the right lobe of the liver it will enter the *hepato-renal recess* to the right of the spine. The upper part of the *right kidney* will be felt and identified, and by following the renal surface downwards and forwards the *hepatic flexure of the colon* will come into view with the great omentum attached to it in front (Fig. 238). The *gall-bladder* is clearly exposed when the liver is raised. It may be followed in a deep direction as it gradually tapers into the *cystic duct*. This exploration leads to the *foramen of Winslow*, into which the finger is readily introduced. The *common bile duct* together with the portal vein and the hepatic artery lie in front of the foramen and are contained within the right free border of the gastro-hepatic omentum (Fig. 238). The *duodenum*

lies just below the foramen, and at this level it bends downwards as it passes from its first into its second stage. The part of the common bile duct in front of the foramen of Winslow is known as the *supraduodenal stage*. The remainder of the duct lies behind the duodenum. The terminal or *transduodenal stage*, however, traverses the duodenal wall obliquely before it opens at the summit of the bile papilla. Just before the bile duct terminates it is joined by the main duct of the pancreas, and at this level it presents a slight dilatation, the *ampulla of Vater*. That part of the bile duct which runs down behind and to the inner side of the second stage of the duodenum is closely related to the head of the pancreas and may be embedded in the substance of the gland.

The supraduodenal stage of the duct, in the absence of adhesions, is readily exposed and examined. With the finger in the foramen of Winslow the duct may be drawn forwards into the wound, more especially in cases of excessive laxity of the peritoneum such as exists with the varying degrees of visceroptosis. The *retroduodenal segment* of the common bile duct may be reached by dividing the peritoneum vertically at the right side of the descending duodenum where it clothes the front of the right kidney above the hepatic flexure of the colon. Through the peritoneal aperture the finger may be introduced and the duodenum mobilised to an extent sufficient to permit of its being drawn forwards and rotated towards the left side. This brings into view the inner concave border of the duodenum and the glandular tissue of the pancreas. Under normal conditions the duct is readily exposed by a slight dissection, but if its lumen should be occupied by a gall-stone its identification will be greatly facilitated. Another method of obtaining access to the lower part of the common bile duct is from the front by first opening into the descending duodenum and then dividing it again posteriorly over the duct. This procedure is rendered easy by the presence of an impacted calculus in the duct.

The Cystic Artery.—This vessel usually proceeds from the right division of the hepatic artery and is readily found or exposed for ligature as it passes along the side of the cystic duct (Fig. 238).

The Stomach and Duodenum.—The pylorus and the prepyloric segment of the stomach, the first and part of the second stage of the duodenum, are overlaid by the liver. These parts together with the right flexure of the colon are exposed in operative procedures directed towards the biliary passages. Furthermore, the gall-bladder, duodenum, colon, and occasionally the pyloric segment of the stomach are not infrequently entangled in adhesions resulting from a previous pericholecystitis or perigastritis. In many cases the chief difficulties encountered in operations on the gall-bladder and common bile duct are due to adhesions within this subhepatic area. The separation of such adhesions demands great care owing to the risk of perforation of one of the hollow viscera. A small perforation may not be recognised and may entail a post-operative peritonitis.

PATHOLOGY.—The Liver.—The level of the lower margin of the liver is subject to some variability. In females with an atonic condition of the muscles and excessive laxity of the visceral peritoneum the liver may acquire an unusual degree of mobility and descend below its normal level (hepatoptosis). Operative procedures upon the gall-bladder or the common bile duct are much facilitated by the ready way in which the mobile liver can be rotated upwards and manipulated in such a way as to enable the parts concerned to be brought through or into the immediate vicinity of the abdominal wound.

The Gall-bladder. The condition of the gall-bladder varies enormously with the various pathological processes to which it is subject. Thus, when exposed in the course of operation, it may appear fairly normal in size and shape, occasionally it is small and contracted, or it may be considerably distended, and with either of these conditions there may be adhesions binding it to neighbouring parts.

Contraction of the Gall-bladder is likely to result from chronic inflammation and subsequent cicatricial changes in its walls. It is frequently met with in association with a calculus or calculi in the common bile duct. Contrary to what might be expected, obstruction of the common duct by gall-stones is not usually accompanied by dilatation of the gall-bladder, but rather by cicatricial changes in the walls of the viscus leading to its marked contraction (Courvoisier's law).

Enlargement of the Gall-bladder may be due to various causes, of which the most common is stenosis or occlusion of the cystic duct or of the common bile duct. A calculus impacted in the cystic duct is a frequent cause, and when this occurs the contents of the gall-bladder consist not of bile, but of clear mucous fluid (*hydrops* or *mucocele*). Cancer involving the cystic duct may lead to a similar result, and cancer of the head of the pancreas sooner or later will compress the common duct and lead to accumulation of bile in the gall-bladder and its progressive distension. We have met with an enormously swollen gall-bladder in a case of cancer at the opening of the bile duct into the duodenum.

Empyema of the Gall-bladder is an occasional sequela of acute cholecystitis. The inflammatory changes result in thickening of the wall of the viscus, and its tissues assume a marked degree of friability. With the pericholecystitis which usually exists, adhesions form and glue the gall-bladder to adjacent parts, more especially the omentum, the colon, and the pylorus. In recent cases these adhesions are soft and easily broken down, but after some time they assume a dense fibrous character.

Fistulæ. Communications may be established between the gall-bladder and any of the surrounding hollow viscera, viz., the stomach, duodenum, colon, and even the pelvis of the ureter. These biliary fistulæ are usually the result of gall-stones which have ulcerated through and which may have successfully travelled onwards and been voided per rectum. Large concretions, however, escaping in this way from the gall-bladder may be arrested in their course, usually in the lower ileum, where the lumen of the bowel narrows somewhat, and occasion acute intestinal obstruction.

The surgeon should bear in mind the possibility of fistulous communication between the gall-bladder and the stomach and intestine when separating adhesions which bind these parts together.

The Abdominal Incision in Operations upon the Biliary Passages. The forms of incision which are most frequently employed for gaining access to the liver and the biliary passages are the following:—

1. A single vertical incision slightly to the inner side of the outer rectus margin and with its upper extremity approximating the ninth costal cartilage.

2. The incision just described may be supplemented by an oblique cut extending upwards and inwards parallel to the costal arch to the linea alba. This is known as Mayo Robson's incision; it is very generally employed when good access is required and it suffices in the majority of cases.

3. Mayo Robson's incision may have an oblique cut carried outwards from its lower extremity into the flat abdominal muscles (Bevan). This, however, is seldom necessary.

4. The incision recommended by Kocher is situated below and parallel to the costal arch. Its inner part extends across the rectus muscle and its sheath, and at its outer extremity it traverses the flat abdominal muscles to a varying extent, according to the exigencies of individual cases. This incision affords good access, but it has the disadvantage of necessitating the division of certain of the intercostal nerves which cross its path.

Fig. 239.—Perthes' Incision to reach the gall-bladder and the common bile duct. A vertical incision has been made about ¾ inch from the middle line. The rectus sheath has been opened, and the right index finger passed between the muscle and the deep layer of the sheath. Before making the deeper portion of the horizontal limb of the incision, two rows of sutures are passed as represented in the figure. These sutures prevent the muscle from retracting when cut.

Fig. 240.—Perthes' Incision.—The flap represented in Fig. 239 has been raised and drawn outwards over the costal arch. The intercostal nerves which enter the deep aspect of the rectus muscle have been exposed. The dotted black line indicates the direction of the incision in the posterior wall of the rectus sheath and the peritoneum; it runs parallel to the costal margin from the upper to the outer angle of the wound.

5. Kehr's incision, which is favoured by many German and other Continental surgeons, traverses the upper part of the linea alba; it then extends through the rectus muscle and its sheath somewhat obliquely about half-way between the ensiform cartilage and the umbilicus, and is finally continued downwards for a short distance in the direction of the right semilunar line. It undoubtedly affords the fullest possible access to the region of the gall-bladder and common bile duct, but it is unnecessary in the majority of cases and does not appear to possess any obvious advantages over Mayo Robson's incision described above.

6. Perthes' incision commences just below the ensiform cartilage and is directed vertically about ¾ inch to the right of the middle line. Having reached a point

immediately to the outer side of the umbilicus, the incision is continued outwards and slightly upwards towards the costal margin. The anterior rectus sheath is opened in a line corresponding with the vertical limb of the incision. The inner border of the rectus is defined, and the index finger is passed between the deep aspect of the muscle and the posterior wall of the sheath at the level of the horizontal skin incision (Fig. 239). Two rows of interrupted sutures are now passed along the line of the horizontal incision, about ½ inch apart; they connect the anterior rectus sheath with the subjacent muscle. The rectus sheath is divided between the two rows of sutures which prevent it from retracting. The angular flap, consisting of the superficial tissues, the anterior rectus sheath, and the underlying rectus muscle, is reflected outwards over the costal arch and, as this is being done, the intercostal nerves which enter the deep aspect of the muscle are exposed (Fig. 240).

The abdomen is opened by dividing the posterior rectus sheath and the peritoneum along an oblique line to the inner side of the nerves and parallel to the costal margin from the upper to the outer angle of the wound.

Should freer access be required, the horizontal limb of the incision may be prolonged still further outwards, and the muscular layers divided parallel to the long axis of their fibres.

This method of incision of the abdominal parietes possesses the following advantages:—(1) There is no resulting paralysis of the rectus muscle as the nerves are carefully safeguarded; (2) the mode of incision adopted for the posterior rectus sheath enables the stomach and intestines to be kept away more easily from the field of operation by packing with compresses than in the incisions of Kocher and Kehr; (3) there is but slight risk of hernia as the sutured layers of the abdominal wall do not lie directly over each other. If a drain is necessary it is brought out at the upper or outer angle of the wound.

The divided margins of the rectus muscle are brought together by deep sutures of catgut which include the overlying sheath; they also grasp the horizontal sutures in the rectus sheath. Before they are tied the margins of the sheath are connected by a continuous catgut suture, which ensures a more accurate degree of apposition.

The vertical section of the rectus sheath is likewise closed by a continuous suture of catgut. This method of approach to the biliary passages has been warmly advocated by Mr. H. M. W. Gray, of Aberdeen, to whose account of it in the *British Journal of Surgery*, October, 1913, I am indebted for the above description.

Many of those who require surgical treatment for gall-stones are women beyond middle age with a tendency to obesity which is often very marked. In such individuals the thickness of the abdominal wall is considerable and it increases to a very marked degree the difficulties attending the intra-abdominal procedures. This difficulty may be largely overcome by making the incision in the skin and subcutaneous fat very free. This enables the wound margins to fall widely apart, and the incision of the deeper muscular and aponeurotic strata, on which the stability of the abdominal wall mainly depends, need not be more extensive than usual.

TROPICAL ABSCESS OF THE LIVER.

HEPATOTOMY.

Preliminary Considerations. The variety of liver abscess which is usually treated by surgical measures is that known as the *solitary* or *tropical*. It appears to have a close connection with dysentery, and is probably dysenteric in character. This for-

of abscess usually originates within the right lobe of the liver, and at first is situated deeply. As it increases in size it causes progressive destruction of the liver tissue and considerable enlargement of the organ, which may be of a fairly uniform character or distinctly limited to a certain area.

The enlarging abscess tends to make its way to the surface, and may seriously complicate matters by rupturing into some neighbouring viscus or cavity. Extension towards the convex aspect of the liver will be indicated by symptoms of diaphragmatic pleurisy, viz., severe pain and friction sounds. There will be an increase in the area of liver dulness, and there may be a distinct bulging of the lower ribs. Should the abscess make its way through the diaphragm it may reach the pleural cavity and set up a diffuse and probably fatal pleurisy. As a rule this complication is prevented by adhesions between the lung and diaphragm. The abscess will then invade the lung and rupture into one of the bronchi, its contents being expectorated, but if the pus is copious in amount it may cause suffocation.

When the abscess extends in a downward direction it may rupture into the peritoneal cavity or, guided by adhesions, it may discharge into one of the hollow viscera, such as the stomach, duodenum, or the colon. Liver abscesses have been known to reach the surface by pointing between the ribs, or through the anterior abdominal wall.

An examination of the hepatic area with X-rays may afford valuable diagnostic help with regard to the site and extent of the abscess. The usual procedure for ascertaining the site of the abscess is an exploratory puncture with a needle of suitable size. It may be necessary to introduce the needle several times before the pus is reached.

The operative approach to the abscess will depend upon its site. Should it tend to make its way forward towards the anterior abdominal wall an incision below the costal arch on the right side will be employed. It occasionally happens that an abscess in the right lobe approaches the surface further back and low down. In such cases the best incision is one below the twelfth rib in the lumbar region. An abscess in the left lobe approaching the surface will be reached by a vertical incision in the epigastrium.

When the abscess increases mainly in an upward direction its evacuation will be accomplished most satisfactorily by the transpleural route. In these cases the base of the right lung is displaced upwards, and the enlarged liver comes to lie in close contact externally with the chest wall in the right hypochondrium, and may even cause the side to bulge. The vertical depth of the costo-diaphragmatic recess of the pleura is increased by the elevation of the lung, and the costal and diaphragmatic layers of the pleura lie in contact over an unusually wide area.

EVACUATION OF THE ABSCESS BY THE ABDOMINAL ROUTE.—The abdomen having been opened and the liver clearly exposed, it will be possible by palpation and inspection to determine the seat of the abscess. This part of the liver may present a distinct elevation, and its consistency on palpation may be much less resistant than that of the surrounding liver. If the abscess does not reveal itself in this way, in consequence of its being more deeply seated within the liver, the exploratory needle will be of service. Should pus be evacuated by the needle the latter must be allowed to remain *in situ* as a guide to the cavity. Before taking any steps to evacuate the abscess contents the usual precaution of packing off the surrounding districts of the peritoneum with long strips of folded gauze rinsed out of hot saline solution must be observed. The wound margin also will be protected by gauze as far as possible.

If the ...cess lies near the surface of the liver its wall may be incised with a sharp-pointe... ...apel, and as the contents escape the surgeon introduces his left index finger in... ...cavity and gently draws the liver towards the abdominal wound.

When the abscess is situated more deeply the exploring needle employed to locate its position will serve as a useful guide. A pair of sinus forceps with closed blades may be passed along the needle and the blades opened as it is withdrawn. A blunt dissector may effect the same purpose, or the path leading to the abscess may be further dilated with the index finger of the surgeon. By adopting such measures there is

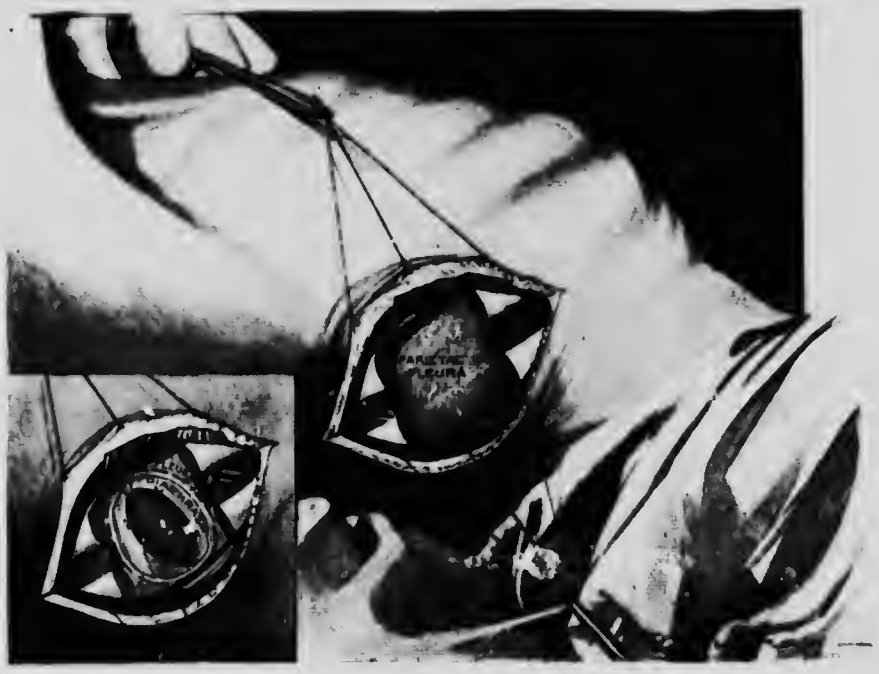

FIG. 241.—Transpleural Hepatotomy. Portions of the eighth and ninth ribs have been resected in front of the posterior axillary line, and the parietal layer of the pleura has been exposed. In the inset figure, the parietal and diaphragmatic layers of the pleura have been connected by suture in order to shut off the pleural cavity. The diaphragm has been incised and the liver exposed.

little risk of wounding any blood vessels of importance. A deep incision into the liver substance with a scalpel would be likely to wound some large veins, with resulting sharp hæmorrhage. The division of the liver tissue by the cautery has been recommended with the intention of preventing bleeding, but it cannot be regarded as of much use for this purpose, as it would probably fail to prevent bleeding from vessels of considerable size. If the bleeding is at all free it may be controlled temporarily by the pressure of the finger in the wound. Gauze pressure may be employed or deep sutures of catgut.

In dealing with these abscesses it is usual to suture the liver to the abdominal wall, and this may be done either before the abscess is opened or after its contents have been evacuated. The preliminary suturing of the liver to the parietal peritoneum

has the disadvantage of narrowing the operative field, and it is not necessary seeing that the peritoneal cavity is protected by gauze packing.

When there is a direct passage from the surface into the abscess cavity, suturing of the liver to the parietes is scarcely necessary, as the abdominal cavity will be protected by the gauze; the liver lies in contact with the abdominal wall and the tube provides a free exit for the pus. When the abscess points on the under-surface of the liver the surgeon must rely on gauze packing to protect the adjoining peritoneum. In such cases the great omentum will furnish a useful protection, as it readily contracts adhesions around the tube and helps to encapsulate the area of infection.

EVACUATION OF THE ABSCESS BY THE TRANSPLEURAL ROUTE. The selection of this route will depend upon the physical signs and upon the result of exploration with the aspirating needle. The usual site selected for the exploration is one of the lower intercostal spaces in the axillary or scapular line. The needle is introduced in the direction of the supposed abscess and the effect of aspiration is noted. If no pus flows the needle is pushed in further and aspiration again attempted. It may be necessary to introduce the needle more deeply still or withdraw it completely and explore in another direction.

An incision is made about 4 inches in length in the long axis of the eighth or ninth rib in front of the posterior axillary line. The selected rib is cleared of its investing structures, including the periosteum, and a piece about 2 inches in length is removed by means of sharp-cutting rib shears. The incision is now extended more deeply by dividing the tissues forming the bed of the rib from one bone section to the other, viz., the parietal and diaphragmatic layers of the pleura.

Assuming that the pleural recess is obliterated by adhesions the diaphragm is divided, and the incision finally is carried through the cortical portion of the liver which forms the outer wall of the abscess. As a precautionary measure, in the absence of pleural adhesions, the cut edge of the diaphragm along the upper margin of the wound may be sutured to the cut edge of the parietal pleura and the more superficial tissues.

A large drainage tube is introduced; its lumen should have a diameter of not less than ¾ inch. It is sometimes useful to introduce two tubes side by side; their length should just suffice to permit them to enter the abscess cavity, and their outer extremities are connected to the parietal tissues by sutures of silkworm gut.

Some surgeons recommend flushing of the abscess cavity and loose packing with iodoform gauze, but we do not consider these measures necessary. The wound is protected with a large absorbent and antiseptic dressing, and if the abscess is of large extent this will require to be changed several times during the first twenty-four hours.

COMMENTS.

Aspiration.—Treatment of liver abscesses by aspiration or by means of a trocar and cannula, followed by drainage through the cannula or by means of a tube introduced within the cannula while it remains *in situ*, is not to be recommended.

A possible indication for aspiration would be inability on the part of the patient to undergo the open operation.

Multiple Abscesses.—The frequency with which more than one abscess is present is difficult to estimate. Different authorities vary very much in their views on this subject.

Zancarol has given the percentage of multiple abscesses as 40 per cent.; Legrand as 20 per cent. The prognosis is unfavourable in these cases.

Sepsis. The purulent contents of tropical abscesses are usually sterile, but after operation pyogenic organisms may gain entrance and cause serious if not fatal consequences.

Careful measures should be taken, therefore, to prevent septic infection in the evacuation of the abscesses and in their subsequent treatment.

Results of Operative Treatment. The mortality in cases of tropical liver abscess submitted to treatment may be regarded as approximately 30 per cent. The prognosis will depend mainly upon the amount of liver substance engaged, the duration of the abscess, and the previous health of the patient.

OPERATIONS UPON THE BILIARY PASSAGES.

Attitude of the Patient. Access to the biliary tract is enormously facilitated by placing a sand-bag or pneumatic cylinder behind the lower dorsal segment of the spine, and if at the same time the head and shoulders are raised somewhat higher than the feet it will be found highly advantageous. Some modern operating tables are provided with a ratchet adjustment, which enables them to be bent at the centre so as to form a double inclined plane over which the body may be arched.

CHOLECYSTOSTOMY.

In this procedure the gall-bladder is exposed and its contents evacuated. A drainage tube is then introduced into its cavity and allowed to remain *in situ* for some days, the exact period varying in different cases.

Indications. The indications for this operation have been well summarised by Mayo Robson as follows:—(1) In operating for gall-stones in the gall-bladder when it has sufficient capacity to permit of drainage and is otherwise not seriously damaged. (2) In operating for gall-stones in the cystic duct, if the duct is free from ulceration and no stricture is present. (3) In operating for gall-stones in the common duct after the removal of the concretions by choledochotomy, if the gall-bladder is not seriously diseased and the cystic duct is patent and not ulcerated. (4) In simple empyema of the gall-bladder when the walls of the gall-bladder are not seriously damaged. (5) In hydrops of the gall-bladder, if the gall-bladder is only of moderate size, if the obstructing cause be capable of removal, and if the cystic duct is not ulcerated or strictured. (6) In certain cases of jaundice due to inflammation of the head of the pancreas compressing the bile duct, where it is not considered necessary or advisable to perform cholecystenterostomy. (7) In cancer of the common duct or of the head of the pancreas obstructing the common duct and setting up jaundice it may occasionally be justifiable to perform cholecystostomy for temporary relief. (8) In rupture or perforation of the biliary passages from injury or disease cholecystostomy may be advisable along with other remedial measures. (9) In gangrene of the gall-bladder or phlegmonous cholecystitis, but only when the patient is so extremely ill that no other operation can be attempted. (10) In infective inflammations of the gall-bladder as in typhoid fever.

The Operation.—*Preliminary Measures.* The patient will have been put through the usual course preparatory to operative procedures generally. It is an advantage to place the individual on the operation table with the support behind the spine before the anæsthesia is administered: this conduces much to the patient's comfort, and there is less likelihood of troublesome backache afterwards.

The Abdominal Incision is directed vertically just within the outer rectus margin

FIG. 242. Cholecystostomy. Method of introducing a drainage tube into the gall-bladder. The tube has been introduced within the cavity of the gall-bladder for a short distance and connected with its sero-muscular layer at one side of the aperture with a suture of fine catgut. Some Lembert sutures have been passed on each side of the tube.

in the manner described above, and if necessary a second incision may be carried from its upper extremity towards the infrasternal angle as recommended by Mayo Robson. Perthes' incision, which has been fully described above, will be found a very useful alternative. Bleeding vessels are seized with forceps and those which spurt are ligatured with fine catgut. Sterile cloths are arranged around the wound so as to cover and protect the raw tissues. They may be retained *in situ* by special forceps, of which the type devised by Moynihan is very suitable, or by a few temporary sutures of silkworm gut.

Examination of the Biliary Tract.—The subhepatic area is now exposed, and in the absence of adhesions the gall-bladder and the surrounding structures may be readily identified.

The gall-bladder is first examined, and the surgeon takes note of its size, its colour, the tension of its walls, and whether palpation reveals one or several concretions in its interior. By raising the liver and rotating it on an imaginary transverse axis the cystic duct will be rendered accessible. It is carefully examined by palpation, and on following it downwards the left index finger will enter the foramen of Winslow and may be passed through the aperture into the lesser peritoneal sac. The supraduodenal stage of the common bile duct is immediately in front of the finger, and as calculi in the duct are usually within this segment their presence will be readily ascertained. Should a concretion have reached the lower or retroduodenal segment of the duct and be retained here it will be recognised most certainly by seizing the second or descending stage of the duodenum between the finger and thumb and palpating successive portions of the bowel from above downwards in the direction of the bile papilla. When adhesions are present the difficulties are enormously increased. If recent they may be gently broken down by means of a dry muslin swab folded round the finger, but if of long standing a careful dissection will be necessary. It should be remembered that an adherent gall-bladder may have established a fistulous communication with the intestine or stomach, and if such should be revealed prompt measures must be taken to close the intestinal or gastric aperture after the gall-bladder has been detached. With patience and care adhesions which at first appear formidable may often be separated and good access provided either to the gall-bladder or the common duct.

FIG. 243. Cholecystostomy. A rubber drainage tube has been fixed in the gall-bladder and the aperture in the latter has been securely closed all round the tube by means of some invaginating sutures passed after the method of Lembert (see Fig. 242). Two of the sutures in the gall-bladder have been made to traverse the deeper tissues of the abdominal wound, one above and one below the tube. The closure of the abdominal wound is effected in layers. (See Figs. 125, 126.)

Evacuation of the Contents of the Gall-bladder.—As the bile within the gall-bladder is infected in cases of cholecystitis every effort must be made to prevent contamination of the peritoneum. Before evacuating the gall-bladder contents some pads or swabs of muslin rinsed out of hot sterile salt solution are packed carefully around the gall-bladder so as to reach into the hepato-renal recess, over the pyloric segment of the stomach and the right extremity of the transverse colon with its attached omentum.

These swabs or pads must not be disturbed until the termination of the operation. Some additional swabs of sterilised muslin are packed all round the gall-bladder, and its contained bile is drained off by means of a trocar and cannula, the puncture being made at or close to the most prominent part of the fundus. The escaping bile is allowed to flow into a small cup or other suitable receptacle. An incision is next made through the wall of the gall-bladder at the site of the puncture, and through it the calculi are extracted. In doing so a blunt gall-stone scoop is employed and gently manipulated, as the lining mucous membrane of the gall-bladder is soft and friable and bleeds freely if injured. When all the calculi have apparently been removed by the scoop the surgeon should pass his index finger along the exterior of the gall-bladder towards the cystic duct to make certain that no stone is lodged there. If

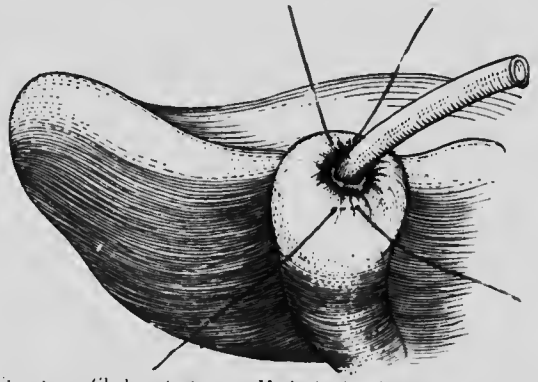

FIG. 244. Cholecystostomy. Method of fixing a tube in the gall-bladder. The tube has been first secured in the aperture by a suture of fine catgut, and a purse-string suture has been passed circularly through the serous and muscular layers of the gall-bladder about ½ inch away from the aperture. By depressing the tube, the margins of the latter are invaginated, and the purse-string suture when drawn tight brings the serous surfaces all round into contact with the tube as represented in the figure. The sutures above and below the tube do not enter the lumen of the gall-bladder; they serve to connect the latter with the deepest stratum of the abdominal wall.

one should be felt it can, as a rule, be dislodged by a little pressure and extracted from the gall-bladder. A large flexible probe should be passed into the gall-bladder, and if possible along the cystic duct into the common duct, in order to guard against the possibility of any stone being left behind.

Drainage of the Gall-bladder is imperative in all cases of calculous or infective cholecystitis. The procedure termed "ideal cholecystotomy," in which the gall-bladder is sutured after the extraction of its contained calculi, has rightly been abandoned in favour of cholecystostomy with drainage.

A piece of red rubber tubing is selected with a diameter of about ⅓ inch and a lumen of ¼ inch. Its wall will require to be sufficiently rigid to prevent any possibility of its collapse. The tube is passed into the cavity of the gall-bladder for about an inch and secured to the margin of the aperture by a suture of fine catgut. This suture traverses the tube and the sero-muscular tissues of the gall-bladder; it should not traverse the mucous membrane. Under ordinary conditions it will serve to retain the tube *in situ* for a week or ten days; being absorbable, it will gradually undergo

softening and solution, so that the tube will become free and may be removed. Fl margins of the aperture around the tube are approximated by a few interrupte sutures of catgut introduced by Lembert's method (Fig. 242), or if preferred th aperture may be closed around the tube by means of a purse-string suture represented in Fig. 244.

Suture of the Gall-bladder to the Abdominal Parietes.—With the tube secured the gall-bladder in the manner just described two courses are open: the gall-bladd with its tube carefully retained by suture to prevent leakage may be allowed to recec within the abdomen, the free end of the tube being brought out through the abdomin wound, or the gall-bladder may be connected by sutures with the deeper strata of th abdominal wall. When feasible we prefer this latter method, and it is carried ou as represented in Fig. 243. A couple of sutures of catgut are introduced one abov and one below the point of emergence of the tube. These sutures do not enter th lumen of the gall-bladder; they take up its serous and muscular layers only. Befo the gall-bladder is sutured to the parietal peritoneum and the deeper layer of the rectu sheath it is carefully wiped with a swab soaked in saline solution and all the protectiv pads are removed from within the abdomen.

Closure of the Abdominal Wound.—This is effected in the usual manner by mean of two lines of continuous catgut suture supplemented by some interrupted sutur of silkworm gut. The first line of suture traverses the peritoneum and the deep layer of the rectus sheath, the second the superficial layer of the sheath, while a thir row approximates the skin and the subcutaneous tissues. The interrupted sutur of silkworm gut should traverse all the parietal tissues with the exception of the per toneum. The adjustment of the skin margins is accomplished very satisfactori by means of Michel's metallic clips.

Drainage.—The rubber tube issuing from the gall-bladder is connected by means a short piece of glass tubing with another tube which conveys the bile to a suitabl receptacle beside the bed.

Dressing of the Wound.—The wound is rendered dry and wiped over with son muslin soaked in a solution of biniodide of mercury in spirit. Finally it is painte with tincture of iodine and a light, dry dressing is applied and secured either wi a binder or a many-tailed flannelette bandage.

CHOLECYSTECTOMY.

Indications.—Resection of the gall-bladder may be undertaken in the followi conditions:—(1) Cancer or other growth, such as sarcoma or endothelioma, assumi that the disease is local and of limited extent. (2) Contraction and distortion of th gall-bladder following repeated attacks of cholecystitis. (3) Dilatation of the ga bladder following obstruction in the cystic duct brought about by a cicatricia stricture or impaction of a gall-stone where it may be assumed that the ulcerati caused by the stone would ultimately lead to stricture were the stone merely remove (4) Phlegmonous or gangrenous cholecystitis. (5) Ulcerative perforation of the ga bladder. (6) Empyema of the gall-bladder. (7) A mucous fistula of the gall-bladd the result of stricture or calculous obstruction of the cystic duct. (8) Gunshot injuri

Cases will be encountered from time to time in which the surgeon may have di culty in deciding for or against cholecystectomy. If it is likely that the disea gall-bladder may regain its normal condition it should be spared. In the presen of an associated chronic pancreatitis the gall-bladder should be preserved in view

the possible necessity later on of drainage of the biliary tract. Furthermore, the surgeon must always consider the resisting power and general condition of his patient before proceeding to remove the gall-bladder, even though the indications for its

FIG. 245.—Cholecystectomy. The abdomen has been opened by Mayo Robson's incision and the liver raised and rotated as much as possible. The gall-bladder has been grasped by an assistant. A muslin swab, such as that represented in the figure, adds much to the security of the grip. The peritoneum over the cystic duct has been incised, and the duct has been seized near its junction with the common bile duct by two pairs of forceps.

removal may appear clear and definite. The less severe procedure of cholecystostomy may help to tide the patient over a critical period.

The Operation.—*Preliminary Measures, etc.*—These differ in no way from what have been described under the heading of "Cholecystostomy." The attitude of the patient is the same and the abdomen is opened by Mayo Robson's incision. The gall-bladder and its surroundings are carefully examined; adhesions, if present, are separated and the liver is rotated upwards.

Resection of the Gall-bladder.—The liver, protected by a sterile muslin swab, held by an assistant and its deep surface, if the degree of rotation has been adequat is directed forwards and faces the surgeon. Some pads rinsed out of hot sterile sa

FIG. 246.—Cholecystectomy. The cystic duct has been divided and its proximal extremity occluded by a ligature of catgut. The cystic artery also has been ligatured and divided. This figure represents the manner in which the gall-bladder is detached. The peritoneum is undermined on each side and divided by successive snips of scissors until the fundus is reached.

solution are packed within the subhepatic area so as to surround the gall-bladd and absorb any of its contents that may escape.

The gall-bladder may be detached from the liver in one or other of two ways, viz by commencing at its rounded extremity or fundus and proceeding towards the cyst duct, or *vice versâ*. We usually prefer the latter alternative.

With the liver held up the cystic duct is defined and at a point about ½ inch fro the common duct its peritoneal covering is divided circumferentially and a cuff the membrane is stripped backwards towards the common duct. The stripp

portion of the duct is seized by two pairs of curved forceps, and the portion between them is divided with scissors, or better still with the cautery (Fig. 246). The stump of the cystic duct is ligatured with fine catgut and the forceps grasping it are removed.

If possible the cystic artery and vein are now exposed, divided between forceps, and the central ends ligatured. They will be found above and slightly to the inner side of the ligatured duct, and may be recognised by sponging the deep part of the wound dry and stripping back the tissues where the cystic duct joins the common bile duct (Fig. 246).

The detachment of the gall-bladder is now undertaken, and in effecting it a strip of peritoneum is reflected from its lateral aspects and fundus. The resulting fringes of membrane should suffice to cover the raw area remaining after the gall-bladder has been removed. The separation of the gall-bladder is usually easy, and the undermining of the peritoneum at its sides may be carried out by the finger supplemented by a curved blunt dissector.

There may be some oozing of blood from the raw area of the liver left after the detachment of the gall-bladder; it can usually be arrested by means of pressure with a swab. If a distinct spouting vessel can be seen it will be secured most readily by a suture of catgut passed through the surrounding tissues with a curved intestinal needle. The peritoneal flaps are then drawn across and connected by a few sutures of catgut.

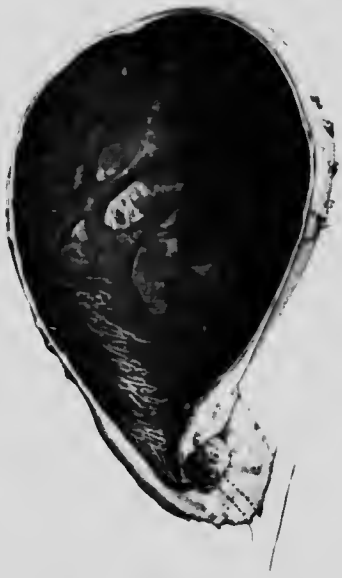

FIG. 247.—Gall-bladder removed by Cholecystectomy. In this case the gall-bladder was greatly distended and its walls hypertrophied; its contents consisted of a clear mucous fluid. A small gall stone had become impacted in the cystic duct, and the walls of the latter had undergone considerable thickening, the result of malignant disease.

If the absence of inflammatory symptoms leads the surgeon to believe that drainage of the bile ducts is not necessary the ligatured stump of the cystic duct may be covered by the peritoneal cuff which was dissected back from it previous to its division. The peritoneal covering will quickly adhere and prevent the possibility of leakage of bile in the event of the retaining ligature softening and giving way before the stump has been securely shut off by adhesions from the general cavity of the peritoneum.

Drainage of the Bile Ducts.—When inflammatory symptoms point to existing infection of the biliary tract the necessity for drainage will be obvious. Immediate drainage may be provided for by drawing forwards the stump of the cystic duct with its retaining forceps. The margins of the orifice are seized by two clips and the occluding forceps removed. As the aperture will probably be too small to admit the end of the drainage tube, it will require to be slit up for a short distance to its junction with the main duct. The tube extends within the lumen of the duct for about ¾ inch and is secured *in situ* by a suture of fine catgut which traverses the wall of the duct close to its cut edge. Another tube split longitudinally and containing a gauze wick is placed at the outer side of this and with its deep extremity reaching into the right kidney pouch. Both tubes are brought out side by side through the abdominal

wound, but if considered advisable the split tube from the kidney pouch may be brough out through a stab wound in the loin.

Should it be decided to postpone drainage for a few days the forceps on the cyst duct are replaced by a ligature of catgut, but the loose adjoining peritoneum is n sutured over the stump. A split rubber tube containing a loose wick of gauze is passe down to the stump and is retained here by a fine catgut suture which traverses th peritoneum alongside the duct. Afte three or four days the occluding ligatu will give way and bile will issue fro the tube, but by this time the tissue adjoining the tube down to the apertur in the duct will have become glue together so as to render leakag into the general peritoneal cavit impossible.

FIG. 248.—The Common Bile Duct and the chief parts concerned in the operation of Supraduodenal Choledochotomy. The principal points to be noted in this figure are, the common bile duct which has been exposed and opened at the right free margin of the gastrohepatic omentum, the pyloric segment of the stomach, the duodenum, and the right extremity of the transverse colon. The deep kidney pouch (hepato-renal recess) is seen at the right side of the duodenum.

CHOLEDOCHOTOMY.

General Considerations.—Gall within the common duct may hav migrated hence from ducts higher up o from the gall-bladder, and it woul appear that stones may increase con siderably in size after having reache this stage of the biliary tract. Some times the duct contains a solitary ston but very frequently several are present Apart from the injurious effects o these concretions in impeding the flo of bile into the duodenum they ar commonly associated with infectiv changes throughout the biliary passage (cholangitis). The bile contains suc organisms as the colon bacillus or th typhoid bacillus, and its sudden arres is frequently followed by a characteristi train of symptoms, with shivering an rigors and an intermittent type o temperature.

Gall-stones within the common duc are movable as a rule, but they ma become fixed, and when this occurs it is usually at the termination of the duct tha their progress is arrested, as this part is somewhat narrowed. Movable calculi seldom manifest their presence by obstructing the flow of bile to a sufficient extent to cause jaundice. This fact is mainly due to the highly dilatable capacity of the duct, whic enables it to expand when bile accumulates within it above a gall-stone. With thi dilatation the obstructing gall-stone finds itself loose once more and the impediment to the bile flow is arrested. In this way a gall-stone within the common duct may ac after the manner of a ball valve. The degree of dilatation which the duct attain

is often considerable; its lumen may be sufficiently capacious to admit the index finger without any forcible effort.

The condition of the gall-bladder when gall-stones are present in the common duct is deserving of note. It will probably have been affected with recurring attacks of cholecystitis, and for this reason mainly its walls will frequently be found to have contracted to an extreme degree so that its contained cavity is greatly reduced and its general outline distorted and altered. Previous attacks of pericholecystitis, too, may have resulted in adhesions between the gall-bladder and the parts with which it is normally related (see p. 392).

In consequence of the infective changes within the bile ducts and the not infrequent obstruction to the escape of bile from the lower part of the common duct into the duodenum infection may also extend along the pancreatic duct to the parenchyma of the gland. Occasionally the back flow of bile along the duct of Wirsung may determine an acute hæmorrhagic pancreatitis, but more frequently the pancreatic changes are of a decidedly chronic character and are rendered manifest by areas of induration of varying extent in the right extremity of the gland. Thus it is not uncommon when operating for gall-stones within the common duct to find such indurated areas. They have been frequently mistaken for malignant disease, and when of limited extent and nodular they may closely simulate a gall-stone impacted in the retroduodenal segment of the duct.

A brief consideration of the facts just enumerated will reveal the urgent necessity for drainage in cases requiring choledochotomy. Such drainage is the obvious treatment for the existing cholangitis and inflammatory changes affecting the pancreas.

The Operation. *Preliminary Measures: Attitude of the Patient, etc.* These details are the same as have been already described under the heading of "Cholecystostomy." If jaundice has been a symptom it will be wise to adopt treatment calculated to promote the coagulability of the blood. We usually employ normal horse serum for this purpose, giving from 10 to 20 c.c. on two or three occasions on alternate days during the week preceding the operation. Calcium lactate may also be employed.

As a rule the common duct is opened in its supraduodenal stage, as the contained concretion slips about readily and can be reached here without much difficulty. Occasionally, however, the calculus may be impacted low down, and if its dislodgment is impossible the duct will require to be incised in its retroduodenal segment. It will be necessary, therefore, to describe the procedure for each segment of the duct.

SUPRADUODENAL CHOLEDOCHOTOMY.—The abdominal incision is made as recommended by Mayo Robson. We have employed Kocher's incision in some cases and have found it useful in providing good access to the duct.

Exposure of the Common Duct.—As in other operations performed upon the biliary passages, adhesions may require division. Should such be necessary the adherent parts are detached with the precautions already given, special attention being directed to the arrest of hæmorrhage. The liver is rotated upwards as already described and held by an assistant. The duct having been defined, the calculus may be felt slipping up and down in its interior. An attempt is made to draw it towards the wound. This is sometimes comparatively easy owing to the mobility of the parts in front of the spine, especially in thin females, but on the other hand in heavy, stout individuals such an accommodating range of mobility may be wanting.

Incision of the Duct and Extraction of the Stone.—Before the extraction is attempted sterile pads or compresses wrung out of hot saline solution should be packed into the

deep recesses of the wound around the duct in order to catch any bile that may escap
and prevent the possibility of peritoneal infection.

The duct having been well defined and brought up towards the wound as far
its range of mobility will permit, is seized between the thumb and first finger of th
left hand, and while the stone is rendered prominent the duct is incised directly ov

FIG. 249.—Supraduodenal Choledochotomy. The abdomen has been opened by Mayo Robson's incision. The liver has been raised, and the fundus of the gall-bladder grasped by an assistant. The common duct has been opened and cleared.

it and its extraction accomplished. A flow of bile will now take place, and as
escapes it is immediately mopped up with swabs. An examination of the duct shoul
always be made at this stage in order to guard against the possibility of another ston
being overlooked and left behind. When the duct, as frequently happens, is dilate
this examination may be satisfactorily conducted with the index finger. A flexibl
gall-stone probe and scoop will also be found useful and should always be at hand.

Drainage.—Suture of the aperture in the duct without drainage has been successful

performed by different surgeons, but in consideration of the fact that infective cholangitis is usually present it will be more prudent to adopt drainage as a routine practice. The method of carrying this out may be either direct or indirect. In direct drainage a tube is introduced through the aperture in the duct, but in indirect drainage the duct incision is closed by suture and the tube is introduced into the gall-bladder

FIG. 250.—Supraduodenal Choledochotomy.—A rubber drainage tube has been introduced into the common bile duct and fixed *in situ*. The divided margins of the peritoneum have been drawn closely together around the tube.

assuming that its walls are sufficiently healthy and its cavity sufficiently capacious for this purpose.

When the tube is introduced into the duct it should be passed upwards for about an inch and connected to the margin of the aperture by a fine suture of catgut. As the aperture is usually too large for the tube it will require to be narrowed by a few additional sutures. These must not enter the lumen; they should pierce its outer layers only, and when they have been introduced a few more may be employed with advantage to bring together the peritoneum over the sutured duct and all round

the issuing rubber tube (Fig. 249). Seeing that leakage of bile is likely to oc
a second tube must be employed; it will be split longitudinally and will cont
a loose gauze wick. Its deep extremity is placed
the deep recess outside the common duct and
should be retained here by a suture of fine catg
this dissolves gradually, and after an interval vary
from five to ten days the tube will be found free
may be removed. The tube in the duct will proba
remain *in situ* for the same time, but when it becor
free it will be necessary to keep the track open
some days longer, and during this time the tube n
be gradually shortened.

FIG. 251.—Supraduodenal Choledochotomy. A rubber drainage tube has been introduced into the common bile duct and the margins of the aperture in the latter have been securely connected over the tube.

When the indirect method of drainage is adop
the aperture in the common duct will be closed
sutures arranged in two strata. The inner sutu
consist of catgut and traverse the walls of the d
without entering its lumen. The outer sutures
concerned in approximating the peritoneum; th
may consist of fine catgut or linen thread. The tu
in the gall-bladder is introduced and retained in
manner already described in the operation of cho
cystostomy. A second tube containing a gau
drain should be passed down so as to come into contact with the sutured duct a
convey any bile that may escape to the surface.

RETRODUODENAL CHOLEDOCHOTOMY.

This procedure will be required when the stone is so firmly impacted in the lower segment of the duct that it cannot be dislodged upwards into the supra-duodenal segment. The method by which this part of the duct may be reached has been already described in the operation of gastro-duodenostomy (p. 262), and is usually alluded to as Kocher's procedure. The duodenum is drawn forwards and the duct exposed from behind. The retained calculus serves as a guide and determines the site of incision into the duct. The extraction is followed by a careful exploration for other stones higher up. All escaping bile is carefully mopped away and the aperture in the duct sutured. Drainage of the retroperitoneal space will be necessary, and for this purpose a split tube containing a gauze drain will be introduced with its deep end in close proximity to the sutured duct and its distal end brought out through a stab wound in the loin at the outer side of the right kidney.

FIG. 252.—Duodeno-Choledochotom
for a calculus impacted in t
ampulla of Vater. The duodenu
has been opened by a vertical
cision in its anterior wall. T
mucous membrane over the i
pacted calculus has been seized wi
two pairs of tenaculum forceps a
drawn forwards in order to stea
the parts and facilitate the manip
lations attending the extraction
the calculus.

DUODENO-CHOLEDOCHOTOMY.—In this procedure the stone in the lower pa
of the common duct is approached from within the lumen of the duodenum. I
feasibility was first brought prominently into note by McBurney and Kocher. Wh
the stone is impacted very low down in the ampulla its extraction may be effect

by exposing the bile papilla within the duodenum and dividing the duct at this level (McBurney). When the stone is retained somewhat higher up the incision to remove it will traverse the posterior duodenal wall and the common duct behind this (Kocher). As the duct at this level, in the absence of adhesions, is separated from the duodenum by some loose tissue, it should be connected after the extraction of the stone with the margins of the duodenal aperture, thus establishing a choledocho-duodenal fistula. Throughout this operation of duodeno-choledochotomy fluids escaping from the duodenum should be carefully mopped away, and it may facilitate matters to clamp the bowel on the gastric side of the aperture during the intraduodenal manipulations so as to prevent fluids issuing through the pylorus from obscuring the view and flooding the wound.

Closure of the Ante'or Duodenal Incision. This is accomplished by two rows of sutures. The first sutures perforate the entire thickness of the divided intestine at each side; they serve to occlude the aperture and arrest bleeding. The outer sutures are passed continuously through the serous and muscular coats only; they serve to depress the first suture line and bring the peritoneal surfaces into contact. Should it be considered advisable to take additional precautions against leakage from the duodenum the right free margin of the great omentum may be drawn over and connected with the bowel in such a way as to overlie and protect the line of suture.

THE GENITO-URINARY TRACT.

OPERATIONS UPON THE KIDNEYS.

ANATOMY.—The kidney as it lies behind the peritoneum is surrounded by a mass of soft fat and lax fascia which allow of a limited range of movement. Under normal circumstances when the kidney is exposed by the lumbar route at an operation this up-and-down movement with respiration is very evident. Under certain conditions the range of this movement may be greatly increased both in extent and direction, and the kidney is then said to be movable or floating.

Behind, the kidney rests upon the psoas muscle and the crus of the diaphragm to the inner side and on the quadratus lumborum and the diaphragm to the outer side. The twelfth rib crosses the kidney obliquely at about the junction of its upper and middle thirds. As the left kidney lies somewhat higher than the right it usually comes into relation with the eleventh rib also.

In front, the relations of the kidney differ on the two sides. On the right, the liver above, the colon below, and the duodenum in the region of the hilum are all in contact with the gland. On the left side the stomach and spleen are in relation to the kidney above, the pancreas crosses the gland about the level of the hilum, and the colon is in contact below. The area of the anterior surface of either kidney which is covered with peritoneum varies greatly in different cases. But as a rule the greater part or whole of the kidney in contact with the liver, duodenum, pancreas, and colon has no peritoneal covering, and is only separated from these organs by a small quantity of connective tissue.

Very closely related to each kidney is the corresponding suprarenal capsule. This lies on the upper pole, and the area of contact may extend along the inner border nearly to the hilum. The only connection between the two consists of some loose areolar tissue, and they have a separate nerve and vascular supply.

The Perirenal Fascia (Fascia renalis). This is a double layer of fibrous tissu derived apparently from the retroperitoneal connective tissue, and it forms a pou in which the kidney, perirenal fat, and renal blood vessels lie along with the suprarenal gland and the upper part of the ureter. Its two layers blend with one anoth along the outer border of the kidney and above where they are firmly attached to th diaphragm, but below they remain separate and may be traced down towards the ili fossa. The posterior layer passes behind the kidney and is attached to the vertebr

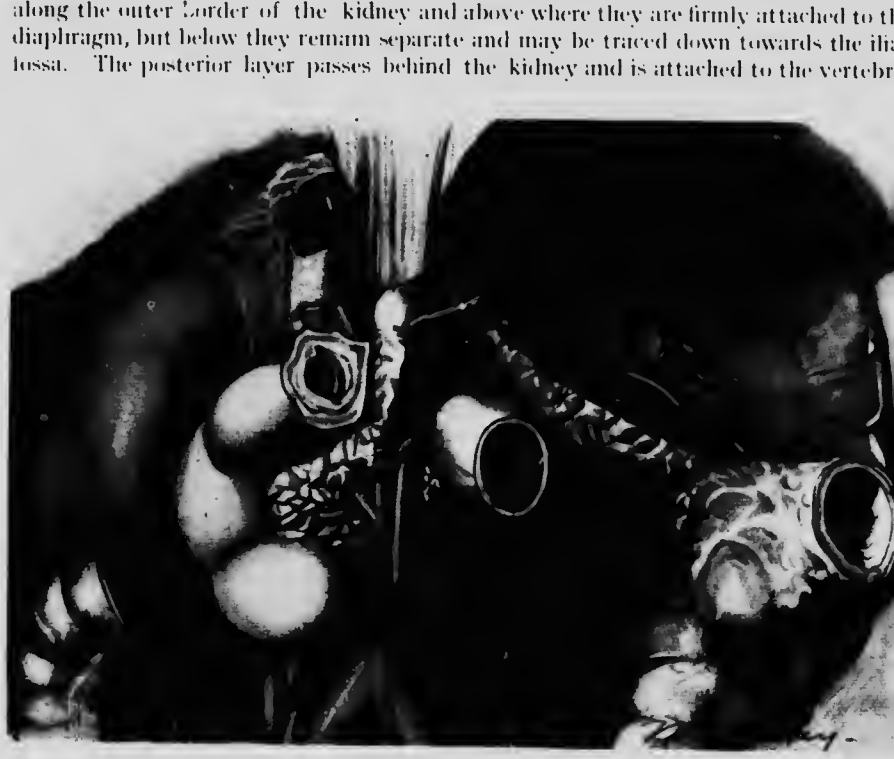

FIG. 253.—The Kidneys and the structures with which they are more immediately related. The descending or second stage of the duodenum lies in front of the right kidney opposite its hilum and in close relationship with the right renal vessels. The hepatic flexure of the colon is seen in front of the lower and outer part of the right kidney. The large area above the colon and at the outer side of the duodenum is related to the posterior aspect of the right lobe of the liver. This area is normally covered by a continuation of the upper layer of the transverse meso-colon, and it bounds the hepato-renal recess posteriorly (see Fig. 248, p. 408). The lower pole of the right kidney is clothed by peritoneum, and is related to the coils of the small intestine. The left kidney is related above its centre to the left extremity of the pancreas, and the area above this is in relationship with the posterior wall of the stomach and the spleen. Below the pancreas the left kidney is related in front and externally with the splenic flexure of the colon and more internally with the coils of the jejuno-ileum.

column along the inner border of the psoas muscle. The anterior layer passes in fron of the kidney and its vessels, and may be traced to the middle line in front of th aorta, where it blends with the corresponding layer of the opposite side (Fig. 254).

The Perirenal Fat (Capsula adiposa). This is a layer of very soft fat of a peculia primrose yellow colour which completely surrounds the kidney. It forms a thicke covering along the convex border and posterior surface of the gland than in front It insinuates itself between the vessels in the hilum and fuses with the walls of th calyces of the ureter. Below the kidney this fat forms a wedge-shaped pad betwee

the layers of the perirenal fascia. As the result of certain pathological conditions the perirenal tissues may be greatly altered in character. Disease of the kidney may give rise to a surrounding inflammation with resulting formation of dense adhesions between the perirenal tissues and the renal capsule and parenchyma, rendering the removal or exposure of the gland very difficult; or suppuration may occur in this fat, giving rise to a perinephritic abscess. Again, the perirenal fat may be greatly increased, assuming a lipomatous condition, or it may be invaded by malignant disease (cancer or sarcoma) which has originated in the kidney.

Renal Capsule (Capsula propria). This is a thin fibro-elastic membrane which

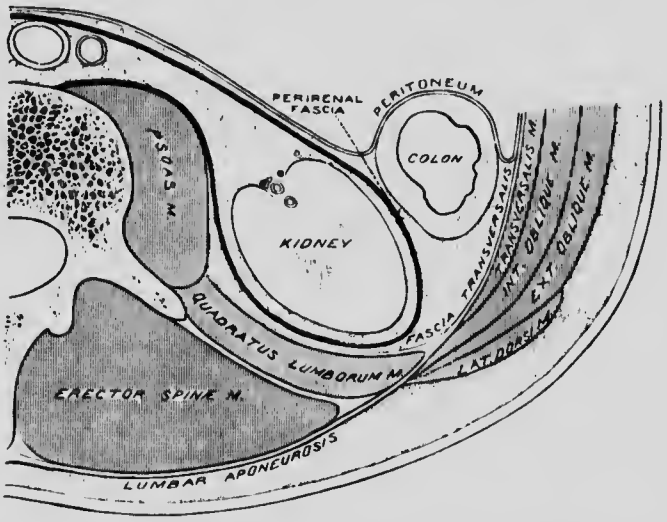

FIG. 253.—The Right Kidney in transverse section and its relationships with the Perirenal Fascia. The fascia transversalis is represented in the figure as a thin membrane investing the deep aspect of the transversalis muscle. It is in contact deeply with some fatty retroperitoneal tissue in which the posterior aspect of the ascending colon is embedded. Another membranous layer, the perirenal fascia is related to the kidney both in front and behind, but is separated from it by some very soft, medullary fat. Posteriorly the perirenal fascia extends inwards in front of the psoas muscle and obtains an attachment to the vertebral column. In front it may be traced to the middle line in front of the renal vessels, the aorta, and the inferior vena cava where it becomes continuous with the corresponding layer upon the opposite side.

closely invests the kidney and is rather loosely attached to it by delicate connective tissue and capillary blood vessels. Along the inner border of the gland it enters the pelvis of the kidney at the hilum and blends with the coats of the ureter and blood vessels. Under normal conditions it can be stripped off the renal parenchyma with great ease without tearing the kidney tissue and with no more than a slight amount of oozing, as only minute vessels are torn in the process. In pathological conditions of the kidney, *i.e.*, chronic nephritis, the attachment of the capsule to the kidney becomes firmer, so that it cannot be stripped off without considerable tearing of the gland. Normally this capsule is attached to the surrounding fatty capsule merely by a few delicate fibrous strands, and separation of the two is easily performed with practically no hæmorrhage. As a result of perinephritis, however, the two may become

fixed. Under such circumstances nephrectomy is attended by great difficulty, a as ordinarily performed it may be impossible. To overcome this difficulty *subcapsu nephrectomy* has been introduced. In this operation the renal capsule is split a stripped off the kidney with the surrounding adherent fatty tissue, and the kidney, fre from its surroundings in this manner, is then removed. The renal capsule m also be invaded by tuberculous or malignant disease which has started in the kidne

The Renal Pedicle.—The structures which form the renal pedicle are– the uret the renal blood vessels, nerves, lymphatics, and some fatty and connective tissue

The ureter as it reaches the hilum dilates, and this dilatation is called the *pel* of the ureter. It is situated behind the vessels, and as it enters the sinus of t kidney it divides into two or three large primary branches, and these again div into a large number of short, stunted secondary branches, called *calyces* or *infundibu* which are attached to the walls of the sinus.

The vessels lie in front of the ureter, the vein being usually situated anterior the artery. The walls of these vessels are surrounded by a fine plexus of nerves deriv mainly from the sympathetic system. As these vessels approach the hilum of t kidney they break up into several large branches, which then enter the hilum separat from one another by a variable amount of fat and connective tissue. In a certa proportion of cases additional or *aberrant vessels* may reach the kidney either at t hilum or at some distance from it, close to either p These aberrant vessels usually arteries, and may spring from the renal ar self or directly from the ao or one of the iliac arteries. Their presence, if u cognised, may lead to seric hæmorrhage in operations upon the kidney especially nephrectomy. They v be more fully referred to in the section on nephr ay (see p. 437). In normal ca the pedicle of the kidney is fairly elastic and resistant and will withstand a considera amount of traction, but it must be remembered that excessive pulling on the kidn in the attempt to dislodge it from its bed and deliver it into the wound may caus tearing of the renal vein or even its avulsion from the vena cava ; this latter accid is more liable to happen in the case of the right kidney. An aberrant renal art may also be torn in the same manner.

Pathological Conditions affecting the Renal Pedicle.—1. The pedicle may be grea increased in bulk from the presence of fibrous and fatty tissue surrounding the vess and ureter ; this is most likely to occur in cases of sclerosing perinephritis and tub culous disease of the kidney.

2. In cases of hydro- and pyonephrosis the pelvis of the ureter may be grea dilated and cause a great increase in the size of the pedicle.

3. In cases of enlargement of the kidney, especially when there is a new grow the pedicle may be much encroached upon and shortened.

4. In the case of a movable kidney, on the other hand, the pedicle is unusua long and loose.

The more usual Methods of dealing with the Renal Pedicle.—In certain explorat operations or in those performed for the removal of calculi it is advisable to secure compress the pedicle either with a clamp or the fingers of the surgeon or his assist in order to prevent hæmorrhage while the renal parenchyma is being incised. In operati of nephrectomy the pedicle may have to be treated by various meth according to the conditions found.

In lumbar nephrectomy the best method is to expose the ureter below the lo

pole of the kidney and divide it. Its central end then serves as a traction cord to bring the renal vessels better into view and facilitates the application of a ligature. In other cases the ureter is exposed and divided as before, but if the vessels cannot be brought sufficiently into view they may be secured by a strong clamp close to the kidney, which is then cut away. As there is now more room for working, the vessels may be isolated sufficiently to allow a ligature to be applied to them, but if this is still impossible the clamp may be left in position for three or four days and then removed. In certain cases when the kidney is exposed by the lumbar route it may be impossible to reach the pedicle. In these cases it may be necessary to remove the kidney piecemeal by morcellation, clamping and tying the vessels as they are divided.

In cases of *subcapsular nephrectomy* the capsule is peeled back over the pedicle, and a clamp is applied over it; the kidney is then cut . A circular incision is now made through the reflected capsule on the proximal side of the clamp, which may enable the pedicle to be reached and the vessels and ureter tied separately, otherwise it may be necessary to transfix the stump and tie with a double ligature, or even in some cases to leave the clamp in position for three or four days. These various methods of dealing with the pedicle are considered in fuller detail in the sections on nephrotomy and nephrectomy (see p. 433).

PREPARATORY MEASURES BEFORE OPERATIONS UPON THE KIDNEY.—Before undertaking any extensive renal operation the surgeon should not only investigate the condition of both kidneys, but he should also study carefully the general condition of the patient and attempt to modify it if necessary. The examination of the condition of the kidneys and their function has reached a high degree of perfection during the last few years by the introduction of the more general use of the urinary segregator and catheterising cystoscope. This part of the subject will be more fully considered in the section dealing with nephrectomy (see p. 428).

General Nutrition.—Very fat patients present special difficulties for operation, as the thickness of the abdominal wall and the enormous amount of fatty perirenal tissue hinder the necessary manipulations, and after operation the heart as well as the alimentary canal functionate badly, and in addition there is a special liability to the occurrence of hypostatic pneumonia (Albarran).

When possible, as in the case of aseptic calculi, it is well to try to modify the general condition of these patients by a careful diet excluding fats and carbohydrates and by ordering regular exercise and massage, since much may be accomplished by these means.

Coexisting Septic Conditions.—It is easy to understand how septic infection may have an important influence on the result of an operation. The surgeon should always try to find out the relation of the kidney trouble to such infection, so that he may modify the latter before operation if possible. In the case of a patient with a large collection of pus in the kidney the symptoms of infection can only be cured by incision and, usually, removal of the kidney. It will, however, as a rule be better not to operate immediately for disease of the kidney in a case where the septic symptoms depend on a lesion elsewhere in the body.

Digestive System.—Particular care should be paid to the state of the bowels. In some patients, especially in the case of movable kidney, the digestive troubles are caused by the kidney lesion and can only be cured by operation.

In patients who are very fat regularity of the bowels should be encouraged befo operation as there is a danger of sluggishness or even paralysis of the intestine aft operation, and a saline purge should be given on the second day.

In the case of all patients, as is the usual custom in general operations, a sali purge should be administered twenty-four or forty-eight hours before operation a a simple enema early on the morning of the operation.

Circulatory System.—It is important to discover the condition of the muscul tissue of the heart. This may be done by auscultation, by the state of the puls and the general condition of the patient.

Operation should not be performed before the action of the heart has been reg lated as far as possible by appropriate measures, *i.e.*, diet, cardiac tonics, stimulati of the renal functions, etc.

Albarran has called attention to the importance of measuring the arterial pressu and if it is found to be high, as it frequently is in renal cases, it should be reduc by suitable medical treatment.

Respiratory System.—The lungs of all patients, and more particularly those wh are elderly, should be carefully examined before operation. Hypostatic congestio favoured by the position on the back, is specially to be feared in those patients wh are the subjects of emphysema or chronic bronchitis. When possible, operati should not be performed till they are in better condition, and ether should not be use as the anæsthetic. In urgent cases the question of spinal anæsthesia may be considere These patients should be carefully protected from cold. After operation they shou be propped up in bed as much and as soon as possible, and use should be made of stim lating expectorants, and, when necessary, blisters and liniments may be applied to th chest.

Nervous System.—The most important nervous phenomena following renal oper tions manifest themselves by the symptoms of prolonged shock. In these cases use ma be made of the usual remedies, as subcutaneous injections of strychnine, caffein or camphorated oil. But most reliance must be placed on infusions of normal sal solution 300 to 500 c.cs. repeated two or three times in the day. These large injectio of saline should not be employed in the case of patients with diminished renal functio especially if there are signs of pulmonary congestion, for fear of the occurrence passive œdema of the lungs.

Renal Functions.—Certain precautions should be taken in order to hasten th return of the renal functions to normal after the operation, and to guard again a prolonged diminution of the renal secretion and reflex anuria.

Non-infected patients who eliminate an insufficient quantity of concentrated uri should be put on a strict diet before operation, and should be given diuretic waters i large quantities every morning for several days before the operation. Barley wat also may be given freely with advantage.

When the patient is passing infected urine an attempt should be made by th internal administration of antiseptics to bring it to a more healthy condition.

Before operating on the kidney, in every case that is possible, a ureteral cathet should be passed and the secretion of the two kidneys studied.

Immediate Preparation for the Operation.—The evening before operation the patie is given a saline purge.

A general cleansing of the body is effected by a warm bath, and the area of operation is disinfected as already described.

An aseptic dressing is then applied and held in place with a flannelette bandage. This dressing is left in position until the following morning, when it is removed and the entire area painted with tincture of iodine; a sterile dressing is again applied and the iodine painting is repeated when the patient has been anæsthetised. In every case the skin should be cleansed from the vertebral column to the umbilicus and from the seventh or eighth rib above to Poupart's ligament and the iliac crest below, so that the surgeon may be prepared for operative difficulties which may necessitate in the case of a lumbar incision the enlargement of the wound downwards parallel to Poupart's ligament, or upwards beyond the costo-vertebral angle.

The patient should be given a simple enema early on the morning of the operation.

Anæsthesia.—A general anæsthetic, whether ether or chloroform, has a deleterious effect on the renal functions. This is shown by a reduction in the amount of urine excreted during the first few days after operation. This may be followed by a slight polyuria, and there may be an abundant discharge of lithates for a few days; in some cases albumen and epithelial cells from the renal tubes are found in the urine. It is impossible to say to what extent these symptoms are caused by the direct shock and injury of the operation to the kidney and by the anæsthetic respectively. In view of the facts, it is advisable not to prolong the anæsthesia more than is absolutely necessary.

Spinal anæsthesia may be employed by those familiar with its use, and it is probably distinctly indicated in certain cases, especially in anuria. In the case of nervous patients morphia or omnopon may be administered subcutaneously half an hour before operation.

Hedonal has recently been employed as an anæsthetic in renal operations with satisfactory results. One great advantage which it possesses is that it is not followed by sickness or vomiting.

Antisepsis during the Operation. It is sometimes advisable to flush the open pelvis of an infected kidney with an antiseptic. Nitrate of silver, 1 part per 1,000, is efficacious and harmless. After the operation it may be advisable to flush the wound if it has been soiled by the escaping contents of a septic kidney; hydrogen peroxide is non-toxic and may be employed to advantage. Its free escape from the wound must be provided for, however, otherwise it may force septic matter into the surrounding connective tissue spaces. Other antiseptics have a harmful action on the delicate renal epithelium, and, being rapidly absorbed, may produce toxic symptoms.

OPERATIONS ON THE KIDNEY.

EXPOSURE OF THE KIDNEY.—The simplest operation that is performed on the kidney, and one which constitutes the first step in all renal operations, is exposure of the gland. Occasionally this may be done as a definite operation to confirm the presence and the healthy condition of the kidney preliminary to nephrectomy of the opposite gland. It may also be done for exploratory purposes in patients with suspected stone, injury, tumour, or other disease, in which cases it is usually followed by further operative measures.

In this operation the kidney as a rule is exposed by a lumbar incision.

EXPLORATION OF THE KIDNEY.—This is merely a further step in the op tion of exposure, the indications being those given above. After the organ has b exposed, both it and the upper end of the ureter are carefully inspected and t palpated. For a complete exploration of the kidney, however, it is necessary to in the gland freely in order to examine its substance between one finger in the inci and one on the outside, and also to examine the interior of the calyces, pelvis, upper part of the ureter.

NEPHROTOMY AND PYELOTOMY.—In these procedures incisions are m either into the renal tissue or through the wall of the pelvis of the ureter. nephrotomy the incision may be made into the renal parenchyma to relieve tens in cases of active or passive congestion; more commonly the incision is carr deeply so as to open up the calyces and pelvis of the ureter for the purpose of ploration or extraction of a stone.

NEPHROSTOMY.—In this procedure a permanent opening is made into the kidn to allow of the escape of the renal secretion. It may be performed in some cases anuria, either true anuria where the secretion of the kidney is suppressed fr increased tension within the kidney capsule, or false anuria where the secretion the kidney cannot escape in a normal manner owing to irremediable obstruct or injury to the ureter.

NEPHROLITHOTOMY means the opening of the kidney for the removal of calc The condition of the affected kidney is subject to considerable variation. In so cases the calculi are associated with advanced septic changes; in others, howev the evidence of sepsis may be insignificant or absent.

NEPHRECTOMY means the removal of the kidney, and may be partial or comple According to the route selected for reaching the gland the terms anterior or *abdomi* and posterior or *lumbar* nephrectomy are employed.

NEPHROPEXY means the fixation of a movable kidney after it has been restor to its normal site.

MEANS OF ACCESS IN OPERATIONS ON THE KIDNEY.—As the kidn lies behind the peritoneum it may be reached either by an *extraperitoneal* or a *tra peritoneal* incision. If the extraperitoneal route is chosen the incision may be made the lumbar region or in the lateral abdominal region; in the latter case the peritone when reached is stripped forwards off the posterior abdominal wall, its division bei carefully avoided; this is sometimes called the *paraperitoneal* method. If t transperitoneal route is chosen the incision may be made either in the middle li or at the outer border of the rectus muscle, viz., in the linea semilunaris (Langenbuch operation).

As the lumbar route gives sufficient room to practise with ease almost all the nece sary operations, and as all published statistics show that it is much safer than t abdominal route, it is natural that in the great majority of cases this method of approac is chosen. The fact that in a very large proportion of cases the surgeon has to opera on a kidney which is already infected is a further important consideration in negativi a transperitoneal incision. The advocates of the abdominal route at one time claim that by this means the two kidneys could be palpated and that in this way defini evidence of the existence and condition of the second kidney could be obtained. T

amount of information, however, that can be gained regarding the functional or even structural condition of a kidney by the hand passed through an abdominal incision is practically useless and often misleading. Besides, the clinical methods employed at the present day will in most cases furnish evidence that the other kidney exists, and will also give reliable information as to the functional value of each gland.

The chief indications for the *transperitoneal* operation are those comparatively rare cases where owing to the large size of the tumour, usually a neoplasm, it cannot be delivered through a lumbar wound, and possibly some few cases where adhesions are so dense that it may be found practically impossible to enucleate the kidney by the lumbar route. The difficulty here may be overcome by doing a combined abdominal and lumbar operation. This procedure will allow of the vessels being ligatured at an early stage through the abdominal incision, and the consequent freedom from hæmorrhage will greatly facilitate the further steps of the operation.

The transperitoneal route should also be chosen in certain cases of injury where hæmorrhage into the peritoneal cavity is occurring, or where it is doubtful if some other intra-abdominal organ is injured as well as the kidney. The advantages claimed for the lateral abdominal or paraperitoneal route over the lumbar are alluded to more fully in a subsequent section (p. 429).

EXPOSURE AND EXPLORATION OF THE KIDNEY BY THE LUMBAR ROUTE FOLLOWED, IF NECESSARY, BY PYELOTOMY AND NEPHROTOMY.

Indications. The chief conditions for which exploration of the kidney may be required are the following:—(1) To determine the presence and condition of the opposite kidney before a nephrectomy. This, however, is rarely necessary at the present day owing to the improved methods available for determining the functional capacity of each kidney separately. (2) In cases of trauma with grave renal symptoms. (3) In cases of anuria unrelieved by medical means. (4) To confirm the diagnosis in cases of suspected (*a*) malignant disease or (*b*) tuberculous disease. (5) for the relief of tension in cases of passive or active hyperæmia, or subcapsular extravasation of blood.

This operation is justified by the following symptoms: persistent or frequent hæmaturia or pyuria of renal origin, especially if blood or pus has been proved by the cystoscope or urinary segregator to be unilateral; frequent attacks of renal colic or persistent one-sided renal pain, associated or not with hæmaturia or pyuria, where the X-rays or ureteral catheter have failed to show the presence of a calculus in the kidney or ureter; when frequent micturition and pain in one renal region without evidence of disease of the bladder raise a suspicion of tuberculosis of the kidney even in the absence of more definite symptoms.

Instruments required in Renal Operations. Two knives; two pairs of scissors, straight and curved; two pairs of dissecting forceps; two or three dozen clip forceps; two renal pedicle clamps; one grooved director; two broad retractors; one aneurysm needle; large fully curved and straight needles; ureteral catheter and bougie; drainage tubes of various sizes.

Position of the Patient. The patient may be placed prone or, more usually, on the side with a support between the ribs and the pelvis, viz., an air-pillow or, still

better, a pillow with three separate air-chambers. The latter is better than a sand-
or other hard pillow, as it fits better into the loin, and while giving the maxim
room between the last rib and the iliac crest on the side to be operated upon it does
strain or bruise the muscles on the healthy side as hard pillows are liable to
In order to make the position more stable the arm on the dependent side is brou
behind the patient, and the shoulder is allowed to rest on a small firm pillow
sand-bag. The leg on the dependent side should be straight and the other flexed
both knee and hip.

Position of the Operator and Assistants. The operator may stand on either s
according to preference, but usually he stands behind the patient, cutting from ab

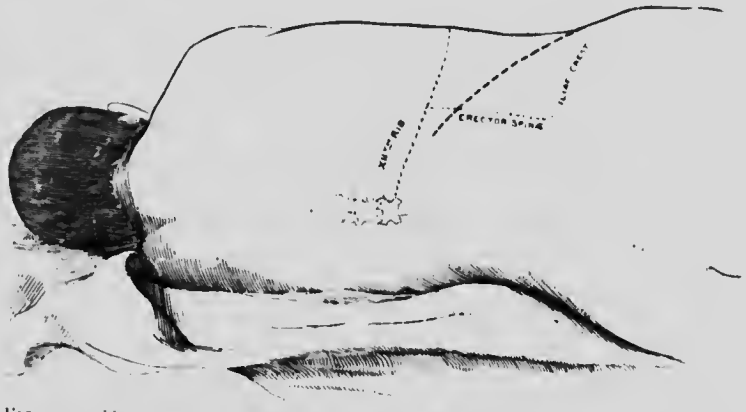

FIG. 255.—The attitude of the patient in operations upon the kidney by the posterior or lumbar route. The line of incision is represented by the heavy dotted line which is directed diagonally across the ilio-costal interval. The twelfth rib above and the iliac crest below are represented in outline. The faint dotted line extending forwards horizontally from the first lumbar vertebra and below the vertebral extremity of the twelfth rib represents the lower line of reflection of the pleura.

downwards on the right side and from below up on the left. One assistant shou
stand opposite the surgeon and a second, if available, on either side as may be require

Landmarks. Before making the incision the following landmarks or boundari
of the ilio-costal space should be carefully recognised :—(*a*) The outer border of t
erector spinæ muscle. This can usually be seen, and can certainly be felt, even in f
patients, parallel to the middle line, and about a hand's breadth from it. (*b*) T
crest of the ilium below can be easily seen or felt. (*c*) The twelfth rib bounds t
space above, and it is most important to make certain that the last rib felt
the twelfth, as if the eleventh is mistaken for it there is grave danger of openi
the pleura. It is a wise precaution to always count the ribs from above downward
commencing at the second costal cartilage at its junction with the sternum.

Stages of the Operation.—*The Incision.*—The incision commences over t
twelfth rib where it is met by the outer border of the erector spinæ muscle; it
carried obliquely downwards and forwards a finger's breadth above the highe
point of the iliac crest to a point opposite to the anterior superior spine, or beyon
this if necessary. The length of the incision will vary with the obesity of t

patient, the space between the last rib and the iliac crest, and the nature of the contemplated operation.

After the incision has been carried through the skin and superficial fascia the muscular strata are encountered, above the latissimus dorsi and below the external oblique. When these have been divided the internal oblique and transversalis muscles and the lumbar aponeurosis are successively exposed and divided. Care is taken to avoid cutting the last dorsal nerve above and the ilio-hypogastric nerve below the line of muscle section. The vessels which accompany these nerves, if divided, are caught

Fig. 256. Exposure of the Kidney by the Lumbar Route. The incision has brought into view the strong aponeurotic sheath of the erector spinæ muscle behind, and in front of this the thin white tendon of the transversalis muscle has been exposed. The flat muscles which have been divided are represented in the figure. The latissimus dorsi and the external oblique form the first muscular stratum and their division has been followed by that of the internal oblique

by forceps. The upper angle of the incision should be extended backwards until the twelfth rib and the external arcuate ligament have been palpated, and then, guided by the finger in the wound, the section is cautiously made with scissors. The outer border of the quadratus lumborum muscle is now exposed and is readily recognised by the almost vertical direction of its fibres. In front of it in the depth of the wound is some loose fat which conceals the peritoneum. To avoid the latter the further deepening of the wound is effected far back at the outer border of the quadratus lumborum muscle, and the underlying posterior layer of the perirenal fascia is divided under cover of this muscle. The finger is introduced through the small aperture thus made and through the perirenal fat, which is soft and friable, and the kidney is recognised. The retrorenal fascia is now divided in the whole length of the incision, and with the

two index fingers drawing the margin of the aperture forwards the lower pole of t
kidney is exposed to view.

Delivery of the Kidney into the Wound. If the kidney is very movable the difficul
in securing it may be overcome by getting the assistant to press back the anter
abdominal wall under the costal arch. Having found the kidney, the fat and retr
renal fascia in front of the opening are caught with forceps, and the fatty tissue
separated from the kidney. In the absence of perirenal adhesions the kidney and
two poles are readily cleared with the finger. Gross alterations and disease of the gla

FIG. 257. Exposure of the Kidney b[illegible] umbar Route. The transversalis tendon, which is represente[illegible]. Fig. 250 has been divided in the direction of the long axis of th[illegible]ound and the fascia transversalis has been exposed. The outer [illegible]order of the quadratus lumborum muscle will be observed in the depth of the wound, in front of the erector spinæ and beneath the transversalis tendon. A loop of ligature has been passed around the ilio-hypogastric nerve in order to draw it away and protect it from injury.

may now be recognised, but for a complete exploration it is necessary to strip the latte
completely, draw it out of the wound, inspect and palpate its surfaces. It may b
necessary in addition to incise it and introduce the finger into the pelvis and calyces
and to examine by sight the cut surfaces of the parenchyma. Through the ren
incision the surgeon may examine the interior of the pelvis of the ureter and catheteris
the latter.

Examination of the Exterior of the Kidney and Pelvis.—Palpation of the kidney give
very uncertain information, since even a large calculus lodged in a calyx may not b
felt. When squeezing the kidney between the fingers one part may feel firmer tha
the rest, or in the case of a kidney which has been dilated by retention, but which i

at the moment empty, the organ may feel more flabby than usual. If it is possible to bend an apparently healthy kidney on itself it is certain that it is not normal. Palpation of the pelvis often gives more certain information; a hardness may be felt that clearly indicates the presence of a stone, though it is possible to mistake for a stone the hardness due to a mass of sclerosed fat, or a covering of hard fat may obscure the presence of a stone.

Examination of the Exterior of the Ureter. The ureter will be found deep in the wound beneath the lower pole of the kidney on the psoas muscle and may be closely applied in front to the deep aspect of the peritoneum. When the ureter is found the presence of adhesions and sclerosis of the surrounding fat may afford evidence of periureteritis, or ureteritis and thickening of the wall of the ureter may be recognised as well as its distension and the presence or absence of temporary or permanent kinks at its point of implantation into the pelvis.

Compression of the Pedicle. Before proceeding to the further stages in the examination of the kidney it is necessary to compress the pedicle. This compression may be instrumental or digital. Digital compression is the better, as it can be graduated and modified as required, and it does not hinder the movements of the surgeon's finger inside the pelvis. When using a clamp it is difficult to avoid including the pelvis of the ureter with the blood vessels; this hinders its exploration and absolutely prevents retrograde catheterisation of the ureter.

Exploration of the Interior of the Kidney and Pelvis. The operator may incise the wall of the pelvis directly—*pyelotomy*—or he may reach it through an incision in the kidney—*nephrotomy*.

By pyelotomy the tip of the finger may be introduced into the pelvis and larger calyces, and by means of a probe the smaller calyces and the upper end of the ureter may be explored; retrograde catheterisation is rendered possible, and small stones may be removed. These procedures can only be carried out when the renal pedicle is long and the kidney has been brought well out of the wound.

By nephrotomy, however, the kidney, the calyces, and the pelvis, together with the upper end of the ureter, can all be thoroughly explored, the kidney being split completely in two if necessary. Experience has shown that the damage done by this free renal section is not followed by serious consequences.

Incision of the Kidney. It has been stated that the branches of the renal artery are so arranged within the substance of the kidney as to constitute two fairly distinct vascular territories and that the plane of demarcation between these does not correspond exactly to the renal convex margin, but is situated slightly posterior to this. In consequence of this it has been recommended that the exploratory incision should be made vertically, a distance of 5 millimetres from the convex border of the kidney on its posterior surface, commencing 1 inch above the junction of the middle and lower thirds of the kidney, and extending from this point downwards for about 2 inches. This incision after traversing a depth of a little more than an inch in a kidney with normal parenchyma will open the large inferior calyx. We do not lay much emphasis upon these directions for making exploratory incisions into the kidney, as a study of injected specimens of the renal blood vessels with fusible metal has convinced us that the vascular territories of the kidney are not sufficiently distinct to have any bearing upon the direction of incision into the renal tissues. In other words, it makes no appreciable difference whether the incision is made exactly along the convex margin of the kidney or some millimetres behind this. An inspection of the beautiful specimens of the injected vessels of the kidney exhibited at the International Congress of Medicine in London, August, 1913, rendered these facts quite clear.

The renal incision should be enlarged sufficiently to allow the finger to be introduced without tearing or bruising the kidney substance. The right index finger is introduced and explores the inferior calyx; it may also be directed upwards into the superior calyx. In this way the whole interior of the pelvis is explored and the kidney substance palpated between one finger inside and another outside. Should further exploration be necessary, the pedicle is still further compressed, and the incision in the kidney is enlarged, so that the organ is divided into two portions. The cut surfaces are then thoroughly inspected.

If the ureter has not already been catheterised from the bladder, a catheter should be passed down for a distance of 25 centimetres. This will ensure that the lower end of the instrument is in the bladder.

Closure of the Renal Incision. When the result of the exploration has been negative, and the urine is known to be aseptic the kidney should be sutured without drainage. If necessary a small drain should be introduced down to the pelvis. Both superficial and deep sutures are used. Deep sutures of medium catgut are passed through the cut edges of the renal capsule and in the kidney about ½ inch apart. They should take a good bite of kidney tissue, being entered about an inch from the margin of the incision and deeply so as to emerge at the deepest part of the cut, and then traversing in a similar manner the other half of the kidney. When these are all passed they are tied with a surgeon's knot, taking care not to tear the renal tissue by drawing them too tightly. Superficial sutures of finer catgut are placed between these. The compression on the pedicle is now released, and if the divided vessels have been controlled the kidney is returned to its place. Should drainage be necessary a small rubber tube is placed obliquely from above downwards, and the stitches are applied around it; these prevent haemorrhage or leakage of urine, and promote closure of the renal wound when the tube is withdrawn.

Reconstitution of the Abdominal Wall. The wound must be carefully closed to prevent the occurrence of a hernia. The divided muscles are sutured in one layer with medium catgut. In passing these sutures the nerves should not be included, otherwise there may be troublesome pain afterwards. The aponeurosis and fascia are sutured with fine catgut, and the skin edges are brought together with silkworm gut or Michel's clips. As a rule drainage will not be required.

The Dressing. The wound is lightly cleansed with a swab soaked in a spirituous solution of biniodide of mercury. It is then wiped dry and finally painted with tincture of iodine. A protective dressing of gauze and absorbent wool is secured *in situ* by a few strips of adhesive plaster. Additional layers of wool held in place by a many tailed bandage add much to the comfort of the patient.

If all goes well the Michel's clips or sutures are removed on the fifth day. If a drain has been used it can generally be removed on the second day, in which case it will not interfere with the primary healing of the wound.

COMMENTS.

Accidents connected with the Lumbar Incision: Wound of the Peritoneum. If the incision is extended too far forwards the peritoneum may be mistaken for the retrorenal fascia, and the colon, if distended with gas, may herniate into the wound and prove troublesome. Extra care must be taken not to open the peritoneum.

In cases where the liver or spleen is enlarged, especially if the kidney is at the same time displaced, either of these organs may be mistaken for the kidney and the peritoneum opened in mistake for the retrorenal fascia. This accident should be at once

recognised by the smooth glistening surface of these organs due to their peritoneal covering; their colour also is darker than that of the kidney. A coil of intestine or the omentum may appear in the wound, showing that the peritoneal cavity has been opened. If the rule of incising the retrorenal fascia far back under cover of the quadratus lumborum muscle is followed there is no danger of opening the peritoneum. If it is opened it should be closed immediately with fine catgut and the retrorenal fascia incised further back.

Wound of the Pleura is a rare accident; it will be recognised by the characteristic hissing sound caused by entrance of air into the pleural cavity. It is liable to occur if the incision is carried up beyond the angle between the last rib and the erector spinæ muscle, or while freeing adhesions around the upper pole of the kidney with a sharp instrument. Should this accident happen, the index finger of the left hand should be applied instantly over the opening and further entrance of air prevented. The tissues surrounding the aperture are caught with one or more clip forceps, and by means of ligatures or deep sutures of catgut the wound in the pleura is occluded. Usually no serious consequences result from this accident. A slight effusion may form but it is rapidly absorbed. There is, however, a danger of septic infection of the serous membrane, and the operation should not be continued until the pleural cavity has been occluded.

Difficulties in freeing the Kidney. Where there are adhesions it may be difficult or even impossible to free the kidney. The peritoneum may be torn in clearing it in front. If this accident should occur the opening must be temporarily closed with forceps and isolation of the kidney continued, the rent in the membrane being sutured subsequently.

Fallacies attending Palpation of the Kidney. Even where a large stone is present in a calyx, the consistence of the gland may feel the same throughout. There may be a prominence on the surface of the kidney, and it may appear firmer than the rest of the gland. This may be a normal pyramid, a neoplasm, or a calculus. Therefore every prominence must be incised. A hardness felt by palpating the external surface of the pelvis may be a stone or a sclerosed lobule of the fat which normally surrounds the pelvis in the hilum of the kidney. Even palpation between one finger inside the kidney and another outside may fail to reveal the presence of stones in the smaller calyces. In these cases a good skiagram is of great value in limiting the field of search.

Difficulties in Retrograde Catheterism of Ureter. Sometimes it may be difficult to feel the orifice of the ureter with the left index finger introduced into the pelvis, especially if the latter is dilated. Furthermore, the surgeon should be aware of the possibility that his assistant's fingers compressing the pedicle are hiding the opening.

Hæmorrhage. If in spite of incising the kidney along the line of separation of the vessels and compressing the pedicle the hæmorrhage is free, the operator need not fear, for it can be at once stopped by applying the two halves of the kidney to one another and pressing their surfaces together. Obvious bleeding vessels may be clipped and tied, but this is usually not necessary or advisable as it causes needless damage to the renal tissue.

If the incision has been made too deep into the hilum and one of the large vessels has been cut, it will almost certainly be necessary to perform immediate nephrectomy.

NEPHRECTOMY.

PRELIMINARY INVESTIGATION. The Estimation of the Functional Capac of the Kidneys. Before undertaking the operation nephrectomy it is absolute necessary to have an accurate knowledge of the functional value of the second kidn This may be obtained by various methods, the most important of which is the examin tion of the urine derived separately from each kidney. This separation may obtained either by the segregator or ureteral catheterisation. At the present d powerful advocates will be found for each of these methods. The advantages segregation are that it is easier to perform, requiring less expensive instruments, electrical installation, and less special knowledge and practice on the part of t operator; also it avoids the risk of infecting the second kidney, and if carefully do will, in most instances, give more correct results than can be obtained by urete catheterisation. The only disadvantage is that in some cases where the bladder infected the secretion of the kidneys is not obtained pure, being contaminated in transit through the bladder.

Urinary Segregation. The best instrument for intravesical segregation is Luy segregator. The bladder should be first washed out with sterile water or boric loti through a soft catheter. A couple of ounces of this fluid are left and the segregat is then passed fully into the bladder. While the urine is being drawn off the patie should be placed on the table in a sitting or semi-sitting position. The instr ment is then withdrawn till the junction of the stem with its curved portion is f tight up against the internal meatus, and the stem is elevated till it becomes horizonta This depresses the curved portion against the floor of the bladder. The rubber septu of the segregator is now raised by a screw movement of the handle. At first the loti escapes by either catheter a.. l then the urine, which is collected. When the instr ment is properly used the fluid escapes from each catheter exactly as it enters t bladder from the ureter, in the case of a normal kidney three or four drops at a ti followed by a slight pause.

Ureteral Catheterisation. The advantage claimed for ureteral catheterisati over segregation is that it affords more accurate results. This is probably not tr as there are many fallacies, such as blocking of the catheter, injury to the urete resulting in bleeding, stimulation of the ureter or kidney by the introduction of t catheter causing increased or diminished secretion. The ureteral catheter also collec urine from the kidney uncontaminated by secretions from the bladder, but it is in the very cases of disease of the bladder that there is the risk of infecting the ureters an kidneys by the introduction into them of catheters which have passed through t bladder. The objections are that it requires an expensive instrument, an electr installation, and considerable skill and practice; also in certain cases it may be foun impossible to introduce the catheters into the ureters, or the rapid escape of p into the bladder may cause the contained fluid to become turbid so quickly that clear view cannot be obtained, and it may be impossible, therefore, to find t ureteral openings. But the most important objection is the danger of infecting t kidney on the healthy side by carrying infection to it from the bladder.

The urine obtained from each kidney by either of these means may be tested as t its specific gravity, freezing point, and percentage of urea, as well as for abnormal co stituents, such as blood, pus, and crystals, and from the determination of these points very accurate conclusion can be drawn as to the functional value of each kidney. Th

conclusion may be made more definite by the subcutaneous injection of methylene blue or phloridzin about half an hour before the commencement of the collection of the urine. The time of appearance and amount of the excretion of the colouring material or sugar in the urine from either side is then observed.

Cryoscopy of the blood has also been recommended, but it is not of much practical use, as it is a difficult and complicated process, and even when the freezing point is determined the very most that can be decided from it is that the functional capacity of all the renal tissue present is or is not sufficient.

Pyelo-Radiography. Another method of investigation of the kidney and the ureter is that of pyelo-radiography. This procedure consists in passing a ureteral cather and injecting a suspension of colloid silver into the renal pelvis and taking a skiagram—a solution of collargol, 5 to 7 per cent., is usually employed. Such a skiagram will reveal the outline of the ureter, pelvis, and calyces, and also of the kidney itself. With this method of investigation valuable information can be obtained concerning the exact anatomical state of each kidney and ureter before operation. It renders possible the detection of the more frequent congenital malformations of the upper urinary tract, such as reduplication of the pelvis and ureters, supernumerary kidneys, the various forms of horseshoe kidney, solitary kidney, ectopic, atrophic, and cystic kidney (Kidd).

Indications for Nephrectomy. (1) Renal tuberculosis. Nephrectomy may be performed either as a primary operation or after drainage of a tuberculous pyonephrosis where a sinus persists. (2) Injury of the kidney. The more obvious conditions requiring nephrectomy are non-penetrating wounds where kidney or ureter is ruptured by a fall or a blow; if there are signs of severe hæmorrhage, or if there is persistent hæmaturia; also penetrating wounds where hæmorrhage does not yield to treatment aided by exploration and plugging, or when a urinary fistula persists. (3) Renal calculus. The cases requiring nephrectomy are mainly those where the kidney parenchyma is destroyed, where stones and sacculi are very numerous, or where the calculus is very large with several branching processes. (4) Cases of hydro- and pyonephrosis due to irremovable causes, or where as a result of these conditions the kidney is completely destroyed. (5) Cases of malignant disease and other tumours, such as sarcoma, carcinoma, hypernephroma, papilloma with persistent hæmorrhage, etc. (6) Rare cases of movable kidney. (7) Disease of the ureter, or new growth in the ureter, as a last resort. (8) Such rare conditions as hydatid or cystic disease when very large and confined to one kidney; also aneurysm of the renal artery.

Choice of Route. The kidney may be removed by any of the routes already described, and the advantages and disadvantages of the different methods of approaching the kidney have been indicated. As a rule the *lumbar* or *retroperitoneal* route should be chosen in almost all cases and the *transperitoneal route* reserved for cases of very large tumour, or cases of injury where it is thought that the peritoneal covering has been torn and that hæmorrhage is occurring into the peritoneal cavity, or when it is uncertain if other intra-abdominal organs are injured as well as the kidney. Even in the case of large tumours removal may be effected by the lateral abdominal or paraperitoneal route if a transverse incision is added and the peritoneum stripped forwards.

The advantages of the *lateral* or *paraperitoneal* abdominal incision in nephrectomy have been well pointed out by Mr. Arthur Ball, F.R.C.S.I., in a paper published in the

" Transactions of the Royal Academy of Medicine of Ireland," 1913 : " An incision made in the line of the fibres of the external oblique muscle a little further out tha an ordinary McBurney appendix incision. It is unnecessary to keep right out clo to the iliac crest as figured in most books in describing the lumbo-iliac incision, and is inadvisable also, for such an incision is not so easy to stitch up, and one is apt wound the deep circumflex iliac vessels with the needle when stitching up the intern oblique muscle, and so have slight but delaying bleeding. The external aponeuros is split in the direction of its fibres, and the internal oblique and transversalis muscl

FIG. 258.—Lumbar Nephrectomy. The kidney, having been exposed through the usual lumbar incision, has been freed from its loose surrounding tissues and drawn out into the wound. The ureter has been exposed in the fatty tissue below the kidney, drawn towards and doubly ligatured preliminary to its division.

cut through across the direction of their fibres—that is, in the same direction as th split in the external oblique. The peritoneal reflection is then sought and retracte towards the middle line. The ureter is next sought for where it crosses the iliac vessels and it must be remembered that it generally pulls up with the peritoneum off th posterior abdominal wall.

" The ureter is followed up to the kidney, and forms the guide to the main rena vessels, and any abnormal vessels are readily seen and dealt with. When the ren vessels are tied the kidney still attached to the ureter is brought out through the woun and the ureter divided as low down as considered necessary."

Mr. Ball does not consider that this incision incurs a marked degree of risk of

ventral hernia developing subsequently. The resulting scar is sound, and this may be attributed to the fact that the external oblique muscle and its aponeurosis are not cut across, but rather split in the direction of their fibres.

When the kidney has been removed dependent drainage may be provided by

FIG. 250.—Lumbar Nephrectomy. Ligature of the renal pedicle. The kidney has been drawn out through the lumbar wound and the fatty tissue investing the renal vessels has been pushed aside. The vessels have been clamped close to the kidney and an aneurysm needle carrying a stout ligature of catgut has been passed through the centre of the pedicle on the vertebral side of the clamp. The loop of the ligature passed in this way has been divided, and the aneurysm needle withdrawn. Two ligatures are thus available, and by knotting them tightly, the renal pedicle is ligatured in two portions.

introducing a rubber tube through a stab wound in the loin. The abdominal wound may then be closed, the muscles being sutured in layers with catgut.

This method of approach to the kidney is to be recommended in cases of new growth in view of the great vascularity of these tumours and the necessity for being in a position to obtain good access to the renal vessels.

LUMBAR NEPHRECTOMY. Instruments. In addition to the instruments

required for general operative work on the kidney the following should be at han
two or three medium-sized powerful clamps slightly curved, for compressing t
pedicle; two large aneurysm or pedicle needles and the thermo-cautery.

Stages of the Operation. *The Lumbar Incision.* This should be free so as
allow easy access to the kidney. If the latter is much enlarged the incision should
carried down in front of the tubercle of the crest of the ilium, even to the level of t
anterior superior spine, or possibly still further. If more room is required abov
portion of the last rib may be resected. In difficult cases the distal segment of t
eleventh rib likewise may be removed subperiosteally, taking special care not
wound the pleura.

Exposure and Stripping of the Kidney.— This is done in the usual way (p. 42
especial care being taken in stripping the upper and lower poles. It is at t
upper pole that adhesions are most likely to be found, and this extremity of the gla
should be attacked first.

Section of the Ureter.— When the kidney has been well stripped the lower po
is seized in the fingers of the left hand and lifted up into the wound. In the soft f
in the space below the kidney the ureter will be felt by the finger as a tight cor
the upward tilting of the kidney having put it on the stretch. If there is any dif
culty in finding it, it is well to remember that owing to its close connection with t
peritoneum it tends to be carried forwards with the membrane rather than rema
behind in contact with the psoas muscle. When found the finger is passed und
it, and a double catgut ligature or two forceps are applied to it with an intervenin
space of about an inch (Fig. 258). A compress having been passed underneath t
ligatures, the ureter is divided by a Paquelin cautery, and the mucous membrane
either end is carefully seared with the point of the cautery. The ureter may also
divided with scissors or scalpel and the ends swabbed with pure carbolic acid. T
lower end is then wrapped in a piece of gauze and dropped into the wound

Freeing of the Pelvis.— When the ureter is divided it is easy by drawing up
proximal end and following it closely with the finger to reach the pelvis and separa
it from the surrounding fat. This is an important step, for if it is not carefully pe
formed it is impossible to form a good pedicle, and there is the danger of cutting th
walls of the pelvis when dividing the vessels and allowing the urine, which is ofte
septic, to escape and contaminate the wound.

Ligature of the Pedicle.—The lower pole is first drawn out of the wound and the
the upper, and with the fingers the loose tissue is stripped back from the vessels ti
the index finger can pass freely around them above the pelvis.

When the pedicle is isolated the kidney is drawn backwards and grasped betwee
the thumb and fingers of the left hand. The pedicle is then enclosed in the blade
of a clamp and tightly secured. If the operator stands behind the patient the clam
will be passed from above on the left side and from below on the right. An aneurysm
needle threaded with stout catgut is now taken in the right hand, and the point of th
needle is pushed through the centre of the pedicle on the proximal side of the clamp
when the point is felt by the left index finger the kidney is turned forwards and th
point made to emerge behind. The loop of catgut is then caught, drawn out, an
divided, and the needle is withdrawn. The pedicle is ligatured in two halves by thes
two strands of catgut without interlocking them. A surgeon's knot is tied, followe
by another knot to prevent slipping. The pedicle is now cut through distal to th
clamp and the kidney removed. The open ends of the renal vessels are now seen o
the cut face of the pedicle. If considered advisable they may be seized with cli

forceps and tied separately with catgut. Finally a stout piece of catgut is placed around the entire pedicle internal to the clamp, which is removed, and tied around the pedicle where it has been constricted by the clamp. In cases where the pedicle is readily accessible the clamp may be dispensed with altogether.

Toilet of the Wound.—The wound is wiped out with compresses, and any additional vessels requiring ligature are secured. Semi-detached fragments of the perirenal fat are removed. The pedicle is carefully inspected and dropped back into the wound after its controlling ligatures have been cut short. The piece of gauze surrounding the distal end of the divided ureter is removed, and if sepsis is absent or not severe the ureter may be dropped back into the wound and a drainage tube passed to the bottom of the space in which it lies. Where, however, severe sepsis is present the ureter should be resected or else brought to the surface and anchored by a suture in the lower angle of the wound.

If the space under the ribs is very large a drainage tube should be placed here also. Gauze is useless as a drain, for it retains fluids in the depths of the wound and its removal is very painful.

Suture of the Wound.—This is effected in the same way as described under "Nephrotomy" (p. 426).

The Dressing. The cavity left after a nephrectomy is always so extensive that considerable oozing occurs, and consequently drainage with abundant absorbent dressings are necessary. Before applying the latter it is well to turn the patient on his back and by firm pressure on the abdomen to empty the cavity as completely as possible. Owing to the oozing the dressings will be quickly soiled, and this will necessitate the outer layers being changed the next day. At the end of forty-eight hours the drainage tube or tubes may be removed if sepsis is not present. After this there is no more soiling, and the dressings may be left in position till the eighth or ninth day, when the stitches are removed and the wound will be found healed.

SUBCAPSULAR NEPHRECTOMY.—When the kidney is fixed by dense adhesions to the surrounding tissues it may be impossible to strip it except with great difficulty and at considerable risk. In such cases subcapsular nephrectomy must be performed. This operation, however, has the disadvantage of making it more difficult to deal with the pedicle.

Exposure and Decapsulation of the Kidney. The kidney is exposed as described, and the capsule proper is divided over a limited area with a knife, the underlying gland tissue being damaged as little as possible. The capsule is then separated from the kidney by a blunt dissector or by the finger. This separation is extended over either pole and both surfaces to the hilum.

The process of subcapsular enucleation is difficult, but with care it can usually be sufficiently accomplished to allow the pedicle to be grasped between the finger and thumb of the left hand, or between the index and middle fingers.

Formation of the Pedicle. As the kidney will not come readily forwards into the wound the clamp to control the pedicle is passed by the sense of touch rather than by sight. The ends of the blades should extend for some distance clear of the pedicle. When the clamp has been tightly applied the kidney is cut away with scissors. Included in the clamp are not only the vessels but also the pelvis of the ureter, and surrounding them all the reflected capsule. Albarran describes the following extra-capsular method of tying the pedicle.

While the divided pedicle is still held by the clamp an incision is made through the reflected capsule all round the pedicle, 1 centimetre internal to the instrument; then

by careful blunt dissection the tissues investing the vessels and ureter are stripped backwards. The ureter is ligatured as low as possible and divided. The vessels are then tied by a double ligature in two portions, and in addition a mass ligature is applied for greater security. The portion of the pedicle on the distal side of the last ligature is then cut away together with the clamp.

Resection of the Capsule Proper.—If possible the capsule proper and the perinephric tissues should be removed piecemeal with scissors, as otherwise a cavity is left with firm resisting walls, which only closes very slowly and usually after prolonged suppuration. The part below the ribs can be removed with comparative ease, but the part under cover of the ribs should be left if the adhesions are firm rather than risk injury to the pleura by persistent efforts to remove it. The further steps are the same as in *extracapsular* nephrectomy, except that, as these cases are usually septic and the pelvis of the ureter is divided in the pedicle with resulting soiling of the wound, it is well to wash out the latter with sterile salt solution. Primary union cannot be expected, and it is better to leave the wound extensively open than to have to remove sutures after a couple of days. The wound should be dressed once or twice daily, and care should be taken to see that union occurs in the deeper parts of the wound so that no suppurating tracts may be left. During the healing process douching the wound daily with a solution of hydrogen peroxide is attended by beneficial results.

LATERAL OR PARAPERITONEAL NEPHRECTOMY.—When the kidney which is to be removed is situated very high up, when its size is great and cannot be lessened by puncture or incision, or when it is very adherent, lumbar nephrectomy as described above presents real difficulties. In these cases more room may be gained by making an additional transverse incision forwards and by resection of portions of the eleventh and twelfth ribs. If these difficulties are foreseen, and especially in cases of new growth, the operator may have recourse with advantage to the lateral route, which gives just as much room as the transperitoneal, and at the same time avoids opening the peritoneal cavity. The drainage, however, is not so good as in lumbar nephrectomy.

The patient lies on his back slightly inclined to the healthy side, and with a firm cushion or air-bag under it so that it is concave.

The Abdominal Incision.—This starts immediately in front of the anterior extremity of the eleventh rib and is carried vertically downwards to a finger's breadth above the anterior superior iliac spine.

In the case of a very large tumour more room may be obtained by carrying another incision forwards from the upper extremity of this along the costal margin, or from its lower extremity parallel to Poupart's ligament.

Stripping of the Peritoneum.—When the incision has been carefully carried through the muscles and transversalis fascia, the peritoneum is recognised and is stripped up from the lateral and posterior abdominal wall. When the renal tumour is reached the fingers pass between the perirenal fascia and the quadratus lumborum and psoas, so that the fatty capsule is lifted forwards with the kidney. An incision through the perirenal fascia behind the kidney exposes large vessels, which usually require to be divided between ligatures. Owing to the thinness of their walls it is better to ligature them at once, as forceps are liable to cause tearing and hæmorrhage. The lower pole of the kidney is fully exposed, and by following it the ureter is found and divided as described above (see p. 432). The ureter is then drawn up with the kidney and followed by the fingers to the inner border of the pelvis. The upper pole of the kidney is now separated from the surrounding fat, and in so doing the presence of vascular adhesions will probably necessitate the division of vessels between ligatures

When the tumour is stripped as thoroughly as possible it is drawn out of the wound and the pedicle further defined without paying special attention to enlarged glands.

Ligature of the Renal Vessels and Extirpation of the Kidney.—These steps are the same as in lumbar nephrectomy (see p. 432).

Extirpation of Fatty Capsule and Glands.—When the preceding steps of the operation have been carried out as described above there remains only the debris of the fatty capsule, especially around and above the pedicle. This is carefully removed, and any enlarged glands are separated and removed by blunt dissection from the front and sides of the aorta if necessary. By proceeding in this way the most delicate part of the operation is done when there is most room, after the removal of the kidney.

Reconstitution of the Abdominal Wall.—The abdominal wall is reconstituted by two layers of sutures, muscular and cutaneous. Two large drainage tubes are placed in the large cavity, as oozing is usually considerable. Gauze plugging may be employed if thought advisable, and a lumbar counter-opening may also be made.

NEPHRECTOMY BY MORCELLATION.—If it is found impossible to remove the kidney as a whole, either by the extracapsular or subcapsular method, it becomes necessary to remove it piecemeal. It is practically only in old-standing cases of calculous or tuberculous pyonephrosis that this becomes necessary. This operation is not suitable for new growths owing to the friability and vascularity of their tissues.

Isolation and Clamping of the Kidney.—The operator should always try to free the lower pole of the kidney first; as a rule it can be sufficiently isolated to allow of the application of a clamp to the lower part of the pedicle. If this is not possible a powerful clamp is passed from the convex border towards the hilum; it crushes the renal tissue and allows the part below the blades to be removed. When the lower pole has been removed it is easier to reach the pedicle and free it. It may now be possible to apply a clamp to it, in which case the rest of the kidney may safely be cut away. If, however, the pedicle is still inaccessible the kidney must be freed, clamped, and cut away bit by bit. The portion under the ribs presents most difficulty; it may be isolated with the fingers and removed in fragments, as there is little danger of excessive hæmorrhage in these cases owing to obliterative changes in the vessels.

Treatment of the Pedicle.—This may now be reduced in size and ligatured in the ordinary way. If not, any vessels that are seen on the cut surface are ligatured, and the clamp is left in position until the third or fourth day, when it may safely be removed without fear of hæmorrhage.

The Dressing.—If the pedicle has been ligatured the dressing and after-treatment are the same as in subcapsular nephrectomy. If a clamp has to be left the wound is packed lightly with antiseptic gauze, which at the same time separates the handles from the edges of the wound. A large pad of wool is applied carefully around the handles to prevent their being moved or pushed aside. The clamp may be removed on the third or fourth day. If the wound is septic the gauze and dressings will have to be changed daily, and the wound should be douched with a solution of hydrogen peroxide. Occasionally the wound will have to be packed tightly with gauze to control excessive oozing from torn vessels.

PARTIAL NEPHRECTOMY.—In a few cases of limited disease of the kidney a partial nephrectomy may be performed. It may be done (1) in the case of small tears or crushes, the result of injuries; (2) for neoplasms which are of strictly limited extent; (3) for abscess, cyst, calculous and other forms of pyelonephritis; (4) for tuberculous disease when apparently limited to one pole of the kidney, but it is

doubtful whether it is ever justifiable in tuberculous cases, owing to the impossibility of deciding that the remainder of the kidney is not affected and the likelihood of infection of the pelvis and upper part of the ureter.

Either pole or the central portion of the kidney may be removed.

The early stages up to the delivery of the kidney into the wound are the same as in total nephrectomy (see p. 432).

During the resection the pedicle is compressed by an assistant or by a clamp with blades ensheathed in rubber.

The Resection and Suture of the Renal Wound. The portion of the kidney to be removed is separated from the remainder of the gland by incisions which converge on one another from the surface, so that the part removed is wedge-shaped. The wound thus left is sutured with catgut, the sutures passing to the depths of the wound and bringing the cut surfaces into accurate apposition throughout their whole extent. Superficial sutures are interposed if necessary. When the pedicle is released no bleeding should occur along the line of suture.

The final steps of the operation are the same as those of an exploratory nephrotomy (see p. 426).

The After-treatment in Cases of Nephrectomy.—This is the same as in all major operations on the kidney. The patient should be kept quiet in the supine position. There is no danger in giving morphia to relieve distress. The diet is gradually increased as the condition of the patient permits. Drainage is continued for a longer or shorter time according to circumstances.

In aseptic cases the drainage tubes are removed on the second day and do not interfere with primary healing. It is well, however, to see that fluids do not collect in the depths of the wound and require to be evacuated at a later date. In septic cases the wound will require daily douching with hydrogen peroxide, and drainage must be kept up until the wound is closed in its deepest part. The patient should be given a saline purge on the second day. When primary union occurs the patient may usually be allowed up during the third week.

COMMENTS.

The Chief Accidents and Difficulties which may arise are—opening of the pleura or peritoneum; opening of renal pouches or the pelvis of the ureter with the escape of septic contents and soiling of the wound; hæmorrhage from an accessory renal artery or from the pedicle, or from tearing of the vena cava. The difficulties may be due to adhesions, the size of the renal tumour, or the shortness or thickness of the pedicle.

Opening of the Peritoneum.—This is liable to occur when freeing the anterior surface of an adherent kidney. In difficult cases it may be avoided by a subcapsular nephrectomy, but this may be impossible or inadvisable, as in cancer, cystic kidney and some pyonephrotic kidneys.

In an aseptic case the rent is closed temporarily with forceps, and the stripping is continued; then after the removal of the kidney the opening is sutured with catgut. In septic cases it is better to suture the tear in the peritoneum at once.

Wound of the Pleura may occur at two stages: first early in the operation if the incision is carried too high above the angle between the twelfth rib and the outer border

of the erector spinæ, and secondly when separating dense adhesions between the upper pole and the diaphragm. The method of dealing with this accident has been indicated in a previous section.

Opening of Renal Pouches may usually be avoided by taking special pains when stripping fluctuating spots. If this accident should happen the wound is carefully wiped, and after removal of the kidney it is flushed freely with hydrogen peroxide and left sufficiently open to permit of free drainage.

Opening of the Pelvis is avoided by finding the ureter in the early stages of the operation, dividing it well below the pelvis, and then clearing it from below. If it is opened the same measures should be adopted as in the case of tearing a pouch.

Hæmorrhage from an Accessory Renal Artery. The accessory vessel may enter the kidney close to the hilum in which case it will be grasped in the clamp and cause no trouble. Sometimes, however, it reaches the kidney at a distance from the hilum close to either pole, in which case it will be found when stripping the kidney and had better be divided between two ligatures or forceps. In the case of a *subcapsular* nephrectomy these vessels are liable to be torn during the process of decapsulation, and are only recognised when hæmorrhage occurs with alarming suddenness. The vessel can usually be caught and ligatured, but if not, a clip may be left in position for a few days, or it may be necessary to tampon the wound.

Hæmorrhage from the Pedicle.—This may be due to a vessel which is not properly grasped by the clamp, more especially if the pedicle is very thick.

Hæmorrhage may result also from slipping of the clamp when the kidney is removed or from slipping of the ligature, but this is unlikely to occur if the method described of using a double ligature and an additional mass ligature is adopted. If it does occur the pedicle may be reclamped and ligatured or the clamp left in position; occasionally it may be necessary to tampon the wound.

Hæmorrhage sometimes occurs from the splitting of a vein in the pedicle when passing the aneurysm needle through it, but it should not happen if the needle is carefully passed by sight. If it does occur the vessel will require to be ligatured or secured by a clamp.

In *subcapsular* nephrectomy when trying to bring the decapsulated kidney into the wound a large vessel may tear and give rise to severe hæmorrhage. In this and other cases where alarming hæmorrhage occurs from a pedicle not yet tied an attempt should be made to arrest it by forceps, but if this does not succeed the kidney had better be removed rapidly, the pedicle being controlled meanwhile as well as possible with the fingers. With more room and the freer access thus obtained the vessel can usually be caught in clamps or forceps.

The inferior vena cava may be torn on either side by dragging too forcibly on the pedicle of the kidney. The tear is likely to occur at the point where the renal vein joins the parent stem. The cava may also be torn in separating adhesions on the right side. It is most liable to happen in cancer of the kidney, but it has also occurred in cases of tuberculous disease and pyonephrosis. Tampon, compression with forceps, lateral ligature, suture, and total ligature have all been practised. Total ligature has given the best results—five recoveries out of seven (Albarran). The circulation is carried on by the azygos and vertebral veins. The outlook is most favourable when the ligature is applied between the iliac and renal veins. If the tear is below the right

renal, which is the lower of the two, the vessel may be ligatured. If the tear is at this point or above it an attempt may be made to suture the vein, or a lateral ligature may be applied; failing this, however, temporary forcipressure may succeed. If the hæmorrhage is very severe it may be impossible to do more than tampon the wound.

Difficulties due to the Large Size of the Renal Tumour. If the tumour is cystic its size may be reduced by aspiration, but if solid it can usually be removed, if there are no strong adhesions, by prolonging the incision downwards and forwards. If this is not possible the outer part of the last rib may be resected. The pleura should be retracted carefully upwards along with the last dorsal nerve. In exceptional cases even the eleventh rib may be removed in the same way, but it is usually preferable to perform either the lateral or the transperitoneal operation.

Dangers and Accidents occurring after the Operation.—Shock may be severe, especially in septic cases with dense adhesions, or where a large malignant tumour has been removed. The method of treating this condition has been already described (see p. 418).

Hæmorrhage in the form of oozing is usually free for the first twenty-four hours or more, but it need not cause alarm as it is only due to small vessels torn in separating the perinephric adhesions. If, however, the hæmorrhage is more abundant, it may be necessary to pack the wound with gauze. Late hæmorrhage occurring after several days is usually the result of sepsis. It may be controlled by forceps applied through the lumbar incision or by packing the wound firmly with gauze.

Oliguria, or even anuria, may occur after nephrectomy in cases where it has been shown beforehand that the other kidney is comparatively healthy and functioning well. At its first appearance the patient should be given infusions of saline and should be freely purged. Theobromine and other diuretics should be administered in large quantities of water. Lavage of the second kidney may be practised through a ureteral catheter with the hope of starting the urinary flow. When these methods fail and the anuria has lasted for three days, even if signs of uræmia have not yet appeared, a nephrostomy should at once be performed on the remaining kidney.

Septic Infection of the wound may be due to faulty technique in an aseptic case, or it may be the result of unavoidable soiling of the wound in septic cases. The temperature is the best guide. Where this rises and remains high after the second or third day in spite of the administration of a saline purge, the wound should be inspected, and if there is any redness, swelling, or tenderness, some of the stitches must be removed, as pus may be retained in the depths of the wound or the drainage tube may be plugged. Flushing of the wound with hydrogen peroxide once or more daily, according to the severity of the infection, will usually effect an improvement.

Hæmaturia may be present for the first twenty-four hours or may last for several days. In the first case it is probably due to escape of blood from the diseased kidney into the bladder during the manipulation of the gland before the ureter is divided. In cases where it lasts longer it comes from the remaining kidney, and is probably due to an acute congestion owing to the increased work thrown on a gland already more or less diseased. If the patient is kept on a milk diet the blood will usually disappear in a few days.

A Purulent Fistula may be due to infected silk ligatures, to the formation of granulation tissue, especially in tuberculous cases, or to the ureteral stump. Silk should not be used for ligatures, especially in septic cases. If it has been used and a purulent fistula results, it may be necessary to open up the wound and search for and remove the infected silk. The most difficult cases to cure are those where the fistula leads to a definite cavity, especially if it is situated high up under the ribs and is lined by tuberculous granulations. Under such circumstances the cicatrix should be freely incised and the cavity scraped and packed with gauze. It may be necessary to resect the lower ribs to enable the walls to come together.

Hernia may occur, but it will be most certainly avoided by careful suturing of the abdominal wall, especially of the deep muscles, and by not allowing the patient out of bed till the wound is firmly healed.

CONSIDERATIONS RESPECTING NEPHRECTOMY IN SPECIAL CONDITIONS.

NEPHRECTOMY IN TRAUMATIC CASES.—Every effort should be made to preserve the gland, or a portion of it at least, and nephrectomy should be reserved for those cases where the gland is severely pulped, where large vessels in the hilum have been torn or the ureter has been torn across, or where, owing to the critical condition of the patient, it is necessary to conclude the operation rapidly and check all hæmorrhage at once.

In all cases the lumbar route is chosen, unless there are symptoms of extensive intraperitoneal hæmorrhage, or a suspicion of injury to other intra-abdominal organs.

Exposure of Kidney and Removal of Extravasated Blood.—The kidney is rapidly exposed and blood and clots removed. If the hæmorrhage is severe the pedicle is rapidly reached and compressed with the fingers; this allows the kidney to be explored better, and bleeding vessels may be caught with forceps. If digital compression is not sufficient a rubber-covered clamp may be temporarily placed on the pedicle. Rents in the kidney may be sutured or a partial nephrectomy performed. If a total nephrectomy is necessary the further steps of the operation are followed in the manner already described.

NEPHRECTOMY IN HYDRONEPHROSIS.—This is chiefly indicated when the parenchyma of the kidney is so completely destroyed that the secreting power of the gland is negligible, or when it is found impossible to perform a conservative plastic operation. In either case the functional capacity of the other kidney will have been tested beforehand.

Usually it is only after the hydronephrotic sac has been opened and the amount of available parenchyma as well as the condition of the pelvis and ureter have been determined by inspection that nephrectomy is decided on.

A limited area of the kidney is exposed and stripped. A trocar is entered through a thinned portion of the sac, and the contents are drawn off. The wound is then protected with gauze wipes and the sac freely opened and wiped dry.

The ureter is exposed below the kidney and followed up to the pelvis, the junction of the two being carefully examined. If nephrectomy is indicated the ureter is ligatured with catgut, and a clip is placed above this; the intervening segment is then divided with the knife or cautery and the mucous membrane of the lower end seared with the thermo-cautery or swabbed with pure carbolic acid.

The ureter is followed up to the pelvis and the lower pole of the kidney isolated one or two fingers inside the sac facilitate the stripping of the surrounding tissues If the peritoneum cannot be separated a piece may be removed with the sac and th opening closed afterwards. If the sac is adherent to the vena cava the adheren part may be left The pedicle is thus formed and tied in the usual manner. Th concluding steps of the operation call for no special comment.

NEPHRECTOMY IN CASES OF PYONEPHROSIS. Usually there is a larg multilocular sac with numerous septa separating loculi filled with pus and stones

FIG. 200. Kidney removed by Lumbar Nephrectomy for Calculous Disease. The renal parenchyma had disappeared to a large extent and both the pelvis of the ureter and the calyces were much dilated. Many calculi were present and these varied greatly in size from very minute particles up to a large mass occupying the pelvis of the ureter. Chemical examination showed that the calculi were of the cystin variety.

The kidney tissue is more or less altered or destroyed, and the thinness of the walls of the loculi makes tearing of them during the process of stripping a likely accident In these cases also the perinephritic fat is altered and converted into a dense fibro fatty mass enveloping the kidney and pedicle, and often the vena cava and aorta as well, being firmly adherent on the one hand to the capsule proper and on the other to the neighbouring tissues. Suppuration in the perirenal tissue may be more or less abundant. As a rule the capsule proper is easily separable from the kidney tissue, and a subcapsular nephrectomy may be done; but in other cases, especially calculous pyonephrosis, the capsule may be freed with the gland tissue. The ureter may be little altered, or it may be large, thick-walled, and tortuous, with valvular folds.

The only objection to opening the sac before extirpating it is the soiling of the wound; but, even with the greatest care in trying to avoid it, accidental tearing of a thin-walled loculus is very likely to occur.

There are two obvious advantages in opening the sac. (1) The evacuation of the pus and calculi reduces the size of the kidney and greatly facilitates its removal. (2) It is only by incising the sac that the operator can judge how much kidney tissue is left and so decide whether a *nephrectomy* or *nephrostomy* is the more suitable operation. Therefore in a case of simple or calculous pyonephrosis the operation should always be commenced as a nephrotomy, and be completed as a nephrostomy or a nephrectomy, according to the existing conditions.

The kidney is exposed by the usual incision. The wound margins are protected with muslin swabs and the kidney is punctured with a trocar through a thinned spot. The pus is allowed to escape and then the cavity is washed out with sterile salt solution. The renal opening is enlarged with scissors sufficiently to allow easy exploration of the interior, both by sight and touch. All stones are removed and the cavity flushed again. The thickness of the walls, the septa and diverticula, and the height to which the gland rises under the ribs are noted. If nephrectomy is considered necessary it is usually possible to perform *subcapsular* nephrectomy as already described, but if this is impossible the operator must proceed with caution to perform the *extracapsular* operation.

When the kidney has been stripped the pedicle may be rendered free enough to allow its being clamped or ligatured and the kidney cut away. Where complete stripping cannot be effected, successive portions of the sac may be cut away after the application of clamps, that is, nephrectomy by morcellation. All stones should first be removed, as their presence may prevent the application of a clamp.

If a thickened and dilated ureter is left in the wound it will expose the patient to the danger of prolonged suppuration, and possibly a urinary fistula. Therefore, if the patient is in good condition, the incision should be extended downwards and a complete ureterectomy effected. As an alternative the duct may be secured with catgut to the lower angle of the incision after destroying its mucous lining with the cautery.

As these cases are septic, all semi-detached pieces of tissue [illegible] and the cavity flushed freely with warm saline solution. Two or more [illegible] are inserted, one to the ureter and another to the pedicle. The [illegible] lightly with antiseptic gauze and the incision left open for a large part [illegible].

The gauze may be removed on the second day, and as a rule at no [illegible] removed. At each dressing, which should be done twice daily at first, the cavity is flushed with hydrogen peroxide. The tubes are gradually shortened, and healing is usually complete in about a month.

NEPHRECTOMY FOR TUBERCULOUS DISEASE.—Apart from cases of miliary tuberculosis there is always more or less enlargement of the kidney, and the gland presents one or more rounded lumps, varying from the size of a pea to that of a walnut, composed of tuberculous material, grey and firm and palpable even when embedded in the gland. The renal surface may be uniformly smooth, but more commonly it is irregular and marbled with grey spots on a dark red surface. Cavities ultimately form by the breaking down of caseous foci which by their enlargement open into the calyces and pelvis. Occasionally the process starts at the apex of a pyramid and gradually spreads towards the periphery. Whatever the mode of formation, these

cavities are practically always multiple, and are separated by kidney tissue which may be but little altered. These cavities contain caseous material or pus. They may be very superficial and thin-walled, in which case they are liable to rupture during the process of stripping the kidney (Fig. 261).

Tuberculous Pyonephrosis.—This is liable to develop sooner or later in nearly all cases. Obstruction of the ureter is caused by narrowing and alteration of the duct from disease, or the duct may be blocked by caseous material derived from the kidney. As a result of the obstruction retention occurs, the gland dilates and is filled with caseous material and purulent fluid. In some cases the kidney finally forms a multilocular sac composed of fibrous tissue and filled with a cheesy-like, fatty white mass. Secondary calculi composed of phosphates and carbonate of lime may form. Perinephritis is the rule and may be of the fibrous, fatty, or suppurative type.

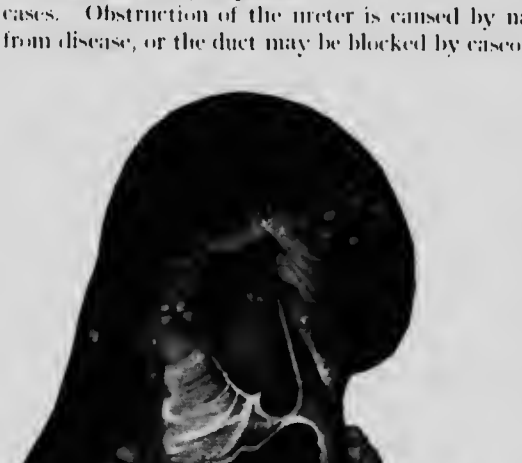

FIG. 261.—Kidney removed for Tuberculous Disease. The disease was most advanced at the lower pole of the kidney which presented on section two cavities with caseating contents. The upper pole contained several discrete tubercle nodules which are clearly represented in the figure. The mucous membrane of the pelvis of the ureter and that of the calyces was studded over with minute tubercles.

Fibrous perinephritis causes dense adhesions between the kidney and the surrounding structures, and may involve even the vena cava and the aorta. But it should be remembered that the capsule proper always separates easily from a tuberculous kidney, so that in these cases a subcapsular nephrectomy is always possible. A fatty perinephritis is particularly common around a tuberculous kidney, and the firm yellow, lobulated fat traversed by fibrous septa often forms a thick envelope round the kidney, pelvis and vessels. It is liable to invade the hilum of the kidney and even spread into the interior of the gland. A perinephritic abscess may form with or without a definite opening into the interior of the gland. It may be a cold abscess due to tuberculous infection, or an acute abscess the result of secondary pyogenic infection. These abscesses may spread extensively and even burst into the pleural cavity. The lymphatic glands in the hilum may be involved and form adherent masses. The renal vessels in these advanced cases present obliterative changes with thickened walls and diminished lumina.

The ureter may be little altered, but more commonly there is a well-marked ureteritis or periureteritis, which may involve only the upper part of the duct or its

whole length. The ureter is sometimes greatly dilated with thickened walls, but on the other hand its lumen may be diminished or even obliterated. It may be surrounded by fibrous tissue and adherent to the peritoneum, but more frequently its isolation is easy. When greatly enlarged its walls are rigid, and on section it presents a large, gaping orifice.

Operative Details.—As it is very important to prevent soiling of the wound, opening of renal pouches should be avoided and the wound protected with gauze wipes when the ureter is being divided. Wherever possible extracapsular nephrectomy is performed. Subcapsular nephrectomy and morcellation should be reserved for exceptionally difficult cases. The danger of allowing the contents of a tuberculous kidney to escape is twofold: general tuberculous infection and intractable post-operative suppuration in the wound with persisting sinuses.

When the ureter has been divided there is no difficulty as a rule in delivering the kidney into the wound, more especially if the latter has been sufficiently enlarged. It is easy then to strip the pedicle and reduce it to a reasonable size. It is ligatured in the ordinary way, but if this is not possible a clamp is applied. It should be placed as far from the pelvis as practicable, so as not to include it in its grasp. When the kidney is not very large the pedicle may be ligatured before the gland is removed. Where, however, the tumour is large a clamp is applied and the kidney cut away, taking care not to make the section too close to the clamp for fear of its slipping and avoiding section of the pelvis if possible. When the ureter is only slightly or not at all altered it may be left in the wound after ligature and cauterisation of its mucous lining. When it is much altered it is better practice to perform a complete ureterectomy, though in most cases it may be sufficient to remove as much as possible through the wound already made, as after cauterisation and ligature a fistula is not likely to occur, seeing that the lower end when separated from the kidney tends to atrophy.

Even in fairly simple cases it is not possible to say to what extent the tuberculous process has invaded the fatty capsule. Therefore in all cases, whether soiled or not, the fatty capsule had better be removed. This is specially necessary, although attended by more difficulty, where adhesions are present.

It is advisable to drain practically every case. In the simplest cases a single drainage tube is passed to the region of the ureter and removed at the end of forty-eight hours. In the worst cases two or more large drainage tubes should be introduced and the greater part of the wound left open.

NEPHRECTOMY FOR NEW GROWTHS OF THE KIDNEY. The following varieties of new growth in the kidney or pelvis may necessitate the performance of a total or partial nephrectomy: adenoma, carcinoma, hypernephroma, sarcoma, papilloma, fibroma, and lipoma. The two latter forms of tumour are so rare as to be merely surgical curiosities, and are recognised only on exposure.

Operative Details.—In performing the lumbar operation the parietal incision should be carried well forwards so as to allow of all manœuvres being accomplished by sight and to enable the operator to bring the tumour out of the wound without excessive traction on the pedicle.

Owing to the frequent invasion of the capsule in malignant cases, the stripping of the kidney must be extracapsular, and great care must be taken to avoid tearing either it or the large veins which surround the kidney. It may be necessary to divide dense

adhesions or large veins between forceps or ligatures. Where the upper pole of the kidne is adherent there should be no hesitation in resecting portions of the eleventh an twelfth ribs in order to allow of the separation being done under the gaze of the surgeon.

Owing to the possibility of the extension of the growth to the renal vein and ver cava and of adhesions to these vessels, all violent dragging on the tumour must b avoided. At the same time, owing to the danger of dislodged clots and fragments o tumour tissue forming emboli, it is specially necessary to strip the pedicle as far a possible before removing the kidney.

It is often difficult in these cases to reduce the pedicle to a size suitable for ligatur If so, one or two clamps should be applied and the tumour cut away. The pedic can now usually be tied in two or three sections. Special care is necessary when passin the needle not to perforate a vein in the pedicle.

Owing to the danger of unrecognisable invasion of the fatty capsule, this shoul be removed as completely as possible. At the same time the suprarenal capsul should be removed too, especially if the upper half of the kidney is involved.

Removal of the Lymphatic Glands is best undertaken after the kidney has bee cut away, as there is then more room. In every case a systematic search must be mad for them around the pedicle, on the crura of the diaphragm, and along the large vessel They are removed when found by dry sponging and blunt dissection, without dragging Special care is needed on the right side owing to the possibility of adhesions betwee these glands and the vena cava. It is useless trying to follow the glands if they ar enlarged upwards towards the thorax and downwards into the pelvis as this ste greatly increases the shock of the operation, and if glandular involvement has alread spread so far complete extirpation is out of the question.

A large cavity with freely oozing walls is always left after the removal of the tumour Two tubes are introduced and the space between them is packed with gauze. Th wound is closed in the usual way, except at the point where the tubes and gauze emerge

If the oozing has ceased after forty-eight hours the drainage tubes may be removed

TRANSPERITONEAL NEPHRECTOMY.—This procedure is usually reserved fo certain cases of injury and neoplasm.

Stages of the Operation.—*The Abdominal Incision* may be made in the middl line in the case of very large tumours which extend to or beyond the centre of th abdomen. In all other cases it is made at the outer border of the rectus, extendin from the rib margin above to below the level of the tumour, and should be mad sufficiently long to give plenty of room.

The Paracolic Division of the Peritoneum.—On opening the peritoneal cavity th coils of small intestine are pushed over to the other side and kept from the area o operation by the introduction of large absorbent pads, which should be wrung out of ho saline solution and have either long tapes or clips attached to them to prevent the ris of their being overlooked and left in the abdomen at the conclusion of the operation The peritoneum covering the tumour is now incised longitudinally about 4 centimetre outside the colon. A small incision is made first with the knife, and this is enlarge with scissors to the full extent of the tumour. This incision is made sufficiently f from the colon to allow the inner cut edge to be sutured to the parietal peritoneum as th last step in the operation and thus isolate the operation area from the general peritone cavity. On the right side there is usually no difficulty in this step of the operatio since enlargement of the kidney has generally pushed the ascending colon downwar

and inwards. On the left side, however, the colon may be stretched across the tumour or even lie to its outer side. Under such circumstances the greater or whole extent of the tumour is covered by the inner layer of the descending mesocolon, beneath which the colic vessels proceed to the gut. There is therefore a danger of injuring these, and great care must be taken to make the incision in the peritoneum obliquely between visible vessels. It is evident that, in the case of a tumour on the left side especially, it may be difficult or impossible to reach and divide the peritoneum outside the colon through a median abdominal incision.

Enucleation of the Tumour.—It has been recommended to ligature the pedicle before enucleation. This may be advisable in cases which present great difficulties owing to adhesions or great friability of the tumour. As a rule it is better practice to enucleate the kidney before tying the pedicle. The peritoneum is stripped from off the front of the kidney, taking care to avoid injury to the large veins which ramify beneath the membrane. The tumour is first isolated outside and below, then its upper and inner part is enucleated, the fingers following the plane of cleavage between it and the loose surrounding tissues. Vascular adhesions are divided between ligatures or a ligature and forceps, the latter on the tumour side.

Division of the Ureter.—The ureter is found and divided in the usual manner. In the case of very large tumours it may be impossible to find it till after the pedicle has been divided. In such cases the vessels of the pedicle are separated if possible from the pelvis, ligatured or clamped, and divided. Then the tumour, which is held only by the duct, is drawn downwards. This puts the ureter on the stretch, and it is at once recognised and divided. In other cases the pelvis may have to be divided in the pedicle with the vessels. Where the ureter has been found and divided its upper end is followed up to the pelvis, which is stripped and separated from the vessels at the hilum.

Ligature of the Pedicle. When the pedicle has been cleared by blunt dissection and reduced to the smallest size possible, the kidney is lifted up in the left hand and a clamp applied, avoiding all dragging on the tumour for fear of embolism or tearing of the vein. A curved aneurysm needle threaded with catgut is passed gently through the pedicle, and the latter is tied in two sections, or, where very thick, in three, each ligature being secured with a triple knot. The tumour is removed by dividing the pedicle distal to the clamp. A second mass ligature may now be applied to the pedicle on the proximal side of those already tied. The clamp is removed, and any vessels visible on the cut surface of the pedicle are ligatured separately. It may be possible in some cases to apply a ligature separately to the artery and vein. If possible this should be done, tying the artery first. Ligatures thus applied are less liable to slip, since they do not include bulky masses of connective tissue along with the vessels.

Removal of Infected Tissue and Glands; Hæmostasis.—The large cavity left is lined with the remains of the perirenal fat. In all cases of malignant growth there is a possibility of this tissue being infiltrated, and it should therefore be completely removed. At the same time hæmorrhage from small vessels is checked by ligature or forceps. At this stage the suprarenal gland is also removed if it is thought advisable to do so. It is at this stage that the delicate task of removal of the lymphatic glands is undertaken. During this process the vena cava is exposed to injury. It may be compressed above and below, and if it is torn or a portion of it has to be removed it may be sutured and its continuity thus restored, or it may be ligatured. As already explained, it is not advisable to attempt the removal of the glands when they are extensively affected as their removal in these cases cannot be complete, and the final results do not justify the increased risk to the patient entailed by the extensive dissections.

Isolation of the Renal Pouch.—The two edges of the paracolic incision in the

peritoneum are united by a few points of suture above and below, leaving the centr portion open. In the same way the upper and lower ends of the incision in the pariet peritoneum of the abdominal incision are sutured, and then the edges of the openi in the posterior peritoneum are sutured to the corresponding edges in the anteri peritoneum, so that the pouch occupied by the renal tumour is completely shut from the general peritoneal cavity and can be freely drained.

Closure of the Wound ; Drainage.— The abdominal wound is closed in the usual wa except in its centre, by deep and superficial sutures. Two large drainage tubes exte from the retroperitoneal cavity to the surface, and if considered advisable anoth drainage tube may be brought out through a stab wound in the loin. Sterilised gau and large pads of wool are applied and are held in place by a many-tailed bandag

The drains will be removed on the third or fourth day and the stitches on the eight The patient may be allowed up at the end of three weeks if all goes well.

COMMENTS.

Peritoneal Adhesions. These may be so firm and extensive that it may impossible to peel the membrane from the front of the kidney, in which case portio of it may have to be removed with the tumour. In such cases it may not be possib to isolate the retroperitoneal cavity in the manner described above.

Wound of the Intestine and its Blood Vessels. If the intestine is torn the re should be closed by a double layer of sutures. If the vessels are injured it may necessary in order to prevent gangrene to resect a portion of the gut and perform lateral or an end-to-end anastomosis. The same procedure may be necessitated involvement of the gut in an extension of the growth ; this, however, is exceptiona

Tearing of the Tumour ; Hæmorrhage.—Portions of the tumour may be so friab that they break down under the finger. This may give rise to severe hæmorrhag which may even prove fatal. Such a result is most readily obviated by pluggi the wound and exposing and clamping the pedicle as rapidly as possible. It may ev be necessary to compress the aorta while the pedicle is being exposed.

Severe and even fatal hæmorrhage may occur also from the large vessels ramifyi over the tumour, *i.e.*, accessory arteries or vascular adhesions. Consequently adhesion or solid cord should not be divided except between ligatures or forceps. in spite of this hæmorrhage is severe or interferes with the view while stripping t tumour, the part already stripped must be tamponed and the pedicle clamped, aft which the stripping can be continued.

Tearing of the pedicle or vena cava may occur from undue traction on the tumo or during the isolation of the pedicle or the removal of the glands. The aorta and ve cava should be instantaneously compressed so as to allow time to apply a clam If the vena cava is torn it may be sutured or ligatured.

Difficulties in the Formation of a Pedicle. In the case of new growths it is qu exceptional to find the pedicle invaded or surrounded by the masses of sclerosed and fibrous tissue that are so common in pyonephrotic and tuberculous cases. I usually easy to obtain a small pedicle or to tie the vessels separately. Difficu may, however, be caused by enlarged glands or even outgrowths of the tumour betw the vessels of the pedicle. In all these cases it is advisable to tie or clamp the ped

first, and then after the removal of the kidney the glands are cleared away. This may necessitate a second ligature being applied nearer to the vertebral column or ligature of the vessels separately.

The Accidents liable to occur after Operation are the same as in lumbar nephrectomy (see p. 438).

Shock is usually more marked, and may require prompt measures for its relief, especially saline infusion administered per rectum, subcutaneously or, in the worst cases, intravenously.

The only point of special importance is bleeding into the cavity left by the removal of the tumour. This may necessitate the opening up of the wound and a search for the bleeding vessel. If found it may be ligatured or caught in a forceps, which is left in position for twenty-four to forty-eight hours; or it may be necessary to tampon the cavity.

NEPHROLITHOTOMY.

GENERAL CONSIDERATIONS.—This operation is indicated in all cases where a stone is known to exist in the kidney and where it is considered improbable that it will escape *per vias naturales*, unless there is some definite contraindication to any operative interference. A stone in the renal pelvis is certain to set up secondary changes in the kidney, which increase the dangers and difficulties of the operation and also militate against its complete and permanent success. The most important of these changes is sepsis, and the danger of waiting for the advent of this complication is shown by statistics which prove that the mortality of nephrolithotomy in aseptic cases is under 2 per cent., while in septic cases it runs to over 8 per cent. (Albarran).

Nephrolithotomy may be indicated by the presence of one or more of the following symptoms: continued hæmaturia or pyuria, especially when shown by the aid of the segregator or cystoscope to be of renal origin and unilateral; pain and tenderness. The pain may be fixed in the lumbar region, or it may radiate to the groin, testis, or the inner side of the thigh, or it may assume the character of a definite renal colic.

A great number of conditions, both of the kidney and neighbouring organs, may simulate a renal calculus, such as lithiasis, tuberculosis of the kidney, hydronephrosis from stricture or valvular obstruction of the ureter, slight non-tuberculous pyelitis, movable kidney, ureteritis, neuralgia of the kidney, interstitial nephritis, gastric and duodenal ulcer, intestinal adhesions, gall-stones, spinal disease, calculus, tuberculosis and new growth in the bladder, and, finally, appendicitis.

Pathology. Renal calculi may be single or multiple, and they vary in size from minute concretions merely a few grains in weight up to large stones with a weight measurable in ounces. Their contour may be smooth and rounded or nodulated, or speculated or irregular, branching and coral-like. They vary also in consistence.

Pure uric acid calculi are hard, smooth, and yellow or reddish in colour.

Oxalate of lime calculi are very hard with an irregular surface like a mulberry; at other times they are coated with sharp spines or minute nodules: they vary from greyish brown to black in colour.

Phosphatic calculi are white or grey, rough and friable.

The rarer forms of calculi are composed of carbonate of lime, cystine, xanthine. In many cases the calculus is formed of concentric layers of different composition. Stones are practically always situated in the pelvis or calyces, or they may lodge in the ureter itself.

The condition of the kidney varies greatly in cases of calculus. The lesions prese may be caused by the stone or may have been present there previous to the formati of the stone. In these cases the diseased condition of the kidney is responsible for t appearance of the stone, which is known as a *secondary* calculus. In the first ca the lesions may be aseptic, such as nephritis, interstitial nephritis, cystic formati hydronephrosis, lipomatosis; or a septic perinephritis may supervene with or witho suppuration—pyelonephritis and pyonephrosis.

Where the calculus is secondary there is always suppurative pyelonephritis, whi may be accompanied by pyonephrosis and ureteral obstruction.

From the operative standpoint it is most important to recognise that a calculo kidney may first of all be either aseptic or septic. If aseptic, it may present a norm contour or it may be atrophied; not infrequently it is surrounded by a great ov development of fat (lipomatosis), and sometimes it is hydronephrotic. In sept cases there may be an associated perinephritis of the suppurative or non-suppurati type, or the kidney itself may be altered to a greater or less extent by the presen of a pyonephrosis.

Preparatory Details. These have been considered already. In septic cases spec efforts are made to reduce the infection by the administration of urotropine and mine waters, and if practicable the pelvis of the kidney is flushed through a ureteral cathet for several days beforehand. In all operations for stone it is most important to have certain knowledge of the comparative functional value of the two kidneys before oper tion, as in many cases it may be found advisable when the kidney is exposed to chan the plan of operation and perform a nephrectomy. It is also advisable when possib to pass a ureteral bougie or catheter into the pelvis of the affected kidney immediate before operation and leave it there, as it will usually show the presence or absen of a stone or stricture in the ureter; and if the pelvis is much dilated it will facilita the finding of the orifice of the ureter after the kidney has been opened, a manœuv which might otherwise be found impossible.

THE OPERATION. The kidney is approached by the lumbar route in the mann already described. When it has been exposed the further steps of the operati will vary according to the condition of the kidney and its immediate surroundings.

The first case to be considered will be one in which the kidney is but little if at altered in appearance from the normal.

The operative details in such a case resemble those already described under t heading of "Renal Exploration," p. 421.

The kidney is exposed, drawn up into the wound, and palpated carefully. is specially close to the hilum that a hardness may be felt indicating the presence o stone, but this may be merely a mass of sclerosed fat.

Exploration of the Pelvis and Calyces. The pedicle should now be compress by the assistant as far from the kidney as possible, or a clamp may be placed up it if possible without including the ureter.

If a stone can be felt it may be cut down upon directly and extracted, otherw an incision is made along the convex margin of the kidney in the direction of t lower calyx and the finger introduced.

The finger inside the kidney now explores methodically the whole of the inte of the pelvis and the calyces. If there is any difficulty in doing this owing to the ass tant's fingers or the clamp compressing the pedicle, it is better to enlarge the open in the kidney at once with the scissors than bruise or tear the kidney tissue with

fingers. If no stone is found after complete examination of the interior, the whole kidney is palpated between the finger inside and the thumb outside. Then the orifice of the ureter is sought; it will be recognised usually as a small dimple below and in front. The upper end of the ureter is explored with a bougie or a long flexible probe. It is advisable on these occasions to have a good radiogram, as it may accurately direct the renal exploration; but at the same time it is to be noted that stones may be present which are not revealed by the best radiograms.

Extraction of the Calculus.—When the calculus is small and loose it is recognised by the index finger of the left hand, which acts as a guide along which the forceps are introduced. The blades then grasp the stone, and it is extracted.

When the stone is large but regular and loose it may be necessary to enlarge the incision in the kidney to avoid lacerating it during the extraction. It is only in the case of exceptionally large stones that they should be broken up and extracted in pieces owing to the great danger of leaving a fragment behind.

If the stone is large and irregular with branches penetrating the calyces the kidney is freely incised, the septa between the branches being divided. The stone is set free with the finger or a blunt dissector, and only when it is loose should an attempt be made to remove it. If possible a stone should not be broken before removal, as a small piece jointed perhaps to the main mass by a narrow stalk may be left behind. It is advisable to rebuild a broken stone after removal to see that it is complete. If a stone or fragment of a stone is embedded in a calyx the orifice of the latter is dilated with forceps, and then by means of the finger outside the kidney the stone is forced into the pelvis and removed. Occasionally it may be necessary to remove such a stone by another incision made through the overlying kidney tissue.

A rubber tube is introduced into the pelvis, and both it and the calyces are flushed with sterilised water so as to remove small stones or fragments which have been overlooked.

Exploration of the Ureter.—Having cleared the kidney of all stones, it is still absolutely necessary to pass a catheter down the ureter into the bladder. In the case at present under review, where the kidney is nearly normal, there is no difficulty in feeling with the pulp of the finger in the pelvis the round cupped orifice of the ureter, and with it as a guide introducing a flexible catheter into the bladder. This does not absolutely prove that there is not a small calculus in the ureter, but it does show that there is a free exit for the secretion of the kidney to the bladder.

Closure of the Kidney Wound.—Though the kidney may be completely closed in cases where the urine is aseptic, yet it is better practice to drain all cases after nephrolithotomy, at least for a few days, as even in the aseptic cases it prevents the accumulation of clots, and it does not interfere to any material extent with healing and the formation of a good, sound cicatrix. A rubber tube with one lateral eye close to the end is placed in the lower part of the pelvis and sutured to the renal parenchyma. The method of suturing wounds of the kidney has been already described (see p. 426).

The kidney is replaced, any loose pieces of fat are removed, and a drainage tube is introduced below the kidney. The wound is closed by two layers of sutures and room is left for the emergence of the two drainage tubes.

Enlarged Calculous Kidney with an Adherent Fatty Capsule.—When this condition obtains the operation is performed as in the preceding cases with certain necessary modifications.

As a rule it is comparatively easy to expose the kidney in its lower half, but it may

be difficult or impossible to gain access to the upper pole. Subcapsular stripp of the kidney should be avoided if possible as it prevents the kidney from being brou up into the wound ; it makes it difficult or impossible to compress the pedicle, and kidney tissue without its capsular covering is so friable that sutures tear thro it even when tied with the greatest care and gentleness. It may therefore be necess to pack the kidney in order to stop the hæmorrhage. If the difficulty in stripping kidney is caused by its high position under the ribs it may be advisable to rese portion of the twelfth rib and even the eleventh rib as well, taking care to remove th subperiosteally so as to avoid opening the pleura.

If it has been found necessary to decapsulate the kidney the assistant cannot ca the pedicle between his fingers in the usual manner, but he may be able to compres against the psoas muscle by introducing his hand in front of the kidney ; or the opera may compress it in this manner with his left hand while making the incision w his right. As soon as the finger is introduced into the kidney it acts as a tamp and stops further bleeding to a great extent. The bleeding can always be complet controlled by pressing the cut surfaces of the kidney together.

When suturing the decapsulated kidney it is necessary to include any remna of the capsule proper and surrounding fat in the sutures and to avoid tying them tightly so as to prevent the danger of their cutting through the kidney tissue.

Perinephric Lipomatosis and Atrophy of the Kidney.—With these conditi stripping of the kidney may be quite impossible, and it may be necessary to decapsula Compression of the pedicle, also, may be impossible, but it is not so important, owing to the atrophy and fibrosis of the kidney the vessels may be so reduced in s that incision of the kidney even without compression of the pedicle may be alm bloodless.

Cases complicated by Renal Retention.—In these cases it is most important pass a ureteral catheter before the operation, owing to the difficulty that may be exp enced in finding the orifice of the ureter in the enlarged pelvis.

Stripping of the Kidney and Compression of the Pedicle.—As the stripping of t kidney proceeds the size of the gland becomes evident. If the dilatation is marked it not necessary to strip the kidney completely ; its lower and central parts are explor and the incision is made where the tissue feels thinned. Before completing the ope tion it is necessary to discover if the ureteral opening is in the most dependent pa of the pelvic pouch and if its calibre is normal. When the ureteral catheter has be passed before the operation and has entered the pelvis the ureteral opening is eas found and these points determined. If not, great difficulty may be experienced finding the ureteral opening and passing a catheter down into the bladder. If the ope ing leading from the pelvis is in a bad position, or if there is a stricture of the urete further steps must be taken to rectify these defects in order to prevent the occurren of a urinary fistula.

Drainage.—In all cases of nephrolithotomy on septic kidneys it will be necessa to place a large drainage tube in the lumbar wound below the kidney and leave it position for four or five days, the lumbar wound being left for the most part ope Where the perirenal cavity is not large the wound may be closed except for the pla of emergence of the drainage tubes.

Dressings and Post-operative Measures.—It is advisable to leave two drains in

cases of nephrolithotomy, one in the pelvis of the kidney to prevent a spreading infection of the gland or a hæmatonephrosis and the other in the lumbar wound to avoid perinephric suppuration or cellulitis. If all goes well the extrarenal drainage tube may be removed at the end of forty-eight hours, but in septic cases it should be retained for four or five days or even longer. The intrarenal tube should have one lateral eye close to its extremity and should be sufficiently stiff to prevent obliteration of its lumen on drawing the kidney sutures tightly round it. It should be long enough to project beyond the dressings, and after the latter are applied it should be joined by a short piece of glass tubing to another rubber tube which ends in a vessel placed beside the bed. When this tube has been placed obliquely in the renal incision, which is firmly closed around it by sutures, it should be practically watertight, and can be used to wash out the kidney pelvis with sterilised water if this step should be necessary for the removal of blood clots. Where there is infection of the kidney a weak solution of nitrate of silver (1 in 1,000) may be used daily for flushing the pelvis in this manner.

COMMENTS.

Tearing of the Pelvis may be caused in trying to remove a sharp-pointed calculus forcibly through too small an opening in the kidney. Removal of the stone should not be attempted until it has been mobilised and is felt to be free on all sides.

Renal Hæmorrhage.—When the pedicle is well compressed this is not usually of consequence, but where good compression is impossible the bleeding may be alarming. In these cases the incision in the kidney should be just large enough to admit the finger into the pelvis and enable it at the same time to plug the renal wound. The stone is set free completely, and then, the incision having been enlarged, it is extracted as rapidly as possible. If in spite of well-placed sutures bleeding persists gauze may be packed around the kidney so as to press its two halves together. It is not advisable, however, to pack the renal wound with gauze if it can be avoided, because it acts as a capillary drain leading the urine into the dressings. This necessitates frequent changing, and if the kidney is septic it encourages the spread of infection to the perinephric tissues and the wound. Furthermore, when the tampons are removed on the second or third day very severe and even fatal hæmorrhage may occur. Gauze plugging delays the healing of the wound, prolongs convalescence, and increases the liability to the formation of a fistula.

If a vessel of considerable size is wounded it may perhaps be possible to suture it, or in the case of a large vein a lateral ligature may be applied; but in most cases it is probable that nephrectomy will have to be done at a later date.

Difficulties attending Nephrolithotomy.—The calculus when found may be difficult to remove owing to its large size or its branching, coral-like character. It is not advisable to break it, as portions are liable to be left behind to form the nuclei of new calculi. If the stone must be broken a small bone forceps will be found the most useful instrument for this purpose. The softness and friability of phosphatic calculi may make their removal difficult. In these cases the removal may sometimes be best effected with a scoop, and then the cavity should be scraped, flushed out, and drained for a week or more. Multiplicity of stones and their presence in separate loculi may also cause difficulty. The finding of one or even several stones does not absolve the operator from thoroughly completing the exploration of the kidney and ureter.

Suppression of Urine and Uræmia are only liable to happen if both kidneys a extremely diseased, but with the great advancement in our present clinical metho of investigation these conditions should be anticipated and steps taken to guard again them. They should be treated by saline purges, hot packing, saline infusions, ar pilocarpine administered subcutaneously. During the first twenty-four or forty-eig hours after the operation retention may occur and require the passage of a cathet to empty the bladder.

Secondary Renal Retention occasionally supervenes after all has gone well for son days and the tube in the pelvis of the kidney has been removed. In these cases th wound must be opened up again and the kidney freely drained.

Urinary Fistula. Usually as soon as the tube in the kidney is removed urin ceases to escape through the wound, or at most the dressings are soiled only for th first few days; but in other cases, especially where the calculus was associated wi pyonephrosis, a urinary fistula may persist for some months or years. This is n due to the inability of the kidney tissue to heal, but to the fact that the urine cann escape freely by the ureter. In cases, therefore, where this sequela is to be fear a large ureteral catheter should be passed at the end of the operation and left i position. If a fistula does form a ureteral catheter should be passed if possible fro below, and if this cannot be done further operative measures must be undertake to remove the obstruction, or as a last resort nephrectomy may be necessary.

The Question of Nephrectomy. During the operation the question of the advisa bility of removing the kidney is liable to arise in cases where there has been conside able handling of the kidney and it has been found necessary to incise it repeatedl where the stone is very large, branched, or difficult to remove, where there are a grea many stones, where the stone is very soft and friable, where the kidney is greatl altered or to a large extent destroyed by pyo- or hydro-nephrosis, and finall in rare cases where it is certain that a stone exists but the most careful search fai to discover it. Each case must be judged on its own merits, taking into considerati the patient's age and general condition, the length of time already spent or sti required to complete the operation, the condition of the other kidney, the amoun of disease, the number of loculi, the character of their contained pus, and the thinnin of the cortex. As a rule, unless the condition of the patient prohibits it, a *primar* nephrectomy is preferable to a secondary operation for removal owing to the increas in the difficulty of performing a *secondary* nephrectomy caused by the formation adhesions resulting from the first operation.

NEPHROSTOMY.

In this procedure a fistulous connection is established between the kidney and th skin for the purpose of effecting temporary or permanent drainage of the kidney.

Indications. The operation may be performed in the following conditions: calcu lous anuria; some cases of nephritis with suppression of urine or severe hæmorrhage some cases of hydronephrosis and pyonephrosis; rare cases of tuberculous kidne with pyonephrosis. In recent years it has been suggested in cases of ectopia vesic as a preliminary step to certain plastic operations or as a permanent means of ex for the urine.

Nephrostomy in Calculous Anuria.—The precarious condition of an anuric patient makes it necessary to perform a simple and rapid operation with a short anæsthesia eliminating shock as much as possible. The question of spinal or even local anæsthesia may be considered in these cases. It should be remembered that the object of the operation is not to remove the stone but to enable the kidney to resume its function. The nature of the operation will vary with the conditions of the particular case. If it is known which is the principal kidney the operator should expose it by the lumbar route, open the kidney, and, if the patient is in a sufficiently good condition, explore and remove the stone, if found. In grave or late cases, however, it is wiser not to endanger the patient by prolonging the operation but to be satisfied with a simple nephrostomy. If the stone is known to be low down in the ureter it may be removed by a special incision, or a nephrostomy may be performed and the stone removed later. When it is not known which is the principal kidney one gland is exposed by the lumbar route, and if it is found small and atrophied or greatly diseased nephrostomy is performed on the other side. A laparotomy in these cases is not advisable as it may be difficult to find and examine the ureters by this route, especially if the patient is fat. Even if a stone is found in the ureter it is not good practice to remove it through the peritoneum as the contents of the ureter above the stone are likely to be septic and it may be necessary to drain the ureter, for if it is sewn up it may leak. Palpation also of the kidneys through the abdominal wound may mislead the surgeon as the larger kidney may be the one more diseased or *vice versâ*, and even if a correct diagnosis is arrived at by this means it will still be necessary to perform the lumbar operation to drain the kidney and remove the calculus.

The Stages of the Operation are the same as for a simple nephrolithotomy. When one or more stones are in the pelvis they are usually easy to remove. If there is no stone in the pelvis the ureter must be examined. If a stone is found in the first few centimetres of the ureter it can usually be pushed up into the pelvis and removed. If this manœuvre fails ureterotomy must be performed. If the stone is situated lower it is better to leave it. In any case the operation must not be prolonged, and it is better to leave the stone if there is any danger or difficulty in removing it as it may find its own way out in a few days, or it may be removed later by a suitable operation when the patient is in a better condition.

It is advisable to pass a ureteral catheter down into the bladder, even if a stone has been found and removed from the pelvis. This is not usually a difficult matter, as the opening of the ureter is easily found owing to the absence of marked dilatation of the pelvis.

Treatment of the Wound in the Kidney.—Even where the stone has been found and removed and the kidney and ureter appear healthy, it is not advisable to close the wound in the kidney as the only advantage of closing it is the prevention of a urinary fistula, but if the ureter is free the fistula will close rapidly. Drainage, on the other hand, guards against infection and prevents blocking of the ureter by blood clot; also a kidney which is left open is likely to functionate well sooner than one which is completely closed. If the stone has been removed and the kidney is comparatively healthy a large drainage tube may be placed in the pelvis and the kidney wound closed round it as described in "Nephrolithotomy." If, however, the stone has not been removed or the gland is much diseased, the edges of the incision in the kidney should be stitched to the cut edges of the muscles, the whole or greater part of the wound in the kidney being left open for the passage of two or more large drainage tubes which pass from the pelvis to the surface and are packed around with gauze.

After-treatment.—Even after a successful operation it is well to continue th ordinary therapeutic measures, saline injections per rectum, milk diet, purgative and diuretics, as it is not rare to see these cases die in a few days after the operatio in spite of an abundant secretion of urine. The drainage tubes should be left in th kidney for at least a couple of days after the function of the kidney has been thoroughl re-established. They can usually be removed from the fifth to the tenth day, an if the ureter is free the fistula will rapidly close, otherwise it will remain open and furth operative interference may be necessary.

NEPHROSTOMY FOR PYONEPHROSIS.—This pathological condition of th kidney may supervene as the result of an infectious lesion of the lower urinary trac or it may result from septic infection of a pre-existing hydronephrosis.

In the first form the ureter is usually greatly distended and thinned, often tortuous and with valve-like obstructions, or it is greatly thickened without marked distensio of the lumen but rather with narrowing from the increased thickness of the ureter wall. In cases consequent on hydronephrosis there is an obstruction to the escap of the renal secretion owing to the faulty position of the ureteral opening, valv formation between the ureter and pelvis, or kinking or constriction of the urete usually in its upper part. The important fact, from an operative point of view is that in almost all cases of pyonephrosis, from whatever cause, there is obstructio which, unless relieved, leads to a permanent urinary fistula. It is the fear of this whic makes many surgeons prefer nephrectomy to nephrostomy in these cases. Th former is a graver operation and does away with an organ whose function may sti be of great value. There are two forms of fistula which may persist after nephrostomy the one which gives exit to pus only and the other which gives exit to pus and urin Purulent fistulæ are due to faulty technique, as they result from the formation o purulent tracts in the perirenal tissues. They may be prevented from occurring b avoiding extensive stripping of the kidney and soiling of the wound and by th use of antiseptics during or after the operation.

Purulent urinary fistulæ are not due to the failure of the diseased kidney tissue t heal, but to the fact that the secretions of the kidney, pus, and urine cannot escap freely through the ureter, and therefore follow the line of least resistance and escap by the lumbar wound. These fistulæ may be due to—(1) The existence of intrarena loculi not communicating freely with the pelvis. These should be avoided by car in breaking down all septa between the loculi. (2) A calculus, false membrane, o debris blocking the orifice of the ureter more or less completely. These also shoul be avoided by care in the performance of the operation. (3) Faulty attachment o the ureter to the pelvis, causing a valve-like fold between the two. This may b overcome by fixing the kidney in an oblique or almost horizontal position at the end o the operation, or performing a plastic operation on the ureter at the same time a the nephrostomy or at a later date. (4) A kink or stricture of the ureter ; this als may be overcome by a suitable plastic operation.

To prevent the occurrence of these troublesome fistulæ Albarran has recommende that in all cases of nephrostomy a ureteral catheter extending from the kidney pelvi to the external meatus should be placed in position at the end of the operation and le to drain the kidney for several days or even weeks. If passed by the ureteral cysto scope before operation it facilitates the finding of the opening of the ureter during th operation, often a matter of great difficulty owing to the dilatation of the pelvis It allows the pelvic drain to be removed at an early date so that the lumbar wound i usually closed within three weeks ; even if after removal of this ureteral drain rena

retention recurs, no harm has been done, as it is only necessary to open up the lumbar wound again. It has the additional advantage of allowing separation of the urines, with a consequent determination of the functional importance and capacity of the two kidneys.

The Introduction of a Ureteral Catheter as recommended by Albarran is carried out as follows: By means of the catheterising cystoscope a ureteral catheter with rounded end is passed into the ureter on the affected side and pushed onwards until it reaches the pelvis, its entrance here being indicated by the escape of purulent urine. The catheter is now pushed on another 4 or 6 centimetres, as if it just entered the pelvis it might easily be displaced by the movements of the patient. When the catheter is arrested without any fluid escaping it may be stopped in the ureter, or it may have entered the pelvis, the fluid in which is too thick to flow. The cystoscope is withdrawn leaving the catheter in place, and the latter is fastened in position either with plaster to the penis or with silk to the pubic hair. This manœuvre may be carried out before or after the patient has been anæsthetised.

Exploration and Incision of the Kidney.—An extensive exposure of the kidney is not advisable owing to the danger of perirenal suppuration and sloughing of the poorly nourished fatty capsule. It is only necessary to reach the convex border by the shortest route and expose a limited area of the tumour.

If the sac is very large it will be well to empty its contents with the trocar and then wash the interior with sterilised water and nitrate of silver (1 : 1,000) before opening it. Where, however, the kidney is not greatly distended it is sufficient to turn the patient slightly on his back. If the kidney is not adherent to the lumbar wall it will be necessary to guard the whole wound, especially the lower part, with compresses so as to prevent contamination by the escaping contents. The thin portion of the exposed kidney is incised and the left index finger is then introduced through the opening, which may be further enlarged with scissors.

A careful exploration is made with the finger of the various loculi, and the intervening septa between them are broken down so as to convert them all into a single cavity communicating with the pelvis. Their contents—pus, stones, membrane, etc.—are removed and the whole cavity is flushed out with a stream of sterilised water. If the septa are too dense to be broken with the finger they must be divided with scissors. Usually the vessels contained in these septa are for the most part insignificant owing to obliterative changes, but occasionally they bleed freely. If this should happen it may be necessary to apply forceps and ligatures. If the ureteral catheter has been passed before the operation the end of it will be found in the pelvis, otherwise it may be difficult or impossible to feel the orifice of the ureter.

Passage of the Ureteral Catheter.—When the catheter has been passed before operation its end is seized and drawn out through the wound. To the end of this small catheter the proximal end of a No. 12 or No. 13 ureteral catheter is attached, then, having oiled the junction of the two, the surgeon gently pushes the large catheter down the ureter, while the assistant withdraws at an equal rate the small catheter from the bladder. This manœuvre requires gentleness for its success. When the extremity of the larger catheter appears at the external urinary meatus, the assistant removes the small catheter and the surgeon passes a silk thread through the upper eye of the renal extremity of the drainage catheter. This extremity of the catheter should be cut on a slant and have four lateral eyes. It is suitably placed in the pelvis, and

the silk thread attached to it is brought out of the lumbar wound and fastened to th skin with strapping.

Renal and Perirenal Drainage.—If the sac is small one drainage tube is suffi cient, but if large two drainage tubes should be placed in the kidney. The actio of these and of the ureteral catheter should now be tested by flushing the kidney wit nitrate of silver solution (1 per 1,000), first through one and then through the othe tube.

The extremities of the incision in the muscles and skin are sutured in the usua manner, but the central portion is left open and packed with gauze.

After-treatment.—The greater part of the secretion of the kidney, a mixture o pus and urine, will escape by the lumbar drain, and should be conveyed to a receptacl beside the bed. Some will escape by the ureteral catheter and some around th drainage tubes into the dressings. These dressings should be changed once or twic daily and the kidney at the same time should be flushed out with nitrat of silver solution both through the catheter and the lumbar drain. If a perirena drain has been used it may be removed on the fourth or fifth day. The length o time the renal drain has to be retained depends on the character of the discharge As long as this consists of thick pus or while flakes and debris continue to be washe out, it must not be removed, but when only turbid urine escapes it may be dispense with. Generally it may be removed at the end of about a fortnight, but if the uretera catheter has not been placed in position the lumbar drain must be continue usually for months in order to avoid a return of the retention when the fistula closes.

When the ureteral drain is effective it drains the kidney very thoroughly, an practically nothing escapes into the dressings after the lumbar drain has been removed and the wound rapidly heals, the silk thread having been detached and the catheter fastened to the penis with strapping or to the pubic hair. The flushing of the kidney through the catheter should be continued, and after a few days more it may be removed This can generally be done from three weeks to a month after the operation.

The catheter in the ureter is usually well borne, even for this long period. Some times the same catheter may be kept in the whole time; if not, a guide should be intro duced, the catheter removed and a fresh one introduced over the guide, which is then taken out.

COMMENTS.

Impossibility of passing the Ureteral Catheter by the Cystoscope from below.— When the patient cannot be cystoscoped or the catheter is arrested in the ureter a catheter may be passed from above into the bladder during the operation and either left projecting into the bladder — a small lithotrite may be passed, with which the end of the catheter is caught — brought out through the urethra. If, however, the catheter cannot be passed from below or above the operator must be satisfied with lumbar drainage alone (Albarran).

Nephrostomy in Hydronephrosis.—In hydronephrosis the operative steps are exactly the same as in pyonephrosis. There is the same necessity to pass the ureteral catheter so as to avoid the continued presence of a fistula. The sac varies very much in size, but generally has a smooth interior, so that there are no septa to be broken down. Owing to the absence of sepsis there is no special danger of infection, and the

flushing of the kidney and the use of antiseptics during and after the operation are not required.

Nephrostomy in Tuberculous Kidney.—This operation is rarely done, but may be called for in the case of a single kidney which is tuberculous, or for advanced disease in both kidneys complicated by ureteral obstruction. Thorough drainage of the multiple cavities which the gland contains cannot be expected, and the fistula usually persists, partly owing to infection of its walls with the tuberculous process.

The incision in the kidney should be small and no effort made to open up all the pockets. The pelvis is merely opened and the main cavities made to communicate with it. The lumbar wound is left widely open.

Nephrostomy in the Normal Kidney.—Nephrostomy in cases of a normal kidney is a very simple operation and can be rapidly performed.

The kidney is exposed and the pelvis freely opened as described in the operation of exploration. The edges of the incision in the kidney are then sutured to the cut edges of the muscles in front and behind, one or two large drainage tubes are passed into the pelvis, some gauze is packed around them, and the extremities of the incision in the superficial tissues are closed with skin sutures, leaving the central part open, through which emerge the drainage tubes and gauze.

NEPHROPEXY.

PATHOLOGICAL CONSIDERATIONS.—Movable kidney is more frequent in women than in men, and from 85 to 90 per cent. of cases occur on the right side.

The kidney descends alone; the suprarenal capsule never accompanies it, being retained in position by its surrounding fibrous investment. The kidney may remain partly under cover of the ribs or it may be so mobile as to descend entirely below these.

In the condition termed *floating kidney* the gland no longer remains in contact with the posterior abdominal wall, but may descend into the pelvis and pass inwards to or beyond the middle line.

Alterations in the Displaced Kidney.—Slight degrees of renal retention are common. All stages from the retention of a few c.cs. of liquid to huge hydronephroses, which by infection may become pyonephroses, are found. At the operation the pelvis is usually empty in these cases of slight retention, but that there has been retention is shown by the fact that the kidney is softer and more pliable than normal. A slight degree of pyelonephritis is not uncommon.

Nephritis with or without slight albuminuria and cylindruria is nearly constant. The capsule is usually thicker than normal, and presents milky patches adherent to the parenchyma. On stripping the capsule small particles of kidney tissue are torn off. Finally, any affection of the kidney may coexist with its mobility, viz., calculus, cyst, neoplasm, etc.

The Pedicle of the Kidney is longer than normal; the vessels, especially the artery, are lengthened, and the kidney is therefore easily delivered from the wound. Various abnormalities of the vessels may exist. The most frequent is a separate artery to the upper pole.

The Ureter to a certain extent follows the movements of the kidney, but as it is too long owing to the lowering of the gland its upper end presents bends and curves. These may become fixed by the formation of adhesions between the bends and the flow of urine may be interfered with to such an extent that retention may develop. When a part of the ureter becomes less movable and is retained by thread-like adhesions it cannot follow the movements of the kidney. A kink occurs and retention of urine in the pelvis commences before the kink is permanently fixed.

In a certain number of cases of renal retention one finds a kink in the ureter at the point where it is crossed by an abnormal vessel. It may be that the vessel causes the kink, and that this leads to retention and hydronephrosis with subsequent displacement of the kidney. Others consider that as the kidney moves downwards the ureter is kinked by the vessel, which prevents the duct from following the gland. This is the more probable explanation. It is important for the surgeon to know that the abnormal vessels control the blood supply of the lower pole of the kidney, and that gangrene of the part of the gland which they supply may result from their division. This, however, has been denied.

The Intestine.—The kidney as it descends draws down the hepatic flexure of the colon, which is adherent to it, and this may cause angulation of this segment of the bowel and obstruction, followed by distension of the cæcum and perhaps appendicitis and colitis. Enteroptosis and laxity of the abdominal wall not infrequently exist in association with movable kidney.

Exploration of the Kidney and Ureter.—During the operation, even in the most simple cases, the surgeon should inspect and palpate the kidney and pelvis in order to discover possible dilatations due to retention, and examine the upper end of the ureter for kinks, fixed or otherwise, and adhesive bands which obstruct the flow of urine. This can only be done by a liberal incision of the soft parts and by freeing the kidney sufficiently to render its pedicle easy of access.

The Replacement of the Kidney.—If the operator endeavours to place the kidney as high as possible so that only the lower pole comes below the ribs, the organ will often be in a bad position and badly fixed, as a certain degree of ptosis of the liver is often present. If in these cases the kidney is pushed up under the ribs the upper pole glides forwards beneath the liver and the gland becomes anteverted. It is difficult to fix the upper pole to the fascia covering the under-surface of the diaphragm, so it remains loose while the lower pole adheres well to the muscles and remains fixed. The subsequent anteversion of the kidney and dragging on the adhesions causes a recurrence of the pains, and may indicate the necessity for another operation. The kidney should be so placed that the opening of the ureter is in the most dependent position and a free outflow provided for the urine.

Fixation of the Kidney.—The area of adhesion between the kidney and its surroundings should be sufficient to prevent secondary displacements of anteversion or retroversion. To obtain a good fixation it is indispensable that no fatty tissue should remain between the kidney and the fascia on the posterior abdominal wall. The possibility of perfect fixation of the kidney without decapsulation has been proved by autopsy on the patients who have died after operation of intercurrent affections. Proliferation of the fibrous tissue of the capsule only occurs if the kidney is first decapsulated.

Damage to the Renal Parenchyma to be avoided. Sutures of all kinds traversing the kidney substance cause the formation of a zone of sclerosis which may be considerable if the friable kidney tissue is cut or torn. Another inconvenience of renal sutures is that, owing to the variable position of the calyces, one of these may be pierced, and if this happens a fistula may result.

In almost all the operations of fixing the kidney without sutures fixation is obtained by a solid cicatrix, the result of allowing the wound to heal by the formation of granulation tissue. The only advantage of this method is that no injury is done to the kidney tissue, the disadvantages are that the cicatrisation takes a long time (two to three months), the kidney is fixed too low down, it is too superficially placed, and it is not sufficiently protected.

NEPHROPEXY (ALBARRAN'S OPERATION).

Stages of the Operation. *Incision of the Soft Parts.* The usual lumbar incision is made, but it need not be very extensive as the long pedicle of a movable kidney allows of its being readily brought out of the wound and greatly facilitates the examination of the gland and the pelvis of the ureter. In opening the retrorenal aponeurotic pouch the surgeon must not forget the possibility of an abnormal posterior reflection of the peritoneum, and should therefore incise the perirenal fascia very far back under cover of the quadratus lumborum muscle.

FIG. 262.—Nephropexy by the method of Albarran. The right kidney has been exposed by a lumbar incision, and having been drawn into the wound its fibrous capsule has been divided and stripped off the parenchyma in the form of four flaps.

Stripping of the kidney must be carefully and thoroughly done so that all the fatty tissue may be pushed aside and no lobules of fat allowed to remain between the gland and the abdominal wall.

Examination of the Kidney.—It is necessary to explore the kidney and the upper part of the ureter to prevent the possibility of leaving an unrecognised lesion of the kidney or allowing a kink of the ureter to persist. The kidney is brought out of the wound and palpated between the fingers. The fat is stripped from the upper end of the ureter and this is examined for kinks. If one is found the adhesions which cause it are separated, and when the kidney is replaced in position it must be clearly ascertained that the kink has disappeared. If it is obvious that one of the branches of the renal artery has caused a kink of the ureter it may require division between ligatures.

Decapsulation of the Kidney.—While the assistant fixes the kidney the capsule is caught in a dissecting forceps and a small incision made with a knife along its convex

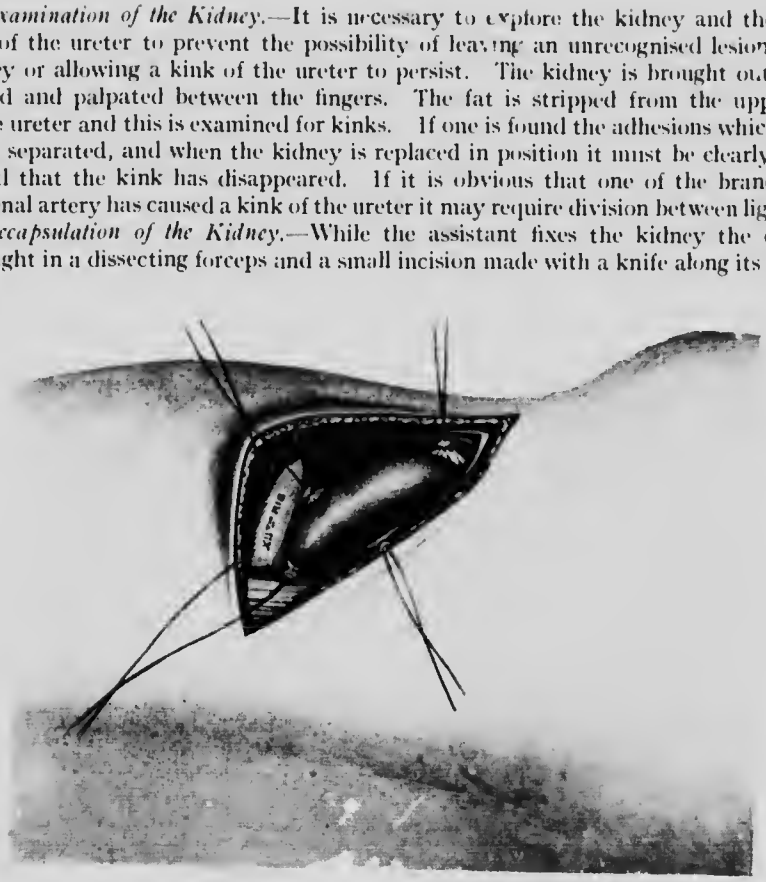

FIG. 203. Nephropexy by the capsule have been ligatured around the twelfth rib and a... rib. ...arran. The four pieces of the renal The upper ligatures have been passed ...n the figure ready to be knotted over the

border, taking care not to cut the ... ...ying kidney tissue (Fig. 202). A grooved director is passed between the capsule and the kidney towards the lower pole and the capsule divided with a knife or scissors; the same manœuvre is repeated towards the upper pole. The capsule is first detached with the director and then with the finger tips from the anterior and posterior surfaces up to the hilum, completely clearing the two poles. The slight oozing which occurs is at once stopped by gentle pressure.

Formation of Capsular Flaps.—While the assistant spreads the anterior flap by holding its two ends the surgeon cuts it in two with scissors from the posterior border to the hilum. Then seizing the cut angle of the capsule with a clip, the assistant presents the upper half to the surgeon while he ties a piece of No. 2 catgut round it close to the hilum. A clip is then placed on the ends of the ligature. He then applies a ligature in the same way on the flap formed by the lower half. The posterior part of the capsule is treated in exactly the same way. Thus four flaps are formed and are tied close to their bases with catgut.

Pushing back the Fatty Capsule.—The kidney is pushed back into the renal fossa. It is essential that no particle of fat remains between the kidney and the abdominal wall. The muscular fibres of the quadratus lumborum are clearly exposed on their anterior surface, and no fat is allowed to intervene between the upper pole of the kidney and the last rib and the diaphragm.

Fixation of the First Ligature to the Last Rib.—With a well-curved needle threaded with one of the ends of the ligature on the upper anterior flap of the capsule the eleventh intercostal space is penetrated from below upwards immediately above the upper border of the last rib. The needle is passed round the rib, keeping close to its anterior aspect, and the point is brought out at its upper border. In the same way one of the

FIG. 261. Nephropexy by the method of Albarran. The four pieces of the renal capsule have been ligatured with catgut, and the two upper ligatures have been made to surround the twelfth rib; the two lower ligatures have been connected with the muscular strata, viz., the transversalis muscle in front, and the quadratus lumborum muscle behind.

ends of the ligature on the upper posterior flap is passed round the rib. The kidney is pushed up under the ribs with the right hand, giving it its proper position, the upper end being hidden by the ribs and almost vertical or inclined slightly forwards. While the surgeon holds the kidney in position the assistant ties first the posterior ligature and then the anterior ligature round the last rib. If the twelfth rib is very short the ligatures may be passed round the eleventh, but it is safer to fix the kidney in these cases to the periosteum and the external arcuate ligament so as to avoid the danger of injuring the pleura in the tenth intercostal space.

Fixation of the Lower Ligatures to the Muscular Wall.—A curved needle threaded with one end of the posterior inferior ligature is passed backwards through the quadratus lumborum muscle, and care is taken not to include the ilio-hypogastric nerve. In the same manner one end of the anterior inferior ligature is passed through the deeper layer of muscle in the anterior margin of the wound. When these two ligatures

have been tied the convex border and a small part of the two surfaces of the kidney will appear at the bottom of the wound.

Suture of the Lumbar Wound.—It is important to see that hæmostasis is complete so as to avoid the occurrence of a hæmatoma, and as a rule it will be advisable to insert a drainage tube for twenty-four hours, seeing that oozing of blood is often abundant. The drain should reach to the lower pole of the kidney. Throughout the whole length of the wound the edges of the muscles and their aponeuroses must be carefully united with interrupted sutures of catgut. The suturing is commenced at the lower angle of the wound because the muscles retract more here, and are readily caught if the upper end of the wound has been already closed. The quadratus lumborum and the transversalis muscles should not be included in these deep sutures as they are already fixed to the kidney, but all the rest of the cut surfaces should be united behind the exposed surface of the gland.

The skin is sutured in the usual way with silkworm gut, carefully approximating the edges.

COMMENTS.

Post-operative Measures.—The head should be kept low without pillows, and the foot of the bed raised. Rest in bed on the back should be continued for three weeks. Four weeks after the operation the patient may go out, but for two months longer she should use an abdominal belt which supports the abdominal contents. Pads designed to retain the kidney in place are not only useless but actually harmful.

Persistence of Symptoms.—When nephropexy has been properly performed and the kidney well fixed it is still possible that some of the symptoms may fail to disappear. It is the nervous symptoms and those which depend on a very marked neurasthenic state which usually persist. Nervous troubles, as a rule, are least improved by the operation.

Digestive troubles persist less frequently, and the pain is the least persistent symptom of the operation.

If the painful crises return it may be assumed that the kidney has not been properly fixed. They may be due to anteversion of the upper pole caused by the liver, or to anteversion of the lower pole pressing on the ureter. By operating according to the above directions recurrence of these painful crises will be avoided. Sometimes patients retain a peculiar sensibility and tenderness—most constant in the region of the kidney, and cannot undertake any fatiguing exercise. Fortunately these cases are rare and are confined to neurasthenic subjects.

THE URETER.

The operative procedures employed in connection with the ureter may be regarded as consisting of two stages, viz., the exposure of the tube by one of the procedures described below and the special measures required for the varying conditions for which the operation is undertaken.

The ureter, like the kidney, may be exposed by the extra- or the trans-peritoneal route, and it will be necessary to consider these according as the part of the ureter affected concerns its lumbar or its intrapelvic stage.

Fig. 205.—Exposure of the Ureter in its lower or pelvic stage by the E[illegible] Route. The tissues of the abdominal wall with the exception of the parietal per[illegible]een divided. The peritoneum covering the iliac fossa has been raised and dr[illegible]s far as the external iliac vessels. The ureter has been exposed as it cr[illegible] iliac artery. The psoas muscle presents distinctly in the wound with the spermatic[illegible] and the genito-crural nerve in relation to its superficial aspect.

EXPOSURE OF THE URETER IN ITS UPPER OR LUMBAR STAGE BY THE EXTRAPERITONEAL ROUTE.—*The Abdominal Incision.*—The patient is placed in the same position as for lumbar nephrectomy, and the same incision made but its lower extremity is prolonged to a point opposite to the anterior superior iliac spine. Should more room be required the incision may be extended inward[illegible]

finger-breadths above Poupart's ligament to the outer border of the rec muscle.

The abdominal tissues will be divided most expeditiously by first deepening wound in the lumbar region down to the level of the extraperitoneal fat and t dividing the remaining tissues from above downwards with stout scissors, the index finger in the wound meanwhile serving as a director. Any vessels which sp are immediately secured by an assistant.

Exposure of the Ureter.—The lower pole of the kidney is cleared. By drawing upwards and backwards and working through the soft fatty tissue below it the ure can usually be exposed without difficulty. The psoas muscle is a valuable deep gui If the peritoneum is drawn outwards to too great an extent the ureter may not readily perceived as it tends to go forwards with the peritoneum rather than rem in contact with the deeper tissues.

The ureter is hooked up with the finger and surrounded with a stout loop of ligature, which enables it to be drawn outwards while the peritoneum is stripped av from it. The loose tissue which surrounds the ureter should not be separated fr it as it contains the vessels by which the ureter is supplied. By retracting the wou margins to the fullest extent the ureter may be followed downwards beyond the po at which it crosses the iliac vessels.

EXPOSURE OF THE URETER IN ITS LOWER OR PELVIC STAGE BY T EXTRAPERITONEAL ROUTE.—The patient lies on the back and the table is stron inclined in the Trendelenburg position.

The Abdominal Incision extends from a point on the lateral aspect of the abdomi wall about 3 inches above the anterior superior spine of the ilium straight downwa and curves inwards at its lower part in the direction of the outer border of the rec muscle, running parallel to and about 1 inch above Poupart's ligament (Fig. 26 Should more room be necessary the incision may be prolonged across the rectus the middle line. The sheath of the muscle is divided and the muscle itself is dra inwards, the deep epigastric vessels being divided between ligatures. This extens of the incision will not be required unless it is desired to expose the ureter quite l down. The method of dividing the muscular strata is similar to that described abo

Exposure of the Ureter.—The peritoneum is raised from the iliac fossa until external iliac artery is exposed. By following the vessel upwards the bifurcation the common iliac artery is reached, and the ureter, which crosses the vessel, is eas identified.

The tendency of the ureter to become displaced forwards with the peritoneu should be borne in mind. With the aid of a blunt needle a loop of silk is passed arou the ureter, and gentle traction is exerted while the latter is being followed downwa to the point at which it is crossed by the vas deferens and still further into the mi of a collection of vessels in the vicinity of its junction with the bladder.

The same mode of exposure is applicable to the female. The ureter is follow downwards to the broad ligament, and on drawing the peritoneum aside the surge recognises the level at which the uterine artery crosses the ureter from without inwar It may be necessary to divide the uterine vessels between ligatures in order to foll the ureter to its vesical extremity.

EXPOSURE OF THE URETER BY THE TRANSPERITONEAL ROUTE. **Lumbar Stage.**—It is only the upper part of the ureter which is readily accessible

this route. Lower down and in the vicinity of the pelvic brim the colic branches of the mesenteric vessels are interposed, and the space between them is too narrow to permit of ready access. The extraperitoneal route is a better mode of approach to the ureter in its lumbar stage.

Pelvic Stage : The Right Ureter. - The patient is placed in the dorsal position

FIG. 266. Exposure of the Right Ureter by the Transperitoneal Route. The abdomen has been opened by a free incision with the patient in the Trendelenburg position. The coils of intestine have been displaced and the ureter exposed by dividing the peritoneum over the bifurcation of the right common iliac artery.

with the table inclined moderately. A median incision is prolonged from the umbilicus to the pubis. The coils of the small intestina are displaced upwards and kept away by means of large compresses. A large broad retractor is placed at the lower angle of the wound. The promontory of the sacrum is a valuable and easily recognised landmark. The bifurcation of the common iliac artery is situated about 1½ inches to its outer side, and about ½ inch still further outwards the ureter will be found crossing

the external iliac artery. At this level the spermatic vessels are a short distance t the outer side of the ureter. In exposing the latter the peritoneum is divided vertical about 2 inches external to the sacral promontory. With a little careful dissection th ureter is isolated and the iliac vessels at the same time safeguarded (Fig. 266).

The Left Ureter.—The pelvic loop of the colon is raised and drawn outward The inner layer of the mesentery is divided at the horizontal level of the sacral pr montory and the ureter is defined at its point of crossing the common iliac arter just before the bifurcation of the vessel.

By most surgeons the extraperitoneal is preferred to the transperitoneal route a it is easier, and the peritoneum is safeguarded from infection in the event of the conten of the ureter being septic.

EXTERNAL URETEROTOMY.

In this procedure the ureter is exposed and its lumen opened for explorator purposes or in order to rectify a constriction or remove a calculus.

Exploratory Ureterotomy.—It may be desired in a case of renal retention to inci the ureter and catheterise it from below upwards or to explore the lower segment the ureter. The extraperitoneal route is usually selected, and the ureter having bee exposed is gently raised and a piece of sterile gauze inserted beneath. The tube lightly compressed above the site selected for the incision either by the fingers of a assistant or by a suitable clamp such as that of Makins for the intestine. The incisio is made longitudinally for a distance of $\frac{1}{2}$ or $\frac{3}{4}$ inch. After the exploration has bee completed the wound in the ureter is closed by three or four interrupted sutures No. 00 catgut, and care is taken not to allow these to pierce the mucous membrane.

Ureterotomy for Constrictions of the Ureter.—The usual site for this operation the upper part of the ureter where it expands into the pelvis (uretero-pyelotomy). may, however, be required lower down. The steps of the operation are as follows The ureter is exposed in the manner already described, a compress is passed beneat it and a suitable clamp is applied above the constricted part. The tube is now incise longitudinally and the line of section extended through the stricture and for a shor distance along the ureter on each side of this. The elongated aperture is closed b interrupted sutures of No. 00 catgut, and these are passed from above downwards i such a way that the wound from having a longitudinal direction becomes transvers (Fig. 267). The first suture connects the upper angle of the wound with the lowe The next sutures are placed at the lateral angles and the remainder between thes and the median suture. It is not advisable to suture the adjoining tissues over th closed ureter, as this might lead to the formation of a mass of scar tissue, which b its hardness and constricting tendencies might compress the ureter. A drainage tub is brought into close proximity with the ureter and the abdominal wound is closed.

URETERORRAPHY; URETERO-URETEROSTOMY.

Ureterorraphy signifies the procedure of suturing a wound of the ureter whic does not involve its entire circumference.

Uretero-ureterostomy is the procedure employed to effect the junction of th proximal and distal extremities of a ureter which has been completely divided.

Wounds of the Ureter are usually caused accidentally, more especially in connection with operations upon the pelvic organs in the female. Adhesions are often present in these cases, and the ureter may be displaced by large uterine tumours.

The wounds vary in direction: they may be longitudinal, transverse or oblique. In the first case the wound margins tend to remain in contact, but in the others the margins gape more or less. After complete division the two ends separate, but not to any considerable extent.

A wound of the ureter is invariably followed by an urinary fistula which has a marked tendency to persist. The fistulous aperture may contract; an ascending infection too is liable to supervene, and under such conditions retention of urine and septic infection of the kidney are almost certain to result.

URETERORRAPHY.—Assuming that a wound of the ureter is recognised during the course of some intra-abdominal procedure, the best method to adopt for the closure of the wound is as follows: The ureter is compressed above the site of the wound by

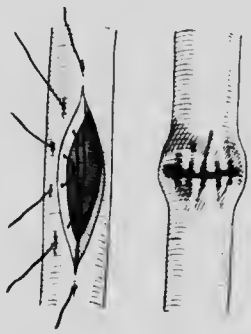

Fig. 267.—Mode of suturing a longitudinal wound of the ureter (Albarran).

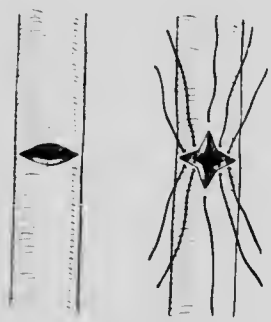

Fig. 268.—Mode of suturing a transverse wound of the ureter (Van Hook).

suitable forceps or by the fingers of an assistant, and it is isolated to the necessary extent to enable the suturing process to be carried out without inconvenience.

Mode of suturing the Divided Ureter.—Catgut, size No. 00, is the most suitable form of suturing material, and is employed with fine, fully curved intestinal needles.

1. *Longitudinal Wounds.*—Unless the ureter is dilated, when the wound margins may be united in the longitudinal axis of the ureter, it is better to introduce the sutures in such a way as to convert the longitudinal wound into one directed transversely. The first suture connects the upper and lower angles of the wound. The next sutures are placed at the lateral angles, and between these and the median suture a few additional ones are placed. This method of suturing has the advantage of preventing narrowing of the lumen of the tube.

2. *Oblique or Transverse Wounds.*—In the case of oblique or transverse wounds direct union of the wound margins would have the effect of producing a ridge projecting into the lumen and narrowing it. To overcome this objection the procedure of Van Hook is to be recommended. It consists in making a short incision on each side of the transverse cut and in the long axis of the ureter as represented in Fig. 268. The upper and lower angles are connected by suture and the remainder of the wound is closed in the transverse direction.

Suture of the Peritoneum : Drainage.—The peritoneal wound is closed over th sutured ureter, fine catgut being employed for the purpose, and a drainage tube i brought into close proximity with the ureter at the wound site. In the female drainag by the vagina may be employed when the ureter is wounded low down near its vesica extremity.

URETERO-URETEROSTOMY.—The mode of procedure will depend upon whethe the division of the ureter has or has not been accompanied by loss of substance. Th following operation is applicable to cases in which the ureter retains its normal length It is a modification by Albarran of the method of junction originally described by Poggi, and the manner in which it is carried out will be readily understood by a refer ence to the adjoining figures. The divided ends having been clearly exposed, th upper segment of the ureter is lightly compressed. From the divided margin of th lower segment an incision is made in its long axis for about $\frac{1}{8}$ inch ; it helps to enlarg the aperture and permit of the invagination of the upper segment into it. A loop o

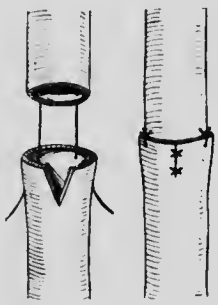

Fig. 269.—Uretero-ureterostomy by the method of Albarran.

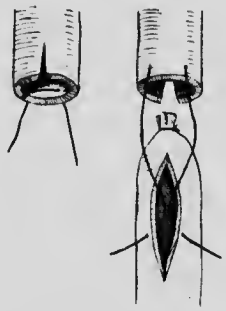

Fig. 270. Uretero-ureterostomy by the method of Van Hook.

catgut suture, No. 00, is passed into the upper segment. The loop lies within th lumen of the tube and its free extremities are made to pass through the walls of th lower segment from within outwards just below the extremity of the longitudina incision and exactly opposite to this (Fig. 269). By drawing on the free ends of th suture the upper segment of the ureter is invaginated into the lower and the end of the suture are knotted. A few additional sutures are passed to close the smal longitudinal wound ; these sutures at the same time are made to pick up the wall o the invaginated segment.

Uretero-Ureterostomy by the Method of Van Hook.—The distal extremity of th divided ureter is occluded by a ligature, and a longitudinal incision is then made int it just beyond the ligature, the length of the incision being about $\frac{1}{2}$ inch. Th proximal gment of the ureter is now divided longitudinally for about $\frac{1}{4}$ inch, com mencing at its cut margin. This precaution is taken in order to ensure the patency of the tube after being invaginated. A suture of fine catgut is passed as represented in Fig. 270 into the upper segment so as to form a U-shaped loop, the end of the latte lying within the tube. The two free extremities of the suture are made to traverse th distal segment of the ureter from within outwards at a slightly lower level than th distal end of the longitudinal slit. By drawing on the free ends the proximal i

invaginated into the distal segment, whereupon the two ends of the suture are knotted. Finally the anastomosis is completed by suturing the margins of the longitudinal wound.

COMMENTS.

Objections to reinforcing Sutures.—Following the practice which has been attended by marked success in intestinal junctions, an attempt might be made in ureteral anastomosis to reinforce the line of junction by additional sutures which engage the surrounding tissues. Such sutures are not to be recommended, as they might promote the formation of a mass of hard tissue around the ureter sufficient to obstruct its lumen.

Urinary Fistulæ.—These are by no means uncommon after operations upon the ureter, and in view of the likelihood of their occurrence one should not neglect to introduce a drainage tube from the abdominal wound down to the sutured ureter and allow it to remain *in situ* for four or five days. If a fistula should occur it may close spontaneously, but it sometimes persists and is followed by renal retention and septic changes in the kidney, which may subsequently necessitate nephrectomy.

URETERO-LITHOTOMY.

Ureteral Calculi.—The more common levels at which calculi are arrested within the ureter are in the vicinity of the renal pelvis above and near the bladder below, or actually in the intravesical stage of the ureter.

Condition of the Ureter.—Where the impaction is of recent date and the urine free from infective changes the condition of the ureter may be but slightly altered. Soon, however, the ureter above becomes dilated, and a calculous hydronephrosis may develop. When the contents of the ureter are septic the walls of the tube become inflamed and thickened and there is a surrounding periureteritis. Perforation of the ureter may take place. The ureter above the calculus is dilated and tortuous and its walls thickened, and as a result of surrounding inflammation there is a tendency to the formation of a quantity of fibro-fatty tissue which renders it fixed and rigid (sclerosing lipomatosis). The kidney suffers from urinary retention, and a pyonephrosis is the usual outcome of obstruction and urinary infection.

Operative Considerations.—The aim of surgical treatment is to remove the obstructing calculus and restore the normal patency of the ureter. A favourable result, however, may be interfered with by a subsequent stricture or fistula and ultimate renal retention.

Steps of the Operation.—*The Introduction of a Ureteral Sound* is advisable in cases in which a calculus is retained in the upper part of the ureter. The sound is usually arrested when it reaches the calculus, but it may slip onwards and reach the renal pelvis. A sound in the ureter greatly facilitates its recognition.

Exposure of the Ureter (*Extraperitoneal*).—This is done in the manner described above. When the ureter has been exposed it is manipulated gently and not stripped to a large extent of its surrounding tissues, as this might interfere with its blood supply.

Division of the Ureter and Extraction of the Calculus.—The ureter above the calculus is first compressed by means of a suitable clamp. The incision into the ureter is best made above the seat of obstruction, because the tube is dilated here and its tissues are in a better condition for retaining sutures. The incision commences at the upper limit of the calculus and is carried upwards to the necessary extent. Should the calculus be retained rather low down in the ureter it may be possible to push it upwards and extract it through an opening at a much higher level. Careful manipulation is essential in extracting the calculus. If irregular in outline it may be first mobilised with a blunt instrument and then extracted with forceps. It is advisable to explore the lumen of the ureter after the stone has been removed, and this may be done by means of a flexible bougie, which is passed from the wound first upwards to the kidney and then downwards to the bladder.

Suture of the Wound in the Ureter: Drainage.—The sutures are introduced with the precautions already given. Albarran recommends the introduction of a ureteral catheter and its retention while the wound is healing. A drainage tube is passed down close to the sutured ureter and is led away from the abdominal wound at its most dependent part.

TRANSPERITONEAL URETERO-LITHOTOMY.—Exposure and division of the ureter from within the peritoneal cavity has not been frequently performed in consequence of the generally accepted belief that it incurs the risk of infecting the peritoneum and subsequent leakage of urine. In a valuable paper by Sinclair White, of Sheffield (*British Medical Journal*, January, 1910), the advantages of this operation have been clearly indicated. He points out that the urine in most cases of impacted ureteral calculi is sterile, and that when it is not so the virulence of the organisms it contains is no greater than that of those found in a suppurating appendix or in a pyosalpinx, lesions which when dealt with by modern methods have scarcely a mortality. "With proper technique a wound in the ureter—even in the pelvic ureter—is almost as easily closed by suturing as a wound in the large intestine, while it is infinitely less likely to reopen from subsequent tension on the sutures. In all extraperitoneal operations the surgeon works at the bottom of a deep and narrow wound, where space and light are at a minimum and the accurate placing of sutures well-nigh an impossibility."

If the patient is placed in the exaggerated Trendelenburg position and a median incision made below the umbilicus, the intestines are easily displaced from within the pelvic cavity and walled off by towels. "If retractors are now used to separate widely the edges of the abdominal wound, a clear and uninterrupted view is obtained of the line of the right ureter throughout its lower two-thirds, while the line of the left ureter can be almost equally well observed if the meso-sigmoid is displaced inwards below and outwards above the pelvic brim. The stone can usually be displaced up to the pelvic brim, which is the most convenient place from which to extract it."

The technique adopted is as follows: The portion of the ureter about to be opened is surrounded with gauze and the peritoneum divided over it; the stone is next grasped between the fingers and the thumb of the left hand, and while so held the ureter is cleanly divided over it in a vertical direction. Should there be any leakage this is at once mopped up. The wound in the ureter is closed by two or more fine catgut sutures passed after the method of Lembert. These, while just missing the mucous membrane, secure firm and accurate apposition of the cut edges, which are slightly inverted. The small opening in the peritoneum is sutured in the usual way, and after removal of the gauze and towels the abdomen is closed without drainage.

"Owing to the inverted posture of the patient and to the fact that the intraperitoneal manipulations temporarily inhibit the renal functions, there is usually no escape of urine when the ureter is incised, but if there should be any reason for dreading this the ureter above and below the site of operation may be temporarily occluded by ligatures.

"In cases of pyonephrosis and hydronephrosis where the ureter is distended and tense, it should be aspirated and temporary ligatures applied before opening it."

If drainage of the operation area is thought to be desirable it can be readily and efficiently provided through a small opening in the flank, the drainage tube ending just short of the place where the ureter has been incised and, of course, extraperitoneally. Where drainage is contemplated the stone should be pushed up as high as the level of the iliac crest before it is removed.

The advantages claimed by Sinclair White for transperitoneal uretero-lithotomy are :—

1. That it, and it alone, enables us to clear up doubtful diagnoses. Thus in the second of his cases the patient complained chiefly of pain on the left side, and although the X-rays left no doubt as to the presence of calculi in the right ureter they also revealed a fairly well developed shadow on the left side. Intraperitoneal palpation showed the left ureter to be free from a calculus, while the origin of the shadow of the pseudo-calculus was traced to a calcified mesenteric gland.

2. It is a less difficult operation than any of the extraperitoneal procedures.

3. It ensures plenty of room and an abundance of light, and the operator is able to carry out the steps it entails with little or no disturbance of the surrounding parts, and with an amount of precision quite unattainable by any other method.

THE BLADDER.

SUPRAPUBIC CYSTOTOMY.

Indications.—This procedure is mainly indicated in the following conditions : (*a*) calculi in the bladder ; (*b*) some vesical growths ; (*c*) senile enlargement of the prostate ; (*d*) certain cases of cystitis which require drainage.

Preliminary Measures.—If time permits it is always advisable to devote some days to the treatment of cystitis which so frequently exists, and for this purpose certain urinary antiseptics, such as urotropin, may be given by the mouth, and the bladder washed out two or three times daily, more especially if the natural efforts to empty it are inefficient.

The Operation.—The bl[illegible] is washed out after the patient has been placed upon the operating table, and [illegible] weak boracic lotion is introduced through a funnel and tube or by means of a sy[illegible]ge. The amount of the fluid depends upon the capacity and degree of sensibility of the bladder, but it usually varies from 8 to 12 ounces. Some surgeons prefer to distend the bladder with air.

Before proceeding to expose the bladder the table is moderately inclined in the Trendelenburg position. The usual measures are adopted for the cleansing and disinfection of the skin.

Exposure of the Bladder.—The cutaneous incision accurately follows the middle line and measures from 3 to 4 inches in length, its lower extremity just exceeding the

upper border of the symphysis pubis. The superficial tissues having been divide
the incision is deepened between the recti and pyramidales muscles, and in doing
the symphysis is clearly defined. The transversalis fascia which has an attachme
to the back of the symphysis is divided, whereupon the finger is introduced into t
lower angle of the wound to define the bladder and at the same time push up t
vesico-pubic reflection of the peritoneum. The manipulations are facilitated
applying retr tors with which the assistant draws aside the wound margins.

Should the finger in the prevesical space detect the bladder but partially distend
and somewhat flaccid it may be brought up more fully into the wound by introduci
an additional amount of fluid by the catheter, or if air has been already introduc

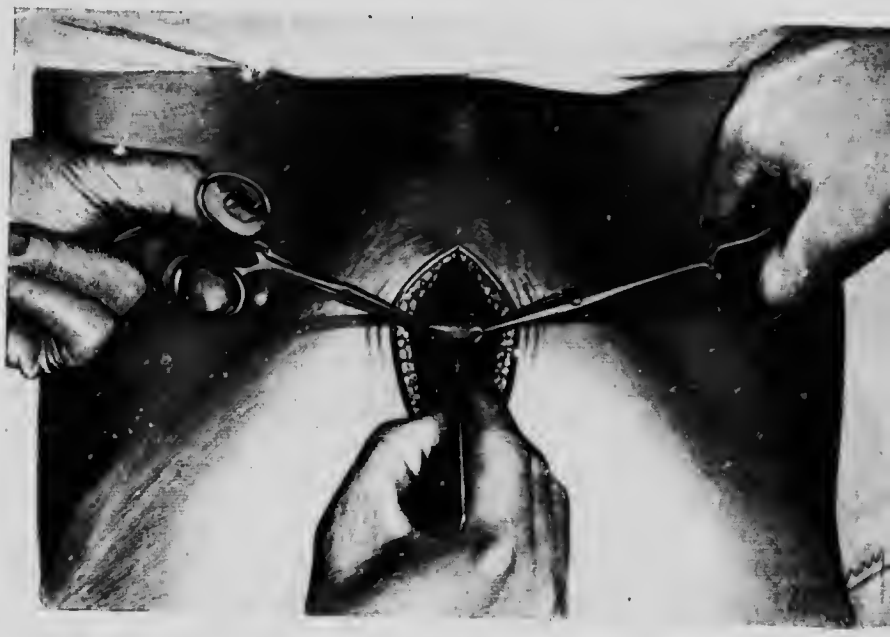

FIG. 271.—Suprapubic Cystotomy. The bladder has been exposed by a median incision above the pubic symphysis. The vesico-pubic reflection of the peritoneum has been raised, and the bladder having been seized with clip forceps, is about to be opened by a stab wound.

some more may now be pumped in, the exact amount necessary being determined b
the index finger of the surgeon in the wound.

It is not advisable to make a broad exposure of the bladder and open up that par
of the prevesical space which lies behind the symphysis. The incision is made in tha
part of the bladder which lies behind the anterior abdominal wall.

Incision of the Bladder.—The bladder is easily recognised by its distinct muscula
wall, and the vesical veins which descend towards the pubis are sometimes very distinct
The incision may be performed by plunging the scalpel boldly into the bladder whil
the peritoneum is held out of the way with the left index finger and cutting downward
towards the symphysis, obvious veins being carefully avoided. The vesical apertur
should be sufficient to admit the index finger. Sometimes the incision of the bladde
is facilitated by seizing its wall with two pairs of hæmostatic forceps and cuttin
between these (Fig. 271).

The margins of the bladder aperture are seized on each side with forceps after the first gush of fluid has taken place.

Intravesical Procedures.—These vary with the nature of the case. Inspection of the interior of the bladder demands a wide aperture and good retraction of the margins of the wound. Artificial light provided by a head lamp with mirror attached may greatly facilitate this mode of investigation.

The extraction of calculi is usually easy unless they are of large size. It is better to extend the incision in the bladder than try by forcible manipulations to extract calculi through a small aperture and at the same time bruise and lacerate the tissues. Should a calculus break in the attempt to remove it great care should be taken not to leave any fragments behind.

Suture of the Bladder: Drainage.—An important question for decision at this stage is whether the bladder wound should or should not be completely closed. When circumstances permit the bladder wound should certainly be closed and the bladder drained by means of a catheter in the urethra.

The chief circumstances which contra-indicate the closure of the bladder are cystitis and obstruction to the urinary outflow along the urethra, such as may be caused by a stricture or an enlarged prostate.

Should it be decided to close the vesical wound the drainage catheter must first be introduced. Its extremity should not project far into the bladder but merely for a short distance within the meatus internus. A full-sized, soft rubber catheter is well adapted for this purpose.

The bladder sutures are arranged in two rows, and catgut should invariably be employed. The first row of sutures traverses the muscular and submucous layers of the bladder wall on each side; the mucous membrane should not be included. This first row may take the form of a continuous line of suture or the sutures may be interrupted. The second row of sutures is of the Lembert type, as employed in intestinal surgery. The individual sutures do not enter the cavity of the bladder; they invert the sutures of the first row. Before the bladder is closed it should be ascertained that the catheter acts properly and that its eye is not blocked with a fragment of blood clot.

FIG. 272.—Method of effecting Suprapubic Drainage of the Bladder. A piece of rubber tubing has been introduced, and the aperture in the bladder has been closed, except at the site of emergence of the tube, by two rows of sutures. The first sutures connect the cut margins of the muscular coat, and those of the second series are introduced on the principle of Lembert's sutures, *i.e.*, they pick up a small portion of the muscular coat of the bladder on each side of the wound and invaginate the first suture line. The sutures at the upper and lower angles of the wound connect the bladder with the deepest fibres of the rectus muscle on each side; they help to shut off the prevesical space, and prevent urinary infiltration of the loose tissues in this region.

Suprapubic Drainage.—In the event of drainage being necessary, the bladder

wound is closed from its upper angle down to where the tube emerges. The tu drains the bladder and facilitates the process of washing out the viscus. This most readily accomplished by allowing the fluid to enter the bladder by a cathet and escape by the suprapubic tube.

The Abdominal Wound may be partially or completely closed according as the bladd wound is sutured in its entire extent or utilised for drainage. When the entire abd minal wound is sutured it is advisable to introduce a drain down to the level of t bladder, lest leakage should occur in the prevesical space. If the bladd wound is sutured carefully above t point of emergence of the tube the urin will be prevented from soaking into t dressings and can be led away by mea of an additional piece of tubing to suitable receptacle.

Fig. 273.—Suprapubic Drainage of the Bladder. A piece of rubber tubing has been fixed in the bladder as represented in Fig. 272, and the suprapubic wound has been closed, except where the tube emerges. One end of a bent piece of glass tubing has been introduced into the bladder tube, and from its other extremity a long piece of rubber tubing leads away to a suitable receptacle.

SUPRAPUBIC CYSTOTOMY BY TRANSVERSE INCISION.—The incisio in the superficial tissues extends trans versely just above the symphysis an measures about 4 inches in length. It outer extremities curve upwards some what so as to avoid the inguinal ring The recti muscles and their aponeuroti coverings are divided a short distanc above their bony attachments so tha a sufficient amount of tissue may b left below the plane of section t permit of careful and efficient suturing The prevesical fat is exposed and displaced upwards beneath the upper margin of th wound, the peritoneal reflection being pushed away at the same time.

The bladder is divided transversely in its suprapubic area, and by means of suitabl retractors its cavity may be rendered accessible to sight and touch.

PERINEAL LITHOTOMY.—The steps of this procedure are fully described i connection with perineal prostatectomy by a median incision (p. 487).

THE PROSTATE.

SENILE ENLARGEMENT.

ANATOMY.—The normal prostate in the adult surrounds the commencement o the urethra. It is intimately connected with the bladder above, with the pelvi connective tissue and fascial layers in front, behind, and at the sides. At its apex it comes into relation with the deep layer of the triangular ligament.

The anterior aspect of the prostate is separated from the symphysis pubis by some of the retropubic fatty tissue; it derives a covering from the pubo-prostatic liga ments which belong to the visceral subdivision of the pelvic fascia, and the urethra emerges from it just in front of the apex. The posterior surface of the prostate i

much more extensive; it presents a shallow groove directed vertically, and is quite smooth. It is invested by the recto-vesical fascia, and is separated by it from the anterior bend of the rectum immediately above the anal canal. The lateral aspect of the prostate on each side presents a rounded border which fails to reach the bladder above, being separated from it by a deep sulcus, in which are lodged the greater number of the veins which constitute the vesico-prostatic plexus. This aspect of the prostate lies in contact with the pelvic fascia which clothes the levator ani muscle. The entire prostate in fact is encased within a distinct membranous capsule derived from the

Fig. 274.—The Normal Prostate viewed from behind. This figure has been drawn from a model of the prostate prepared by Professor A. F. Dixon, Trinity College, Dublin. The right seminal vesicle and the corresponding vas deferens are seen disappearing into the prostatic sinus which is situated at the upper limit of the posterior aspect of the prostate. The left seminal vesicle and its companion vas deferens have been removed. That part of the prostate in front of the prostatic sinus is known as its prespermatic, that behind, as its retrospermatic segment

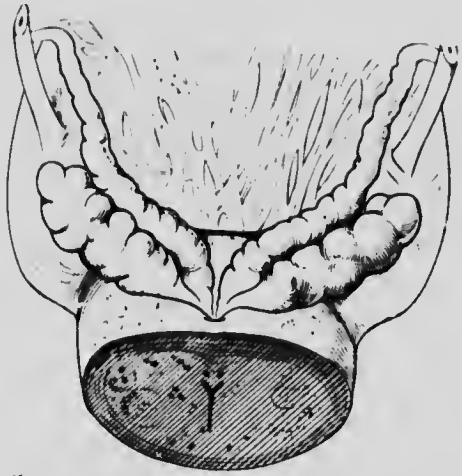

Fig. 275.—The Adenomatous Prostate viewed from behind. This figure presents a marked contrast with Fig. 274. The prostatic sinus, where the seminal vesicles and the vasa deferentia enter the prostate is not situated at the upper level of its posterior surface, but at some distance lower down. This altered relationship is due to the great development of the prespermatic portion of the prostate in the adenomatous form of enlargement (see Fig. 277).

pelvic fascia and which is usually referred to as the *prostatic capsule*. The large veins of the prostatic plexus also lie within this fascial envelope.

Its anterior or preurethral segment forms about one-third of the entire mass of the prostate, and is mainly composed of smooth muscular tissue. The retrourethral segment presents an upper smaller division, the so-called "middle lobe," or prespermatic portion, and a lower or retrospermatic portion which is situated below and behind the common ejaculatory ducts and usually contains a considerable amount of glandular tissue.

When the prostate is removed in the cadaver and the investing tissues dissected away the chief points deserving of note are the deep sulcus at its junction with the bladder and the relationships above and behind of the vasa deferentia and the seminal

vesicles. The common ejaculatory ducts enter the prostate at the rid[illegible] which mar
the upper limit of its posterior surface. The space which they enter is known as t
prostatic sinus, and they traverse the organ obliquely in the direction of the ver
montanum or the prominent ridge of mucous membrane which is situated upon t
posterior wall of the urethra (Fig. 277). Certain points in the general anatomy
the prostate may be observed on section of the organ both in the antero-posterior a
horizontal directions.

The Prostate in Sagittal Section.—This section shows the normal vertical directi

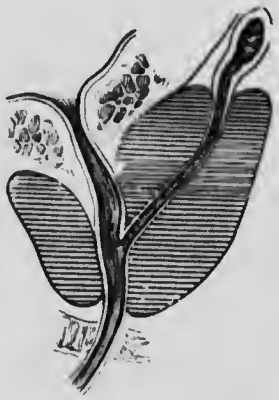

FIG. 276.—The Normal Prostate in Sagittal Section. The prostate presents a portion in front of the urethra, but its main mass which is situated behind this consists of two subdivisions which have been named respectively, its prespermatic, and its retrospermatic portions. The common ejaculatory duct, represented in the figure, serves to separate these two portions. It is to be noted that the seminal duct enters the prostate behind at the upper limit of its posterior surface, viz., at the prostatic sinus (see Fig. 274).

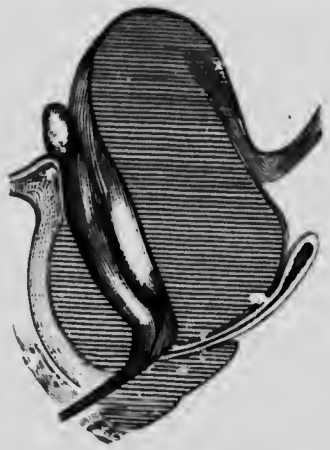

FIG. 277.—The Adenomatous Prostate in Sagittal Section. The subdivisions of the prostate situated behind the urethra have undergone a marked change. The prespermatic segment has increased in size to a considerable extent, but the retrospermatic segment appears to have appreciably diminished. The seminal duct does not enter the bladder at the level of the vesico-prostatic junction as in Fig. 276, but at some distance lower down. The urethra has undergone a marked degree of elongation and it presents a sharp antero-posterior curve, the summit of the latter corresponding to the position of the verumontanum and the openings of the seminal ducts.

and extent of the prostatic urethra, also the two main portions of the organ, whic
are situated respectively in front of and behind the urethra (Fig. 276). The part behin
the urethra is traversed by the common ejaculatory ducts, and on sagittal sectio
these divide the posterior segment of the prostate into two parts, an upper or *presper
matic* and a lower or *retrospermatic* portion. The first of these is related to the bladde
floor above and to the supramontanal portion of the prostatic urethra in front. The
lower portion is related in front to that part of the prostatic urethra which extend
between the verumontanum and the triangular ligament. In the more frequent form
of prostatic enlargement the upper or prespermatic part is the one which is mainly i
not entirely involved; it may reach an enormous size, with the result that the sper

matic ducts and the prostatic tissue behind these are pressed downwards and backwards to a considerable extent.

The Prostate in Horizontal Section. If a horizontal section of the normal prostate be made near its vesical aspect the following parts may be observed: the canal of the urethra, surrounded by the circularly arranged bundles of the internal sphincter muscle. The spermatic ducts lie near the posterior border of the section, and the interval between these and the urethra is occupied by the prespermatic portion of the posterior segment of the prostate; as represented in the section it appears as a commissure connecting the two lateral lobes of the prostate behind the urethra. The contour of the lateral lobes is distinct, and with the naked eye it is possible to differen-

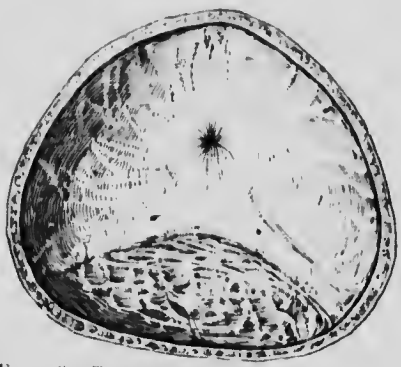

FIG. 278.—The Floor of the Normal Bladder. The meatus internus of the urethra is surrounded by a slightly raised margin caused by the internal sphincter. The openings of the ureters are seen further back. Each opens on the summit of a ridge, and between the two, there is the well-pronounced interureteric fold. The smooth, flat, triangular area bounded by the meatus internus in front, and by the openings of the ureters behind is known as the trigone; it overlies the base of the prostate, and may consequently be termed the prostatic area of the bladder floor.

FIG. 279.—An Adenomatous Prostate viewed from within the Bladder. The prostatic area of the bladder floor presents ... upwardly projecting masses ... smallest is situated in front ... meatus internus, and the ... der are arranged behind ... on each side of the aperture ... completely occupy the ... the trigone and abut posteriorly upon the openings of the ureters and the interureteric fold.

tiate its glandular from its fibro-myomatous elements. A layer of unstriated muscle surrounds the prostate at its periphery, and outside this will be noted the large venous prostatic plexus, surrounded externally by a membranous investment derived from the pelvic fascia.

The Structure of the Prostate.—The prostate is largely composed of unstriped muscular tissue. This latter together with some connective tissue exclusively forms its outer cortical layer, and sends a large number of processes inwards which are connected with a central collection of unstriped muscle fibres surrounding the urethra and stretching across the middle line from one side to the other in front of it, the internal sphincter. In addition to its muscular element the prostate contains a varying proportion of glandular tissue. The fully developed prostatic glands are divided into two groups, viz., the *periurethral* and the *lateral* prostatic glands. Above the level of the verumontanum these gland groups seem fairly distinct, being separated

by the unstriped fibres of the internal sphincter muscle. According to Cuneo it wou appear that in the development of the senile enlarged prostate the adenomato masses are formed mainly if not entirely from the periurethral glands, more particul those of the supramontanal or prespermatic segment of the urethra, and that t lateral prostatic glands do not play an important part, but are rather compressed a to a large extent obliterated. According to Cuneo's view the greater part of the norm prostatic tissue is expanded and pushed aside by the periurethral adenomatous mass and is not removed in the process of enucleatio such as is performed in the modern suprapul operation.

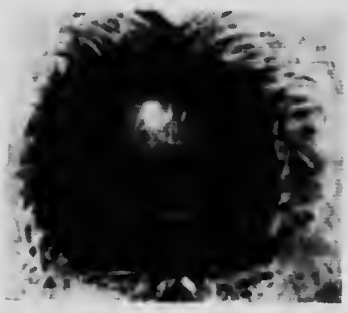

FIG. 280.—An Adenomatous Prostate viewed from within the Bladder. The prespermatic portion of the prostate, sometimes alluded to as the "middle lobe," has undergone a marked degree of enlargement and projects upwards into the bladder in the form of a smooth, hemispherical mass with a tendency to advance forwards and overhang the orifice of the urethra. A catheter has been passed through the latter, and made to project for a short distance into the cavity of the bladder. The orifices of the ureters and the interureteric fold are seen behind the adenomatous mass. The muscular coat of the bladder has undergone a marked degree of hypertrophy.

PATHOLOGY. The Enlarged Prostate. T nature of the enlargement varies according as t glandular or fibro-myomatous element of t prostate participates mainly in its productio Although the types of enlargement are n always capable of being sharply differentiate yet it is possible to divide them into two ma groups, (*a*) the adenomatous and (*b*) the fibr myomatous.

The Adenomatous Prostate is the more fr quently observed type, and it is the form enlargement which is particularly well suited f removal by enucleation.

The nature of the adenomatous prostate w be most readily understood by first noting th appearances which may be observed in a specime removed from the cadaver. In typical examp the following investigation will prove instructive:

The Adenomatous Prostate viewed from with the Bladder.—The general level of the prostat area of the bladder floor is raised and behind it a depression is often noted The area surrounding the urethra may appear uniformly raised, but more frequentl it presents one or more upwardly projecting masses separated by grooves o varying depth, or these may be more or less confluent and present the appearan of a thick rounded lip surrounding a crater-like cavity which leads into the urethra the sensation conveyed by it to the examining finger being not unlike that of a larg and patulous cervix uteri.

When a single projecting mass only is observed it usually occupies the middl line behind the urethra, and as it develops it tends to advance from behind forward over the meatus so as to conceal it partially or completely from view. These varyin appearances are clearly represented in the specimens figured in the text (Figs. 277 280).

The Adenomatous Prostate viewed after the Surrounding Tissues have been dissected away.—The greatly increased bulk of the prostate will be very obvious. In th normal prostate the spermatic ducts enter it behind at the level of the vesico-prostati sulcus (Fig. 274), but in the adenomatous specimen this sulcus is separated by

considerable vertical distance from the ducts owing to the great upward development of the prespermatic prostatic segment (Fig. 275). The ducts together with the retrospermatic segment have come to occupy a lower level; this latter segment, too, will not be found to have undergone adenomatous enlargement, but rather to have been pushed aside in a downward and backward direction.

The Adenomatous Prostate in Sagittal Section. A section in this plane contrasts forcibly with a similar section through the normal prostate. The diagram represented in Fig. 277 will serve to illustrate the changes which have taken place. These are most evident in the increased length and the degree of curvature of the prostatic urethra and in the marked development of the prespermatic portion of the prostate. This part has increased greatly in size, and has advanced upwards towards the bladder in the manner already noted and forwards so as to overlie the internal orifice of the urethra. Behind this upward growth of the prostate the bladder floor is depressed, forming the post-prostatic pouch in which calculi are sometimes found.

FIG. 281.—An Adenomatous Prostate viewed from behind, and also in Cross Section. This figure has been drawn from the same specimen as that represented by Fig. 280. The seminal vesicles and the vasa deferentia are seen entering the prostatic sinus behind at some distance below the vesico-prostatic junction. The prespermatic segment of the prostate has undergone a marked degree of enlargement (see Fig. 277). The sectional view of the prostate presents a peripheral layer of prostatic tissue greatly thinned and stretched. A large adenomatous mass is situated on each side of the urethra, and this latter is reduced to a linear slit, elongated in the antero-posterior direction. The ejaculatory ducts are seen in cross section just before opening upon the summit of the ridge known as the verumontanum.

The retrospermatic segment of the prostate does not present any appreciable enlargement; both it and the spermatic ducts have been pushed downwards and backwards by the large adenomatous mass. The verumontanum is situated at the point where the urethra presents its angular bend.

The Adenomatous Prostate viewed in Horizontal Section.—The condition represented in Fig. 281 shows a typical arrangement in this form of prostatic enlargement, and it will be instructive to contrast it with the section through the normal prostate at a corresponding level. The greater part of the section is made up of a large adenomatous mass on each side. It is closely related to the urethra, which has become elongated from before backwards and laterally compressed, presenting the appearance of an antero-posterior slit. The adenomatous masses are bounded circumferentially by the greatly expanded portions of the lateral lobes which have not undergone adenomatous change. It would appear that the greater part of the original prostate is contained in these peripheral expansions. The spermatic ducts are seen cut across near the posterior border of the section. In the process of enucleation the adenomatous masses are shelled out of their investing layer of prostatic tissue.

The supramontanal segment of the urethra is usually detached at the same time, bu the posterior urethral wall at the level of the verumontanum frequently remai intact, and the spermatic ducts which terminate here are not damaged. Th retrospermatic segment of the prostate also remains behind at the lower and bac part of the cavity, which remains after the adenomatous masses have been removed

PROSTATECTOMY.

PRELIMINARY DETAILS.—A full preliminary investigation is necessary in a cases and should be conducted with special reference to the prostate and bladde the kidneys, and the general condition of the patient.

The Prostate and Bladder. The history will have been obtained and note take of the symptoms, especially the frequency of micturition, incontinence, pain, hæma turia, etc. The nature of the prostatic enlargement can usually be determined wit a fair degree of accuracy by means of a digital examination per rectum with th patient in the genu-pectoral position, and also when lying on his back, the bladde having been previously emptied. The adenomatous prostate is smooth and elastic a median groove may be detected separating its two lateral lobes, and the enti organ will be found to have a definite though possibly limited range of mobility The size of the prostate, however, as observed by rectal examination, can in no wa be regarded as an indication for operation *per se*, as a prostate apparently quite sma may demand operative treatment more urgently than one of very large proportions.

A cystoscopic examination will reveal the extent of the prostatic enlargemen upwards towards the bladder, and at the same time note can be taken of the bladde mucous membrane and its degree of trabeculation, the flow of urine from the ureter orifices, and the presence or absence of a vesical calculus.

In some cases of enlarged prostate with obstruction the bladder becomes greatl distended, and may be detected as a rounded, elastic tumour in the hypogastric regio This distended condition of the bladder may be associated with dribbling away o urine, and the nature of the incontinence may be overlooked.

In connection with the investigation of the bladder the amount of *residual urin* should be ascertained. This is done by ordering the patient to empty his bladder a completely as possible by voluntary effort and then noting how much more urin may be drawn off with a catheter.

The Kidneys.—These are liable to suffer in two ways as the result of enlarge prostate, first by the increased pressure within the ureters resulting from distension of the bladder, and secondly in consequence of ascending infection from the bladde following on cystitis.

The ureters with their pelves may be very much dilated and the secreting tissue of the kidneys seriously damaged. Interstitial nephritis is the usual renal condition associated with enlarged prostate, and when infective changes supervene the gravity o the condition cannot be overestimated. Uræmia is the chief complication to be feared in prostatic cases, and the majority of the fatal cases are due to this cause.

The condition of the renal secretory function must be investigated as fully a possible in all cases before undertaking prostatectomy. The quantity of urine passe in twenty-four hours should be determined, also its specific gravity and its tota

percentage of solids, more particularly urea. The urine will be examined also for albumin and sugar.

"A very important group of symptoms should always be looked for when the prostatic difficulty has been of long standing—thirst, a dry mouth and tongue, a dry harsh skin, polyuria, and constant dull lumbar aching. These symptoms are absolutely typical of grave damage to the kidneys inflicted by long-continued back pressure. This group of symptoms may arise in cases of difficult micturition from stricture, prostatic or any other obstruction to the free outflow of urine, and are the effects of

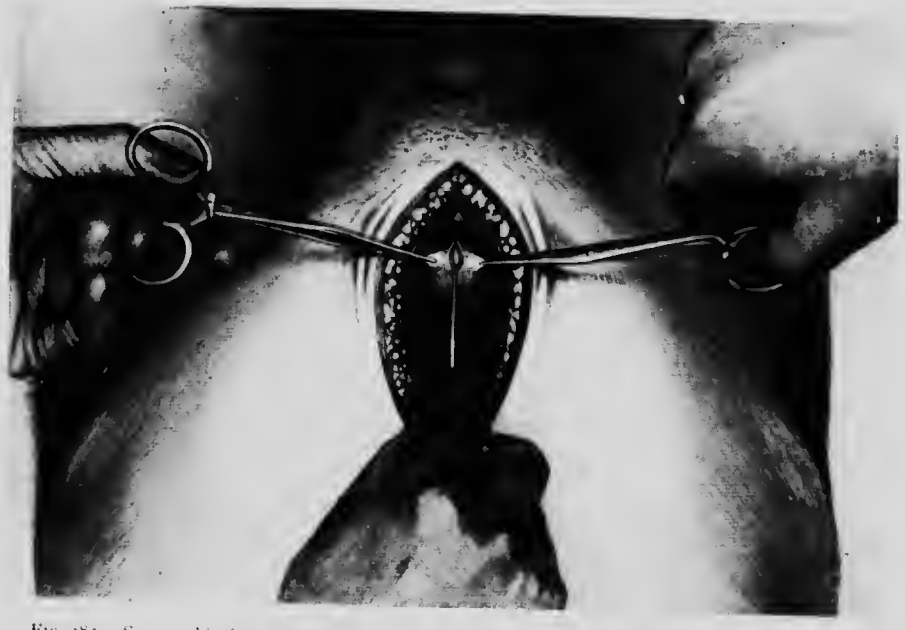

FIG. 282.—Suprapubic Cystotomy. The bladder has been exposed by a median incision above the symphysis pubis, and the peritoneal reflection has been raised. The bladder has been seized by two pairs of clip forceps and drawn forwards. The tissues of the bladder are progressively divided until the mucous membrane is reached; this is recognised by its pale colour, and is most readily divided by a sharp puncture.

a back pressure which has spent itself first upon the bladder, then upon the ureters, and finally the kidneys" (Pardoe).

The General Condition of the Patient.—In elderly men who suffer from the effects of enlarged prostate the condition of the heart and lungs will require a careful investigation. Bronchitis and emphysema are often present and may seriously complicate operative treatment. The heart may be weak, as shown by a feeble and irregular pulse, and the vessels will probably be found in a state of pronounced atheromatous degeneration.

Indications for Prostatectomy.—(1) Enlargement of the prostate in association with over-distension of the bladder, extreme frequency of micturition, and dribbling of urine, especially during sleep. In cases of this type retention is liable to occur suddenly

and without warning. (2) Cases with recurring retention. (3) Cases in which the catheter has been employed daily for weeks, months, or even years, but in which a certain amount of urine can yet be passed by voluntary effort. (4) Cases entirely dependent upon the catheter and probably complicated with cystitis and vesical calculi. Hæmorrhages may have occurred, and there may be a history of recurring rigors with high fever.

For the majority of those who suffer from the effects of enlarged prostate the continued employment of the catheter is attended by danger and often by great discomfort. For such individuals enucleation is the best form of treatment, and it should be performed before septic infection has taken place. There is undoubtedly a marked tolerance to the catheter exhibited by certain prostatic subjects, and in these cases operative measures need not be urged so insistently. It makes an enormous difference, however, according as prostatectomy is performed on a patient in sound general health or after his resistance has been lowered by a long period of suffering with septic changes in the bladder and kidneys. In patients of this latter class it may be necessary to undertake the treatment in two stages, first draining the bladder and relieving the kidneys by a suprapubic cystotomy and later on enucleating the adenomatous masses from the prostate when the local conditions have improved.

PROSTATECTOMY.—Two forms of operation are performed and are known respectively as *supra-pubic* and *perineal* prostatectomy, according to the route selected for approaching the prostate.

Preparatory Measures.—A preparatory course of treatment is frequently necessary with a view to relieving the cystitis which is so prone to succeed the use of the catheter. The urine may be foul and ammoniacal, containing a quantity of ropy mucus. In such cases washing out the bladder for some days is highly beneficial, and the efficiency of this treatment is enormously increased by the internal administration of urinary antiseptics. A combination which we have found very useful is that of urotropin with acid sodium phosphate. Twenty-five grains of urotropin and 1 drachm of acid sodium phosphate are dissolved in a pint of water, and the mixture is administered a wineglassful at a time throughout each period of twenty-four hours. A rapid improvement in the character of the urine quickly follows: its offensive odour disappears and its normal acid reaction returns. Boracic solution may be employed for washing out the bladder. A solution of silver nitrate $\frac{1}{2}$ grain to the fluid ounce of water may also be employed with advantage.

The condition of the bowels is carefully regulated, and as an aperient sulphate of soda is excellent. The condition of the heart and lungs must be attended to, and any symptoms of bronchitic inflammation must be allayed before the operation is undertaken.

Anæsthesia.—It has been our custom to employ nitrous oxide gas followed by ether by the open method, but in cases presenting any tendency to bronchitic trouble we have considered it safer to rely on anæsthesia by means of chloroform. Except when the bladder is being opened and the actual enucleation in progress the anæsthesia need not be profound. Suprapubic prostatectomy is an operation which can usually be performed very quickly, and this is a great advantage so far as the anæsthesia is concerned, as the less ether or chloroform administered the less will be the resulting shock.

We have employed hedonal anæsthesia in a few instances and found it very satisfactory.

In cases of enlarged prostate with septic complications and a bad general condition spinal anæsthesia with some surgeons has apparently given satisfactory results, but we cannot speak from personal experience of its efficacy.

SUPRAPUBIC PROSTATECTOMY.

Steps of the Suprapubic Operation.—The operating table is inclined slightly in the Trendelenburg position, and the lower limbs of the patient are separated and securely retained at some distance apart. The theatre should be warm and the patient's skin protected against any possibility of chill. The bladder is washed out and then filled with warm boracic solution. The catheter is retained *in situ* until the bladder has been opened.

Suprapubic Cystotomy.- For the details of this stage of the operation the reader is referred to p. 471.

The Enucleation.—If rubber gloves are worn, that protecting the right hand is now removed. The surgeon introduces his right index finger into the bladder and notes the extent and general character of the prostatic enlargement. If a calculus is present it is removed. Before commencing the enucleation the left index finger, protected by a rubber glove is introduced into the rectum, and by pressing against the prostate the latter is raised within the bladder, and the size of the prostatic mass can be more readily appreciated when it is thus interposed between the two fingers. The adenomatous masses lie beneath the mucous membrane, and this may either be incised with a scalpel or torn through with the finger-nail. When the basal portion of the prostate projects upwards the finger-nail quickly makes its way through its delicate membranous covering by working from within the urethra, but when the prostatic area of the bladder floor is merely expanded without any considerable intravesical projection the overlying mucous membrane may be incised with a long-handled scalpel behind and at each side of the urethra.

The finger is directed to the peripheral part of the adenomatous mass, and having found the proper line of cleavage, the enucleation is commenced. As a rule it is easy to carry the finger around the mass on each side and behind. In front the masses may remain connected in the middle line, but not uncommonly they become separated here, with the result that when removed they resemble a crescent open in front. Although quite free in front, behind, and at the sides, the prostatic mass may still be held by its urethral connections. If undue force be exerted at this stage the urethra may be torn across, and the tear may take place at the junction of its prostatic and membranous stages rather than above the verumontanum, which is the proper level as it ensures the preservation of the ejaculatory ducts. If the prostate is held so firmly that it requires forcible traction to detach it from the urethra it would be better to draw the mass forwards with forceps and sever its urethral connections with curved scissors introduced through the bladder from behind forwards under the mass than run the risk of stretching the urethra and causing it to tear at its junction with or even in the membranous stage.

Toilet of the Wound : Drainage.—With one finger in the rectum and another in the bladder the walls of the prostatic cavity are gently squeezed together, and this may help to diminish the bleeding, which is sometimes considerable. Washing out the bladder with a stream of hot sterile water at a temperature of 110° F. is useful in checking oozing, but unless the temperature of the irrigating fluid is sufficiently high the bleeding may be aggravated. A rubber tube of large size is selected for drainage ;

FIG. 284.—Suprapubic Prostatectomy. The bladder has been exposed by a median incision and opened. The mucous membrane on each side of and behind the urethra has been divided, and the process of enucleation of the adenomatous mass commenced. The left index finger, protected by a rubber glove, has been introduced into the rectum, it presses against the prostate and pushes it forwards while the enucleation is in progress.

its lumen should measure not less than $\frac{3}{4}$ inch, and it should have two lateral perfora-tions near its intravesical extremity, which will be so arranged as to penetrate into the bladder for about an inch. On no account should the tube come into contact with the prostatic wound or the bladder floor, as it might cause bleeding and symptoms of irritation. It is fixed *in situ* by a suture of silkworm gut, and a few additional sutures

of catgut may be passed through the bladder wound so as to close it up all round the tube.

The Abdominal Wound is partially closed by some interrupted sutures of silkworm gut, and in addition to these a few deep sutures of catgut may be made to connect

FIG. 284.—Suprapubic Prostatectomy. The right index finger from within the bladder has completed the enucleation of the peri-urethral adenomatous mass, and this latter is in the act of being delivered through the suprapubic wound.

the margins of the recti muscles except where the tube emerges. It is better not to close up the abdominal wound too closely around the tube, as it might prevent the escape of urine from the bladder and lead to its diffusion in the prevesical space with resulting cellulitis.

The Dressing.—The wound and the tube are covered with some layers of antiseptic gauze and several pads of sterile absorbent wool, which will require to be changed when they become soaked with urine.

The After-treatment.—A hypodermic injection of morphia may usually be give if the pain is severe; aspirin is sometimes useful in 10-grain doses at night.

Drainage from the bladder during the first twenty-four hours may be hampere by clots which block the tube. They are most readily removed by means of lon forceps.

The bladder will require irrigation twice daily for the first five or six days; this most successfully accomplished by means of a portable douche can held a few fe over the level of the bed provided with a suitable length of tubing and a large catheter The catheter is introduced within the suprapubic drainage tube, and the irrigatin fluid is allowed to flow through. As a rule no instrument is passed into the bladde along the urethra for a week or ten days, as it would be very likely to cause bleeding

Boracic lotion is employed during the first week for irrigation purposes, but afte this it will often be found advantageous to employ in addition a solution of peroxid of hydrogen, more especially if the urine is offensive and if the case is one in whic cystitis was present before the operation. A good method of cleansing the bladde consists in introducing a stream of peroxide solution by the urethra and allowing to flow away by the suprapubic tube. Peroxide solution, however, should not be use for bladder irrigation unless it has a free means of exit through the suprapubic wound

The large tube first introduced into the bladder may be removed towards the en of the first week and for a few days longer a smaller tube may be employed, more par ticularly in cases where the abdominal wall is very thick and the wound leading t the bladder very deep. The irrigation may now be conducted under slightly increase pressure, as the current cleanses the prostatic recess and escapes by the suprapubic tube

The wound granulates steadily and progressively narrows in, but it seldom close sooner than four or five weeks after the operation.

Post-operative Complications.—The principal of these are—(1) hæmorrhage (2) shock; (3) sepsis; (4) pulmonary and cardiac complications; (5) orchitis; an (6) the development of phosphatic concretions within the bladder, and in contact wit the margins of the suprapubic wound.

PERINEAL PROSTATECTOMY.

This procedure is still favoured by some surgeons, but it has been practised with diminishing frequency in recent years, the majority giving the preference to th suprapubic operation. Dr. Young, of the Johns Hopkins Hospital, Baltimore especially has brought it into prominence and has employed it with success in a large number of cases.

The method of performing the operation has varied somewhat with differen surgeons, one of the chief differences consisting in the special form of incision employed, some preferring a median, others a curved transverse incision between the anus and the scrotum.

Another important difference consists in the method adopted for effecting the enucleation. In one form of procedure the urethra is opened and the adenomatous masses exposed by tearing with the finger through the urethral wall; in another the prostatic urethra is not opened, but the enucleation is carried out through latera incisions one on each side of the urethra and parallel to it

The general preliminary treatment is the same as for suprapubic prostatectomy.

Before the patient is put into the lithotomy position a catheter is passed and the

bladder washed out. Some boracic solution is introduced and allowed to remain in. A metal staff grooved along its convexity is passed into the bladder, as its introduction is easier now than when the lithotomy position has been assumed. The sound is carefully held *in situ* by an assistant.

The best form of operating table is one which can be readily inclined at a varying angle. When the patient has been anæsthetised he is placed in the lithotomy position with the buttocks coming down well to the edge of the table. A rubber sheet with pneumatic crescentic cushion is placed beneath the sacrum.

The table is now inclined so as to lower the patient's head and shoulders and at the same time render the perineal region more accessible to the surgeon.

PERINEAL PROSTATECTOMY BY A MEDIAN INCISION. *The Perineal Incision* extends from behind the scrotum which is held upwards by an assistant to within $\frac{3}{4}$ inch of the anus. The tissues are divided progressively until the bulb is exposed. The deeper part of the incision is behind this, and with the tip of the index finger the grooved staff will be felt as it lies within the membranous urethra. The wall of the urethra is divided by cutting directly on to the groove of the staff and prolonging the incision along the floor of the urethra for a short distance. This step is facilitated by the assistant in charge of the staff making its convexity prominent in the perineum. A grooved director is passed, with the staff as a guide, into the bladder, and the staff is then withdrawn.

With the director held in the left hand the surgeon introduces his right index finger into the urethra and insinuates it gently as far as the apex of the prostate. The director is now withdrawn, and the finger is made to penetrate more deeply with a rotatory motion. When the prostate is of moderate size the finger may enter the bladder, but when it is large this is usually impossible.

The Enucleation.—The mucous membrane of the urethra on one side is torn through with the index finger, and the peripheral aspect of the adenomatous mass, *i.e.*, the line of cleavage, is quickly recognised. The finger is next carried with a sweeping movement outwards and forwards, and readily effects the separation up to the middle line in front. The upper aspect of the adenomatous mass is separated from the mucous membrane of the bladder floor by hooking the finger over it. Having torn through the remaining connections of the mass, it is grasped with a pair of lithotomy forceps and removed, care being taken not to stretch the aperture in the urethra to too great an extent.

The enucleation and removal of the opposite lateral lobe is carried out in a similar way.

When the lateral lobes are large their enucleation will be much facilitated by seizing each in turn with forceps and drawing it down while the finger in the wound separates the mass from its surroundings. The enucleation of one lateral mass renders the corresponding procedure on the opposite side much easier.

The removal of large adenomatous growths may sometimes be effected piecemeal so as to avoid stretching the urethral wound to an injurious extent and lacerating the compressor urethræ muscle.

The removal of the lateral adenomatous masses is followed when necessary by that of the enlarged middle lobe, but sometimes the latter can be more effectively removed in conjunction with one of the lateral lobes.

An adherent middle lobe is rendered accessible by passing the finger of the right hand into the space vacated by the adenomatous mass on the left side and pushing the middle lobe over to the right, when it can be separated from its connections

with the bladder and urethra. This is facilitated by traction on the lobe with forceps.

When the enucleation has been skilfully performed the vesical orifice will be felt as a soft ring and the mucous membrane around the orifice will be intact. The retro-spermatic segment of the prostate remains behind and the mucous membrane upon the floor of the cavity at the level of the verumontanum is uninjured.

Hæmorrhage is sometimes free during the enucleation process, but when this has been terminated irrigation of the bladder and the prostatic cavity with a stream of hot water will quickly arrest oozing and remove clots. A large rubber catheter is passed into the bladder from the wound and should be so arranged that its eye lies just a short distance within the vesical orifice. It is retained *in situ* by a stitch passing through the perineal tissues.

The Dressing.—Iodoform ganze, 1 inch wide, is packed into the prostatic cavity beside the catheter by means of long forceps. The introduction of the gauze is facilitated by seizing the remaining prostatic tissue with vulsellum forceps and drawing it down towards the perineum. The catheter is connected to a tube leading to a urinary receptacle in which there is a solution of perchloride of mercury. Should the catheter become blocked the urine will leak into the perineal dressings, but this is not usually a matter of much consequence.

The bladder may be washed out if symptoms of cystitis are present, and if the urine is foul the administration of urotropin by the mouth will have a highly beneficial effect.

The perineal gauze is removed after twenty-four hours. The catheter is removed also, and the wound cavity is irrigated with warm sterile salt solution.

The urine escapes through the fistula for some days, but after one or two weeks it begins to flow again by the urethra.

PERINEAL PROSTATECTOMY BY A TRANSVERSE CURVED INCISION.—The attitude of the patient is the same as in the last operation. A curved staff grooved along its convexity is introduced into the bladder and held steadily by an assistant.

The Cutaneous Incision is made from left to right; it is concave backwards and extends from one ischial tuberosity to the other; its central point is about 1½ inches in front of the anus.

Exposure of the Membranous Urethra.—The tissues are progressively divided in the direction of the bulb of the corpus spongiosum. This latter is invested by the accelerator urinæ muscle, the fibres of which are readily recognised by their direction, which is forwards and outwards from the median raphé. The wound margins are separated by means of two pairs of forceps, which are applied respectively to the tissues covering the bulb in front and to the margin of the wound behind. The chief danger in deepening the wound behind the bulb is injury to the rectum, but this will be most certainly prevented by introducing the left index finger, protected by a glove, into the rectum and at the same time depressing the posterior part of the wound with the thumb. By a process of careful dissection the tissues behind the bulb are divided, and by drawing the latter forwards the vertically directed fibres of the recto-urethralis muscle are exposed and divided close to the urethra so as to safeguard the rectum. Free exposure of the depth of the wound by means of retractors and good illumination is essential while this part of the operation is being carried out.

Separation of the Prostate from the Rectum.—After division of the recto-urethralis muscle the knife is momentarily discarded, and the right index finger, directed against the membranous urethra, presses the tissues backwards towards the rectum and

cautiously opens up the retroprostatic space, any lateral resisting bands being divided at the same time. The wound is further widened by dividing the tissues sufficiently on each side, and in so doing the posterior aspect of the prostate is fully exposed.

The Prostatectomy. It is at this stage that the combination of the Trendelenburg with the lithotomy position is particularly useful, as it brings the region of the operation more fully into view.

The accessibility of the prostate may be further facilitated by adopting the procedure of Young, of Baltimore, who by means of a special depressor introduced through a limited aperture in the membranous urethra exerts traction upon the prostate and

FIG. 285.—Circumcision. The penis having been grasped by the left hand, the surgeon proceeds to divide the skin of the prepuce all round by successive snips of scissors.

enables it to be drawn downwards towards the perineum. The posterior part of the wound is depressed at the same time by a broad retractor.

As it is desirable to preserve that part of the prostate which corresponds to the urethral floor, the lateral adenomatous masses are exposed by a vertical incision on each side. The margins of each incision are seized with forceps, and the finger or a blunt dissector is insinuated between the tumour and its prostatic envelope. When the mass has been freed to some extent its further separation is facilitated by seizing it with vulsellum forceps and detaching it from its surroundings with a blunt dissector.

The urethra may be opened during the manipulations incidental to the enucleation of the masses, but such an accident is not of serious moment. An existing median lobe may be reached and removed through one of the lateral cavities, or if the urethra has been opened an easy route of approach will be available.

Some surgeons prefer to incise the prostate in the middle line and deliberately

open up the urethra, as it facilitates the enucleation of the lateral adenomatous masses and affords good access to the middle lobe.

Drainage. A full-sized rubber catheter is introduced along the urethra into the bladder. The prostatic cavity is packed with iodoform gauze as in the last operation.

The wound of the urethra may be partially or completely closed by a number of interrupted sutures of catgut. The drainage catheter emerges from the membranous segment and is prevented from slipping out by means of a suture which connects it with the anterior margin of the wound.

A few additional sutures may be introduced to partially close the deeper strata of

FIG. 286.—Circumcision. The skin of the prepuce having been divided all round, the margin of the preputial orifice is seized on each side with forceps and a median dorsal incision is made with blunt pointed scissors back to meet the circumferential incision. In doing this, care should be taken not to injure the glans penis.

the wound. The margins of the cutaneous wound are also brought together to some extent.

Post-operative Measures.—The gauze plugging is removed after twenty-four or forty-eight hours. The drainage catheter will be retained for four or five days, and after its removal another catheter may be passed from the external meatus into the bladder and retained for a few days.

During the period of healing of the perineal wound the occasional passage of large sounds would seem advisable.

THE PENIS.

CIRCUMCISION. This simple procedure is usually carried out in young children, but occasionally its performance is indicated in adults.

In a well-marked case of congenital phimosis the prepuce is unusually long and its orifice quite small. This is the type of case in which circumcision is most clearly

indicated, as it is often attended by difficulty with micturition necessitating straining, which in turn may occasion the development of a hernia or a rectal prolapse. Reflex disturbances, too, are common with this condition owing apparently to irritation beneath the prepuce.

The Operation. Young children are easily anæsthetised by means of ether dropped on to a Skinner's mask. We frequently employ nitrous oxide gas followed by ether and find that it is well taken; ether should always be used instead of chloroform.

In adults local or infiltration anæsthesia is very satisfactory.

The method of removing the redundant prepuce which we usually employ is represented in the adjoining Figs. 285–288. The parts having been cleansed and disinfected

Fig. 285.—Circumcision. The dorsal division of the prepuce represented in Fig. 286 is followed by that of the mucous membrane parallel to the margin of the glans penis, and at a little distance away from this on each side.

in the usual way, the preputial integument is divided all round by successive snips of sharp scissors. On the dorsum the line of section runs transversely just in front of the corona of the glans; it inclines forwards slightly at the sides and crosses beneath the prepuce opposite the anterior extremity of the glans penis. The cutaneous incision is quickly made in this way, and it ensures that there is no redundancy on either side.

The margins of the preputial aperture are seized on each side with hæmostatic forceps, and an incision is carried back in the middle line of the dorsum to meet the circumferential cutaneous incision. Some care is required in doing this, as the glans may be adherent to the prepuce. Such adhesions are readily broken down by means of a probe or a narrow blunt dissector, which should be introduced beneath the prepuce and made to clear the glans all round before this longitudinal section is made. After making the dorsal incision the prepuce is folded back, and masses of smegma, if present, are removed with a dry swab.

On each side the mucous membrane is divided in the line of the cutaneous incision as represented in Fig. 287. Finally the frænum is divided, and at the same time the small artery which it contains and which usually bleeds freely is seized with a pair of fine-pointed hæmostatic forceps.

The first suture is introduced through the divided frænum and the adjoining integument; it consists of fine catgut, and in introducing it an attempt should be made to underrun the frænal artery. The ends of this suture are cut and left long. The second suture is introduced behind the centre of the corona through the skin and mucous membrane; it also is cut, the ends being left long. By drawing these two sutures apart the introduction of the remainder is rendered easy, as the mucous and cutaneous margins are approximated and the sutures can be spaced at regular intervals.

Fig. 288. Circumcision. The prepuce has been completely divided all round. Sutures of fine catgut connect the skin and mucous membrane behind the corona of the glans and at the level of the frænum. By drawing these sutures apart, the margins of the skin and mucous membrane are approximated and the introduction of the remaining sutures is facilitated.

Finally the sutures are all cut short, and if any bleeding is observed one or two additional sutures may be introduced so as to underrun the bleeding points.

The dressing consists of boracic or lano-cyllin ointment, and the bedclothes should be prevented in the case of young children from coming into contact with the wound by means of a cradle or some similar device.

COMMENTS.

Excessive removal of integument is to be avoided. A sufficient amount should be left to protect the corona of the glans and prevent any dragging on the skin during erection.

The freeing of adhesions between the prepuce and the glans should be carefully accomplished.

The method of dividing the integument by seizing it with forceps in front of the glans and cutting away the redundant part is not to be recommended, as in inexperienced hands it entails the risk of wounding the glans.

AMPUTATION OF THE PENIS. This operation is usually performed for malignant disease of the organ. By the time the patient seeks advice the growth has usually reached considerable dimensions so as to involve both the glans and the prepuce, this latter being invariably redundant in such cases. The relationship between phimosis and epithelioma of the penis is well recognised, and it would appear that the retention of irritating secretions beneath a long prepuce is a frequent determining factor in originating the disease.

When the growth is of limited extent and confined to the glans and the overlying prepuce the section of the penis may be undertaken in front of the scrotum, but when the infiltration has extended for some distance along the corpus spongiosum so as to be recognisable as a hard cord it will be safer to remove the entire penis.

The inguinal glands, which are primarily connected with the involved cutaneous and mucous areas, must be removed simultaneously by a process of careful dissection

AMPUTATION OF THE PENIS IN FRONT OF THE SCROTUM. In cases in which this operation is indicated the disease will be of limited extent, involving the glans penis and perhaps the prepuce to some extent. The operation consists of two parts, viz., the removal of the diseased part and the clearance of the inguinal glands on both sides.

Fig. 280.—The Lymphatics of the Penis and Scrotum.

The usual stringent precautions are taken to ensure an aseptic result. The area of disease is swabbed over with the tincture, or, perhaps better still, with the liquor iodi (B.P.), and the excess removed with a dry muslin swab. Another piece of muslin rinsed out of an alcoholic solution of biniodide of mercury is wound around the end of the penis and carefully secured against slipping. The surrounding parts, too, having previously been subjected to a careful cleansing, are treated with tincture of iodine or Harrington's solution.

The control of bleeding is most certainly ensured by constricting the penis as far back as possible with a piece of thin rubber tubing. It will facilitate matters if the glans penis be seized with sharp-toothed forceps and drawn forwards. The surgeon draws back the penile integument and makes a circular incision around the organ at a safe distance behind the growth. The superficial tissues are progressively divided until the corpora cavernosa and the corpus spongiosum are exposed. The next step consists in cutting across the corpora cavernosa. This section may be accomplished by cutting from the dorsum or by first transfixing the penis in the sulcus between the corpus spongiosum and the corpora cavernosa with a slender, long-bladed tenotome and then cutting towards the dorsum. The corpus spongiosum is dissected away from the distal segment of the penis for a distance of about ½ inch and cut across.

Any obvious vessels are now secured and ligatured with fine catgut; the principal are the dorsal arteries of the penis and the arteries to the corpora cavernosa.

Sutures of catgut are introduced through the corpora cavernosa from side to side;

they serve to bring the cut margins of the tunica albuginea together, and at the same time they arrest bleeding.

The projecting segment of the corpus spongiosum is split along its dorsal aspect, folded back, and connected by suture with the cutaneous margin.

The glandular dissection consists in making an oblique incision on each side in the fold of the groin, undermining the superficial tissues, and dissecting away the glands with their surrounding fatty and cellular tissues. For fuller details of the next operation,

COMPLETE EXTIRPATION OF THE PENIS. The procedure entails the removal of the entire penis together with the inguinal glands in each groin. The first part of the operation is performed with the patient lying on his back; the second stage necessitates the lithotomy position.

Fig. 290.—Epithelioma of the Penis. The growth had involved the glans and the prepuce, and the corpus spongiosum for a short distance behind the glans was hard and infiltrated. The entire penis was removed and the inguinal glands were dissected away on each side (see Fig. 293).

The First or Inguinal Stage.—The parts are carefully cleansed and disinfected. The growth, which will probably be in an ulcerating condition and exuding a foul discharge, is smeared over with tincture of iodine and then enveloped in a muslin swab rinsed out of an alcoholic solution of biniodide of mercury.

The cutaneous incisions follow the fold of the groin on each side and surround the penis at its junction with the scrotum. Numerous superficial vessels require hæmostatic forceps but after a few minutes these may be removed, and it will be found that the bleeding has ceased. In each groin the cutaneous margins of the wound are undermined over the corresponding glandular area, and by means of a careful dissection the entire group of glands together with their afferent vessels and surrounding tissues are raised from off the fascia lata, commencing near the anterior superior spine and gradually working inwards. As the dissection approaches the middle line the surgeon carefully defines the femoral ring and detaches the superficial tissues which overlie it. It is here that a communication exists between the inguinal and the iliac glands, as the efferents of the former pass upwards through the femoral canal to reach the glands of the external iliac group.

When the inguinal dissection has been accomplished on both sides the tissues at the peno-scrotal junction are divided more fully, and the body of the penis is exposed back to the pubic arch where the crura of the corpora cavernosa diverge from the corpus spongiosum. The spermatic cord is seen on each side at its emergence from the external

abdominal ring The wound is plugged temporarily with dry muslin swabs and covered with a sterile towel while the second stage of the operation is in progress.

The Second or Perineal Stage.—The patient having been placed in the lithotomy position and all details as to cleansing and disinfection having been attended to, an assistant draws the scrotum up out of the way and the surgeon, sitting opposite the perineum, makes an incision in the middle line from a point just behind the scrotum

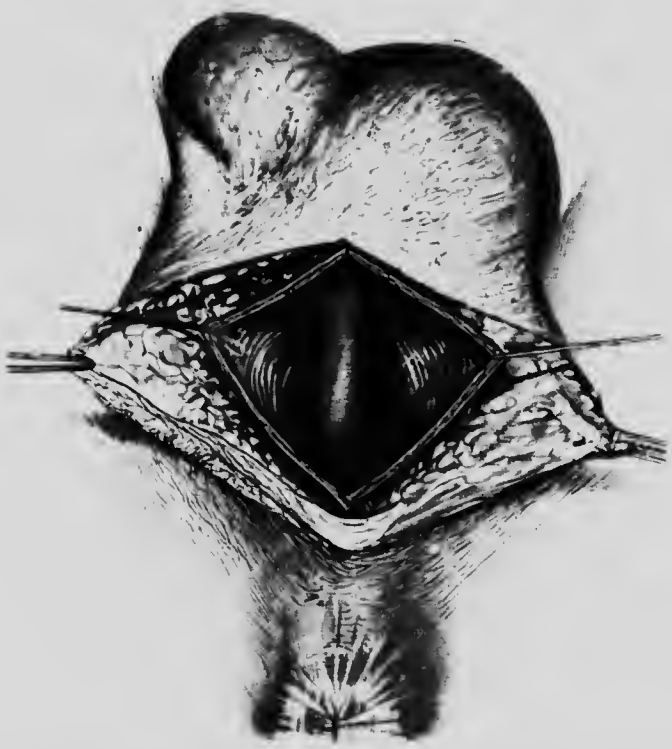

Fig. 291.—Complete Excision of the Penis for Epithelioma. A median incision has been made in the perineum between the scrotum and the anus. The accelerator urinæ muscle has been divided in the middle line and dissected back on each side from the corpus spongiosum.

to within ¾ inch of the anus. The superficial tissues are progressively divided until the fibres of the accelerator urinæ muscle are exposed. These overlie the corpus spongiosum and its posterior bulbous extremity, both of which are now exposed by a median incision. The muscular tissue is turned aside and held by clip forceps (Fig. 291). A point is now selected about an inch or 1½ inches in front of the bulb, and at this level the corpus spongiosum is cut completely across between forceps. The proximal segment is dissected from its connections with the crura of the corpora cavernosa, and with a catheter or sound in its interior to serve as a guide it is freed all round and drawn back into the perineum, where it is retained until a later stage of the operation.

The crura must now be detached from the pubic arch. Each crus is exposed in turn by dividing the overlying perineal tissues, any bleeding vessels being immediately secured with hæmostatic forceps. The attachments of the crus to the bone are very intimate, and are most readily severed by means of a sharp periosteal elevator or a bone chisel. When the detachment is almost complete the posterior part of the crus

FIG. 292.—Complete Excision of the Penis for Epithelioma. The corpus spongiosum has been divided about an inch in front of the bulb and dissected back to the level of the triangular ligament. A soft rubber catheter has been passed along the urethra to the bladder. The crus penis on each side has been detached from the bone and the dorsal vessels and nerves of the penis have been divided beneath the pubic arch.

together with the artery to the crus from the internal pudic artery is seized with two pairs of clip forceps and divided between these. The main part of the crus is then completely detached from the bone, and when this procedure has been repeated upon the other side the two crura will be found completely free (Fig. 292). It finally remains to sever the few remaining attachments of the root of the penis, and as this is being done the dorsal vein will be divided close beneath the pubic arch and secured

with forceps preliminary to its ligature. The penis is now free and is removed by drawing it upwards through the wound in front of the scrotum.

The posterior pointed extremity of the crus on each side is tied with catgut so as to occlude the artery to the corpus cavernosum which is found at this level. Any other obvious bleeding points are secured by ligature and the wound cavity rendered as dry as possible.

The mobilised stump of the corpus spongiosum is drawn back and brought out between the margins of the perineal wound midway between the anus and the scrotum. Before connecting it with the skin the reflected portions of the accelerator urinæ muscle

FIG. 293.—Complete excision of the penis for epithelioma. This figure represents the appearances presented by the healed wound in the inguinal region on each side, following the extirpation of the inguinal glands, together with their investing tissues.

are brought around it and sutured in such a way as to form for it a modified sphincter. The cut extremity of the corpus spongiosum should protrude for a short distance beyond the sutured perineal wound so that its retraction may be more certainly avoided. A catheter is introduced into the bladder and tied in for two or three days so that the urine may be conveyed to a suitable receptacle and prevented from coming into contact with the wound. The cutaneous margins in front of and behind the protruding corpus spongiosum are brought together by means of a few interrupted sutures of silkworm gut.

Closure of the Inguinal Wounds.—A sterile compress is laid against the perineal wound, and the patient is placed on the table in the supine position. As a precautionary

measure against sepsis the surgeon changes his gloves before proceeding to close the large inguinal wound.

The wound margins are first approximated by a variable number of interrupted sutures of silkworm gut arranged at regular intervals, and the interspaces between these are then adjusted by means of Michel's metallic clips or by additional interrupted sutures. The incision surrounding the penis in front of the scrotum, when adjusted,

FIG. 204.—Complete excision of the penis for epithelioma. This figure represents the appearance presented by the healed wound in the perineum. The orifice of the urethra is seen on the summit of a small elevation situated midway between the scrotum and the anus.

comes to assume a vertical direction. If any small vessels continue to ooze a rubber drainage tube had better be introduced on each side and removed after twenty-four hours.

COMMENTS.

An alternative procedure to that just described consists in splitting the scrotum and connecting the inguinal with the perineal wound. There does not appear, however, to be any advantage in doing this, and we prefer therefore to leave the scrotum intact.

THE SCROTUM, TESTICLE, AND SPERMATIC CORD.

VARICOCELE.—Indications for Operation.—In the great majority of cases of varicocele there is no need for operative measures. The chief indications for operation are an excessive degree of varicosity of the spermatic veins with marked elongation of the cord, evidence of atrophy of the testis or severe neuralgic pain.

A large percentage of varicocele operations concerns cases in which candidates for the services must have the veins of the cord removed before their physical condition is considered satisfactory.

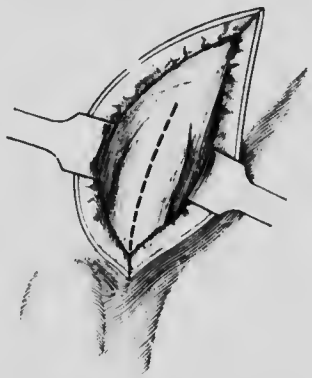

FIG. 295.—Operation for Varicocele. The superficial tissues have been divided over the external abdominal ring, and the spermatic cord exposed. The interrupted black line represents the direction of the incision in the ensheathing tissues of the cord.

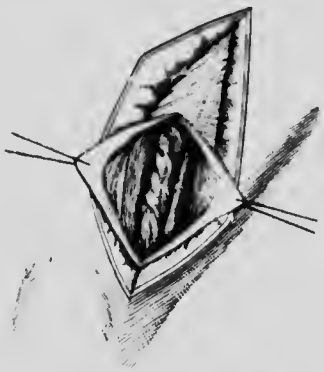

FIG. 296.—The ensheathing tissues of the cord, viz., the intercolumnar fascia, the cremaster muscle, and the transversalis fascia have been divided and the spermatic vessels exposed.

The Operation.—Infiltration anæsthesia by means of novocain and adrenalin is very well adapted for these cases. The skin and the subcutaneous tissues are first

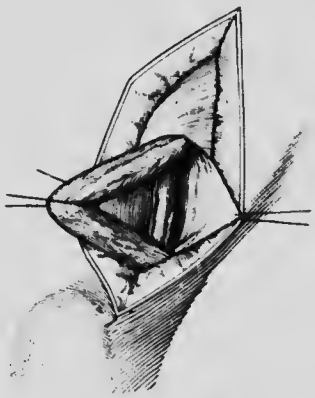

FIG. 297.—The spermatic vessels have been separated from the vas deferens and the slender blood vessels by which this latter is accompanied, and drawn forwards in the form of a loop.

FIG. 298.—Following the excision of a segment of the varicose spermatic veins, the ligatures securing the divided vessels have been passed respectively outwards and inwards through the investing tissues of the cord, and the two stumps have been brought close together.

anæsthetised, and subsequently when the cord is exposed at its emergence from the external abdominal ring its coverings are pierced with the needle and its tissues also infiltrated to the necessary extent.

The skin incision, about 1½ inches in length, is made over the external ring and does not encroach upon the scrotum. The superficial tissues are divided and haemorrhage from the external pudic vessels is arrested.

The cord is exposed just beyond the ring. Its ensheathing layers, viz., the intercolumnar, cremasteric, and transversalis fasciæ, are divided between clip forceps and the large tortuous spermatic veins clearly defined. These are gently drawn forwards and separated from the easily recognised vas deferens and its vessels for a distance of about 2 inches.

The spermatic veins, together with the spermatic artery which they envelop and conceal, are crushed in two places about 2 inches apart. Ligatures of catgut are applied in the grooves formed by the crushing forceps, and the intervening segment is removed.

The lower stump is drawn upwards towards the external ring, and the two free ends of the ligature holding it are passed, one outwards and one inwards, through the ensheathing layers of the cord (Fig. 298). The upper stump is brought into approximation with the lower, and the ends of its retaining ligature are passed through the sheath of the cord in a similar manner. The free ends of both ligatures are then knotted and the aperture in the sheath accurately closed over the occluded vessels. The cord is at the same time shortened and the testis securely suspended. The wound is carefully inspected, and any superficial vessels which bleed are effectively controlled.

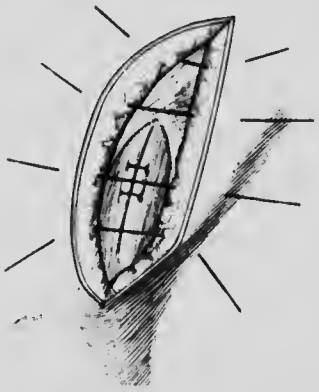

FIG. 299.—The ligatures traversing the ensheathing tissues of the cord and represented in Fig. 298, have been knotted, and the margins of the sheath brought together over the spermatic veins. The superficial wound is about to be closed by interrupted sutures of silk-worm gut.

The superficial wound is closed by a few sutures of silkworm gut. Michel's clips are very suitable in this region.

The wound is smeared with tincture of iodine and covered with a dry muslin swab which is secured with strapping.

COMMENTS.

Resection of the Scrotum.—As there frequently is great laxity of the scrotal tissues in association with varicocele some operators have sought to improve matters and afford better support to the testis by excising a portion of the fundus of the scrotum so as to shorten it; such a step, however, is rarely necessary.

Manipulation of the Cord.—In exposing and isolating the spermatic veins the cord should be gently manipulated. It is quite unnecessary to raise it from its bed upon the finger or a director. If the veins are first exposed as above described they can be drawn forwards and separated from the vas without difficulty and without forcible traction.

CASTRATION.—Indications.—The removal of the testicle is mainly indicated in the following conditions: (1) malignant disease—cancer or sarcoma; (2) the majority of cases of tuberculous disease which are submitted for treatment; (3) certain cases of disorganising inflammatory disease in which the tissue of the gland has been extensively destroyed, *e.g.*, simple and syphilitic orchitis; (4) cer-

tain cases of undescended testicle, more especially those in which previous attempts to replace the gland in the scrotum have failed and where its presence in the groin causes pain and inconvenience or in cases where it is affected by disease.

The Operation.—The extent of the procedure will depend upon the nature of the condition for which it is undertaken. It will first be described in a simple case and in cases complicated by sinus formation, and subsequently the more extensive measures required for malignant disease will be reviewed in detail.

The Superficial Incision and Exposure of the Testicle.—As the testicle, owing to its mobility, can be pushed upwards and made prominent in the inguinal region, the cutaneous incision is made over the site of the external abdominal ring and for a varying extent below this, but unless the testicle has attained a considerable size the incision will be confined mainly to the groin, as an incision here is more easily closed and can be more efficiently protected by dressings than if made through the scrotum. While the incision is being made the testicle is pushed upwards and maintained in the vicinity of the external abdominal ring. As a rule the section is carried down to the level of the tunica vaginalis, and then both it and the testicle are drawn upwards out of the wound. Should any band of tissue retain the testicle at the bottom of the scrotum it will be divided between clip forceps. The scrotal ligament of Waldeyer, which represents the remains of the gubernaculum of the fœtus, is sometimes very distinct at the lower part of the testicle where it is connected with the scrotal tissues.

The cavity of the tunica vaginalis is now opened as it is desirable to note the condition of the testicle, especially if doubt exists as to the nature of the disease.

The Ligature and Division of the Cord.—In the absence of any necessity to resect a segment of the cord it is divided a short distance above the gland, but in the event of its invasion by the disease it is followed upwards for a short distance in the direction of the external ring, and its investing tunics derived from the cremaster muscle and the transversalis fascia are divided to the necessary extent. The cord proper is readily divided into two parts, viz., the group of vessels formed by the spermatic artery with its accompanying veins and the vas deferens with its group of vessels. These are identified and separately ligatured with strong iodised catgut. They are then divided about ¼ inch beyond the ligatures and the testicle removed. This method of dealing with the cord is better than the application of a single mass ligature. Should such a ligature, however, be employed it would be advisable to first crush the cord with a powerful clamp such as that of Doyen. When the crushing has been effectively performed a fine ligature will suffice, and the risk of this slipping will be reduced to a minimum.

Suture of the Wound: Drainage.—The entire wound area is carefully inspected, and any vessel which is found to bleed is efficiently controlled. As a precaution a short piece of rubber tubing is introduced into the scrotal cavity through a puncture at its most dependent point. The wound is closed by two or three sutures of silkworm gut, and the cutaneous margins are accurately approximated by means of metallic clips or a few additional fine sutures.

CASTRATION FOR NON-MALIGNANT DISEASE OF THE TESTICLE IN WHICH THE SCROTAL TISSUES ARE INVOLVED.—It occasionally happens that by the time operation is undertaken suppuration has extended from the testicle to the scrotum and discharging sinuses are present, or perhaps an open ulcerating sore or a fungating mass exists. In tuberculous disease it is not at all uncommon to find discharging sinuses surrounded by areas of blue undermined skin.

The course which we adopt usually in these cases is to first cleanse and disinfect the parts as thoroughly as possible and then expose the structures of the cord by an oblique incision in the inguinal region, opening up the canal as in Bassini's herniotomy. The spermatic vessels are doubly ligatured and divided, and then the vas with its vessels is treated in the same manner. If the case is tuberculous an attempt may be made to trace the vas inwards and divide it with the thermo-cautery as near the bladder as possible. The distal end of the cord with its attached ligatures is pushed down into the scrotum and the entire inguinal wound closed in strata.

The second stage of the operation consists in making an elliptical incision around the diseased scrotal integument and deepening this progressively until the testicle is reached, whereupon it is completely freed from its surroundings, and as the cord has been already divided it may be drawn down and removed. All bleeding vessels are carefully secured and the scrotal wound closed with the exception of its lower angle, where a drainage tube is introduced.

CASTRATION FOR MALIGNANT DISEASE.—The operative measures applicable to a case of malignant disease of the testicle are much more extensive than those already indicated. The glands which receive afferent vessels from the testicle are those in the lumbar region which are arranged around the aorta and the vena cava; and unless these glands are exposed and removed the operation cannot be termed radical. Furthermore, the necessity for a complete operation is rendered all the more obvious by reason of the fact that malignant disease of the testicle is a most fatal disease. It is all-important, therefore, that an early diagnosis should be made and that the operative measures should be complete.

The parts removed will include the testicle, the spermatic cord, the spermatic artery up to its origin from the aorta, the spermatic vein close to its junction with the vena cava on the right side, with the renal vein on the left side, the lymphatics from the testicle and the glands to which they proceed, together with the fatty and connective tissues by which these are surrounded, all in one piece.

The Operation.—*The Cutaneous Incision* extends over the upper part of the tumour in the direction of the external abdominal ring, and from this level it is directed outwards to a point about an inch internal to the anterior superior spine of the ilium and from thence in a slightly curved direction upwards towards the costal margin opposite the tip of the tenth rib.

Exposure of the Testicle and Spermatic Cord.—The spermatic cord is exposed at its emergence from the external abdominal ring, and the scrotal tissues are divided to a sufficient extent to enable the tumour to be clearly defined. It may possibly happen that the diagnosis of malignant disease is uncertain, and if so it will be necessary to incise the testicle before proceeding further. Assuming that no doubt as to the malignant character of the tumour exists, the further stages of the operation are undertaken.

The Lymphatic Dissection and Removal of the Diseased Parts.—The incision is extended upwards through the abdominal muscles in the direction already indicated until the peritoneum is exposed. The spermatic cord is followed to the internal abdominal ring, where its constituent parts separate, the spermatic vessels extending upwards to the aorta and vena cava and the vas deferens in the direction of the pelvic cavity. Traction on the cord brings these vessels into evidence, and the peritoneum is pushed away in a mesial direction so as to expose them more fully. The vas is traced as far downwards as possible into the pelvis and divided between ligatures with scissors or the actual cautery.

The next stage in the operation consists in ligaturing and dividing the spermatic vessels and clearing away the lymphatic glands already indicated. The area over which this dissection is made extends from the level of the renal vessels above to the bifurcation of the common iliac artery below and from the outer border of the psoas muscle externally to the middle line internally. In carrying out this lymphatic extirpation the gland-containing tissues are wiped away as far as possible with a dry swab, and any vessels which bleed are secured and the ureter carefully protected from injury. Finally the raised peritoneum is allowed to fall back and resume its original position, and the

FIG. 300.—Encysted hydrocele of the tunica vaginalis. The left testicle forms a distinct projection at the bottom of the scrotum and above it the cavity of the tunica vaginalis on that side is distended by a large encysted hydrocele.

extensive abdominal wound is closed. The sutures employed for this purpose consist of chromicised catgut, and they are arranged in strata.

If the surgeon is apprehensive of hæmorrhage from oozing vessels of capillary size and the development of a hæmatoma, a counter-opening may be made posteriorly between the iliac crest and the last rib and a drainage tube introduced into the retro-peritoneal area.

HYDROCELE OF THE TUNICA VAGINALIS.—The simple procedure of tapping a hydrocele with a trocar and cannula, although efficient in removing the fluid, can only be regarded as a palliative measure, as the process usually has to be repeated at intervals of varying duration. In some individuals this treatment may nevertheless

be advisable, more especially in elderly and debilitated men in whom measures of a more elaborate kind might not be well borne.

In young adults, however, and in the absence of any definite contraindications, we prefer to treat cases of hydrocele by operative measures, and the two procedures about to be described are those which we usually employ.

EXCISION OF THE PARIETAL LAYER OF THE TUNICA VAGINALIS.—This operation consists in opening into the cavity of the tunica vaginalis, allowing the contained fluid to escape, detaching the parietal layer of the membrane from the investing scrotal tissues, cutting it away in the vicinity of the testicle, and closing the wound.

The usual measures are adopted for cleansing and disinfection of the area of operation. The cutaneous incision, about 3 inches in length, extends from the upper part of the scrotum to the inguinal region at the level of the external abdominal ring. While the superficial tissues are being divided an assistant grasping the affected side of the scrotum pushes the hydrocele upwards so as to make it prominent in the groin.

The overlying tissues are progressively divided and bleeding vessels are carefully secured with hæmostatic forceps. When the tunica vaginalis is reached it is exposed for a limited extent and divided, but before doing so its contents may with advantage be drawn off with a trocar and cannula. The membrane is incised, and with one index finger inside the cavity the overlying tissues are progressively peeled off much in the same way that the sac of a hernia is stripped of its investing tissues, the process being greatly facilitated by dry sponging with a folded muslin swab.

The next step consists in making the section through the tunica vaginalis close up to the testicle, and as this is likely to be followed by an undesirable amount of bleeding it will be well to divide the membrane by successive sections into a series of strips and ligature these separately with fine catgut. Another efficient way of dividing the membrane is by means of the actual cautery at a dull red heat.

A modification of this operation suggested by Klapp is to pass a series of radially directed sutures through the tunica vaginalis. When these are drawn tight and knotted the membrane is thrown into folds which collectively form a collar surrounding the testis.

Before closing the wound the divided tissues are carefully inspected, and any vessel observed to bleed is seized with forceps and either twisted or tied with fine catgut. One of the most likely complications which may follow this operation is hæmorrhage, and its amount may be sufficient to form a large collection within the scrotum. One cannot be too careful therefore in effecting hæmostasis before the wound is closed, and as an additional precaution a drainage tube had better be introduced through a puncture in the scrotum and allowed to remain for twenty-four or forty-eight hours.

The wound is closed by two or three deep sutures of silkworm gut, the sites for their introduction having been indicated at the commencement of the operation by scratching lightly with a sharp needle at right angles to the line of the cutaneous incision. The intervals between these sutures may be closed by Michel's clips or by a few additional interrupted sutures of silkworm gut or horsehair.

OPERATION FOR HYDROCELE BY EVERSION OF THE SAC (Jaboulay).—The preliminaries are similar to those described in the last operation. The tunica vaginalis is exposed, and before opening it it may, if not greatly distended, be drawn upwards together with the testicle from out of the scrotum. The membrane is incised

freely by a vertical incision, and its cut edges are then folded back so as to meet behind the testicle. They are secured in this position by means of a few interrupted sutures of catgut, the highest of which connects the serous margins behind the lower extremity of the spermatic cord

The testicle is restored to the cavity of the scrotum, and the same precautions are taken to arrest bleeding as in the last operation. Drainage is established and the wound closed as before.

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