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CONTENTS

	PAGE.
ORIGINAL ARTICLES:	
COLONEL J. G. ADAMI, MAJOR F. B. BOWMAN, CAPTAINS F. ADAMS, A. G. FLEMING, C. D. FARQUHARSON, C. IMRIE, and R. M. JANES. Combined Inquiry into the Presence of Diphtheria and Diphtheroid Bacilli in Wounds	34
LIEUTENANT-COLONEL T. B. FUTCHER. Chronic Hypertrophic Pulmonary Osteo-Arthropathy following Bronchiectasis	38
LIEUTENANT-COLONEL J. MEAKINS and CAPTAIN T. W. WALKER. The After-effects of Wounds of the Chest and their Treatment	40
CAPTAIN B. S. CORNELL. On the Examination of the Sputum for Albumin in Pulmonary Tuberculosis and Chronic Bronchitis...	45
	46
PROCEEDINGS OF CLINICAL SOCIETIES OF THE C.A.M.C.:	
Etchinghill Clinical Society	47
ADMINISTRATIVE NOTES:—	
The C.A.M.C. and the Military Hospitals Commission	47
CORPS NEWS:—	
Honours and Awards	48
Promotions	48
Struck off Strength	48

This Bulletin is issued to every unit of the Canadian Army Medical Corps. It will be passed for reading, and will be initialled by all Officers. After return it will be kept on file by the Officer Commanding for further reference.

COMBINED INQUIRY INTO THE PRESENCE OF DIPHTHERIA AND DIPHTHEROID BACILLI IN OPEN WOUNDS.

By COLONEL J. G. ADAMI, MAJOR F. B. BOWMAN, CAPTAINS F. ADAMS, A. G. FLEMING, C. D. FARQUHARSON, C. IMRIE, and R. M. JANES, C.A.M.C.

THERE appeared in the *Journal of the American Medical Association* for September 8, 1917, an article by Majors J. G. Fitzgerald and D. E. Robertson of No. 2 Military Division, Canada, entitled "Report of an Outbreak of Diphtheric Wound Infection among Returned Soldiers." These observers report that as the result of a thorough investigation of all infected wounds in returned men of the C.E.F. in their Division, carried out between May 20 and June 7, 1917, no less than forty out of sixty-seven cases afforded cultures of *B. diphtheriæ*. They admit that in some cases the infection may well have been conveyed from case to case by a nurse whose duty it was to dress the suppurating amputation cases. This nurse was found to have a slight wound of the index finger which yielded cultures of *B. diphtheriæ;* particulars are given which indicate that she may have distributed the infection from wound to wound. That she could not be held entirely responsible for the outbreak is shown by the fact that other cases with infected wounds showed themselves in soldiers who had returned to Canada after the nurse had been taken off duty and sent to the Isolation Department; two or three cases were discovered in men immediately upon their arrival in Toronto from overseas. And the authors conclude: "It was extremely probable, therefore, that patients with diphtheric wound infection were being returned to Canada from overseas."

The extraordinarily high proportion of positive cases affording cultures of the diphtheria bacillus from wounds in this outbreak is undoubtedly calculated to afford the impression that infection of open wounds with *B. diphtheriæ* is a common, not to say widespread, condition in military hospitals overseas. That the characteristic membrane formation occurred in certain of their cases, but not in all, is evident from their description and illustrations. From that description it is equally evident that in some cases the existence and isolation of virulent Klebs-Loeffler bacilli was proved by inoculation experiments. Their paper would have been more complete had precise figures been given regarding these matters. One of the two authors is a bacteriologist and serologist of distinction, Director of the Serological Institute of the University of Toronto, to the activities of which, in the preparation of antitoxins and vaccines, the Canadian Expeditionary Force and Canada at large is heavily indebted. Of the existence of the epidemic in Ontario in 1917 there is no doubt; that there were cases of infection of wounds with virulent diphtheria bacilli and membrane formation is not disputed. The fact that some of the cases are reported to have afforded cultures of the diphtheria bacillus immediately upon arrival in Toronto from overseas, rendered it essential that in England an inquiry be set on foot to determine the frequency of the presence of *B. diphtheriæ* and allied diphtheroids in the wounds of patients in Canadian military hospitals.

To our knowledge no such investigation on an adequate scale has hitherto been attempted. It is not an easy matter, but on the contrary demands much laborious work on the part of the bacteriologist, and when it is remembered that in hospitals of 1,500 to 2,000 beds the daily routine is in itself sufficient to occupy fully the time of the laboratory staff, the additional work thrown upon that staff by an investgation of this order is no light matter. It is not sufficient to make smear cultures from the wounds upon Loeffler's blood serum, and to call any granulated bacteria diphtheria bacilli, and that because non-toxic diphtheroids may be present in wounds and may grow equally well upon "Loeffler," and, what is more, in general when stained may show the palisade arrangement and the metachromatic granules that used to be regarded as characteristic of the Klebs-Loeffler bacillus. All such bacteria have next to be gained in pure culture, and put through their paces on media containing different "sugars." This will throw out all the diphtheroids. But even this is insufficient. There are strains which morphologically and by fermentation tests conform wholly with the *B. diphtheriæ*, but are absolutely harmless. It is necessary with every strain answering to the properties of the *B. diphtheriæ* to conduct inoculations upon the guinea-pig, thereby to determine whether it is harmless or pathogenic, or if such a course be regarded as a "counsel of perfection" this must be laid down, namely (1) that in the absence of clinical signs no bacillus can be accepted as the genuine Klebs-Loeffler bacillus without the confirmatory proof of inoculation, and (2) that where in a wound there is glazing and membrane formation, inoculation must be employed to demonstrate that this is due to the diphtheria bacilli present, and not to the *Micrococcus aureus* or other organism; when this has been proved, then other cases in the ward showing membrane formation may reasonably be diagnosed as diphtherial from microscopical and cultural findings without the test of inoculation.

Early in August information regarding the outbreak in No. 2 Military Division was forwarded by the D.G.M.S., Ottawa, to the D.M.S. Canadians, and the A.Ds.M.S. in England were advised and asked to issue the necessary instructions for a bacteriological examination of all open suppurating wounds in Canadian hospitals (A.M.D. 25-1-5 of August 10, 1917). If the number of cases in any area was very large, it was held sufficient that every alternate case be examined. So also it was asked that the personnel of the hospitals be examined to determine the existence of diphtheria "carriers." Subsequently in the Shorncliffe area this examination for carriers was restricted to a group of the larger hospitals, active and convalescent.

"CARRIERS."

As regards carriers, the outcome of the investigation was to demonstrate a striking absence of carriers among the personnel of the different hospitals. Most hospitals report "all negative." The pathologists at Eastbourne and Orpington (Captains Douglas and Imrie) afforded nominal rolls of the personnel examined. At the former hospital cultures from the throats of 157 officers, N.C.Os., nursing sisters, and men yielded no Klebs-Loeffler bacilli, and only three growths of diphtheroids; three out of thirteen patients examined yielded diphtheroids (no *B. diphtheriæ*). Similarly from Orpington the report showed 111 of the personnel examined, not a single culture obtained of the Klebs-Loeffler bacillus, but twenty-four throats yielded Hofmann's bacillus (the common diphtheroid of the throat).

INFECTION OF WOUNDS. PRELIMINARY OBSERVATIONS.

The replies regarding the bacteriological examination of suppurating wounds were not so complete. Many hospital laboratories were not in the position to carry out the investigation, they were not equipped for an investigation on so extensive a scale, nor had they the requisite staff to carry it out in addition to the insistent routine work. Captain Fleming, pathologist at the Duchess of Connaught Canadian Red Cross Hospital at Taplow, reported that for some little time in connection with the Carrel-Dakin and Flavine treatment of wounds they had conducted a routine examination, with cultures, of all suppurating wounds, and had never encountered *B. diphtheriæ*. Captain T. R. Little reported from the Central Laboratory at Hastings that few cases with suppurating wounds came into the hospitals of that area; he had made a full bacteriological examination of six cases, of which four yielded diphtheria-like organisms. 0·5 c.c. of a standard suspension of a twenty-four-hour culture of *B. diphtheriæ* inoculated into guinea-pigs or young rabbits will cause death within seventy-two hours. Taking these four cultures he had inoculated with 0·5, 1·0 and 1·5 c.c. of suspensions of each into young half-grown rabbits, and not one of them had succumbed. It deserves note that prior to the War Captain Little had been engaged upon a study of the diphtheroids.

COMBINED INVESTIGATION.

Here the matter rested until the appearance of the paper above-mentioned by Majors Fitzgerald and Robertson, when the D.M.S. Canadians directed that at the Central Laboratory, Folkestone, and at Nos. 4, 15 and 16 Canadian General Hospitals, a combined investigation be made into the matter of the infection of open wounds by members of the diphtheria group. At these centres it was considered that conditions were such, both as regards the nature of the cases admitted and the laboratory accommodation, as to afford the most favour-

able conditions for the inquiry. Subsequently it was found that the laboratory at No. 4 Canadian General Hospital was not prepared to undertake the investigation, this hospital having only recently been transferred from Salonika, and the laboratory was not as yet in full working order.

From the office of the D.M.S. directions were forwarded to each participating laboratory detailing the scope and plan of the investigation. Those directions were full and precise. Their main features may here be referred to in abstract. The attempt was made to reduce to a minimum the procedure for differentiating between the different members of the diphtheria group, and to provide methods which had been tested and proved reliable. (1) Sterilized swabs, labelled, were to be provided for use in the wards. (2) Fresh smears were to be examined by either Loeffler's or Neisser's method, and attention was called to the fact that the majority of wound diphtheroids are indistinguishable from the Klebs-Loeffler bacillus under the microscope. (3) Blood serum plates were recommended in place of slanted test-tubes for the first cultures. (4) Pure cultures of the diphtheroids recognized were to be obtained on blood serum slants (*B. diphtheriæ* colonies remain white, wound diphtheroids often, as they become older, acquire a pinkish or yellowish tinge). (5) For the sugar tests of these pure cultures Hiss's serum water medium was recommended as base, plus 1 per cent. of the sugar, together with azolitmin or litmus as indicator.* Four sugars only were to be used: dextrose, lactose, saccharose, and dextrine. These four saccharides were chosen in the first place to ensure the recognition of *B. diphtheriæ*. Dextrose (glucose) is a typical monosaccharide, lactose a useful disaccharide. Neither saccharose (sucrose) nor dextrine are for general bacteriological purposes regarded as of first importance, i.e., with other bacterial species. The latter, it is true, is a representative polysaccharide, yet care is requisite in the preparation of dextrine broth, lest it be overheated and undergo hydrolysis with production of dextrose and levulose (this was noted in the directions given). But with a striking constancy the Klebs-Loeffler bacillus ferments dextrine with production of acid, and fails to ferment saccharose. Saccharose and lactose are also useful in differentiating between the other members of the group. As regards the other saccharides, levulose (as between the main members of the group) reacts in the same way as does dextrose, and might therefore be excluded. The same is largely true of maltose, and where it is not, the confusion that has been introduced by some members of what in other respects is the same sub-group fermenting this sugar, and others failing to ferment it, renders its employment inadvisable. Mannite could be neglected, since it is not fermented by any members of the group. Other glucosides are both difficult to procure in a state of purity, and when procured do not afford constant results; their use, that is to say, is corroborative rather than of fundamental importance. We admit that glycerine might have been added to the series. Mellon has found this representative of the alcohols of distinct service in differentiating between the diphtheroids. Our object, however, was not so much to make a full differentiation between the many members of the group, as with the greatest economy of material and labour to recognize the main types, and above all to distinguish clearly between *B. diphtheriæ* and the other members. All forms which produced acid with dextrose and dextrine, and were negative with saccharose, were to be regarded provisionally as the Klebs-Loeffler bacillus; all others as diphtheroids. The following formulæ were afforded:—

	Dextrose	Lactose	Saccharose	Dextrine
B. diphtheriæ	+	+	−	+
B. hofmanni	−	−	−	−
B. xerosis	+	−	+	−
Wound diphtheroids ...	+	+	+	±

(6) *Toxin Formation.*—The determining test as between the diphtheria bacillus and diphtheroids is toxin formation. The investigation was planned to discover in the first place whether virulent micro-organisms are to be encountered in open wounds, and only in the second place how frequently other members of the group gain entrance to wounds. What determines whether a given organism is the true Klebs-Loeffler bacillus, and therefore of serious import, is not its morphology or staining reactions, or cultural characteristics, but its capacity to produce ectotoxins, and thus to affect the health of the patient. Detailed directions were therefore given as to the preparation of a broth, according to Dean's method, found to be most favourable for the rapid production of toxins. Having made twenty-four hours' growths in Erlenmeyer flasks of the bacilli to be tested, a guinea-pig was to be inoculated subcutaneously with 1·0 c.c. of the same. If toxic effects were produced, then four guinea-pigs were to be taken; two of them were to be given each 300 units of anti-diphtheria serum, and now one normal and one immunized guinea-pig were to be inoculated with 0·5 c.c. of the twenty-four hours' broth culture, and the other pair with 1·0 c.c. If the growth was one of true virulent diphtheria bacilli, the larger dose should cause death of the untreated guinea-pig within twenty-four hours.

A separate report was asked for each case affording members of the group, both true Klebs-Loeffler bacilli and diphtheroids.

It is generally agreed by those engaged in this investigation that no dependence can be placed upon smears from wounds as discovering the presence or absence of bacilli of the diphtheria group. This fact, in itself, is evidence of the absence of widespread diphtherial wound infection. Where there is widespread infection with membrane formation it should not be difficult to encounter the characteristic bacilli in relative abundance. Presence or absence of diphtheroids was determined by smears from the first, mixed, cultures on blood serum plates. This has introduced a difficulty in affording exact statistics, e.g., at Folkestone bacilli resembling *B. diphtheriæ* were detected forty-one times, and that from forty cases, but from only twenty-four out of these forty cases were pure cultures isolated and studied,* one wound affording two separate diphtheroid organisms. Thus our first table giving the number of cases affording bacilli belonging to this group does not tally with the second table giving the relative frequency of the different members of the group isolated.

RESULTS.

The results obtained by this combined investigation may here be succinctly tabulated:—

Laboratory	Observer	Number of cases examined	Number affording true *B. diphtheriæ*	Number affording diphtheroids
No. 1 Canadian General Laboratory, Folkestone	Captain F. Adams	121	1	40
No. 16 Canadian General Hospital, Orpington ...	Captain C. Imrie	60	1	7
No. 15 Canadian General Hospital, Taplow ...	(1) Captains A. G. Fleming and R. M. Janes	100	0	0
	(2) Captain C. D. Farquharson	25	0	9
		306	2	56

The following additional data deserve note:—

(1) *Folkestone.*

Two cases afforded growths which culturally, tinctorially, and by the fermentation tests had the properties of the Klebs-Loeffler bacillus. One of these (No. 69, a sloughing stump of the thigh) afforded two separate strains of diphtheria-like bacilli. Of these one gave the sugar reactions of a wound diphtheroid, the other of the Klebs-Loeffler

* Mellon objects that litmus is not a sufficiently delicate indicator, and recommends Andrade's medium, or, failing this, neutral red. Azolitmin was recommended after a careful test. Major Bowman and Captain Adams found that constant results were obtained by eight days' and even by four days' growth in the Hiss's medium.

* That any of the seventeen remaining cases were those of true diphtherial infection is improbable from the fact that the method of isolation employed was that which has proved itself the optimum for isolation of *B. diphtheriæ*.

bacillus. Upon inoculation into guinea-pigs both were found non-virulent, like results being obtained on repeating the test. The other case (No. 77), with a granulating ulcer on the leg, gave virulent diphtheria bacilli, 1·0 c.c. of the broth culture causing death within forty-eight hours, with œdema at the site of injection and bright red suprarenals. Regarding this case, it is interesting to note that further inquiries elicited that the man had been isolated when coming out of the trenches in France as a case of suspected diphtheria. The strains of wound diphtheroids isolated were almost entirely of the *B. xerosis* type, one alone affording the sugar reactions characteristic of *B. hofmanni*.

Captain Adams reports at a later date "the cultures that gave the proper sugar reactions for true diphtheria kept on sub-culture their small colonies, characteristic morphology and staining for at least two months. On the other hand the diphtheroids, after a week or two, changed their character. The colonies originally too robust for true diphtheria became still bigger, and many of the strains developed a creamy or pink colour. The bacilli also shortened, and many strains lost their granules."

(2) *Orpington.*

Captain Imrie's report from Orpington is strikingly similar, both as regards the immediate and the late results. Here also two strains were isolated which, until inoculation tests were made, appeared both to be the genuine Klebs-Loeffler bacilli; upon inoculation one of the two was found to be non-virulent. The other diphtheroids were of the usual wound diphtheroid type (negative to dextrine) with one exception. He likewise calls attention to the coarser, more confluent growth of the diphtheroids isolated by him, and their assumption of a yellowish colour.

(3) *Taplow.*

The results at Taplow are curious and interesting. Captain Fleming had prior to the War made yearly for the Toronto Board of Health several thousand examinations, microscopical and cultural, in cases of diphtheria and suspected diphtheria. Add to this that for months he had been engaged upon the routine study of wound bacteriology at Taplow, particularly in connection with the progress of wounds subjected to the Carrel-Dakin treatment. Prior to taking up this particular investigation he had never encountered diphtheria-like bacilli at No. 15 Military Hospital. For the purpose of this examination he and Captain R. M. Janes studied approximately 100 wounds by the routine laid down (they forward sixty detailed negative reports and offered to make out the remainder if desired). An analysis of the sixty reports forwarded shows that swabs were made from open wounds of various orders and varying duration from two weeks to twenty-two months, subjected to various orders of treatment, drainage (nine cases), Dakin's (thirteen), fomentations (five), saline (twenty-one), &c. These results varied so widely from those obtained at Folkestone and Orpington that the two observers offered to engage in another series, when both were transferred elsewhere. Captain Farquharson, who succeeded, undertook this additional investigation some two months later, and now in a series of twenty-five cases encountered diphtheroids nine times. Of these nine only one was the commoner type of wound diphtheroid negative to dextrine, five were of the rarer type fermenting dextrine, two were of the xerosis type, and one *B. hofmanni*.

Combining these results into a table we find the following:—

Dextrose	Lactose	Saccharose	Dextrine		Folkestone	Orpington	Taplow	Total number of diphtheroids
+	+	+	+	Wound diphtheroids (type I)	0	1	5	6
+	+	+	−	,, ,, (,, II) ...	0	5	1	6
+	+	−	+	*B. diphtheriæ*, virulent	1	1	0	2
+	+	−	+	,, non-virulent	1	1	0	2
+	−	+	−	Wound diphtheroids (III), xerosis type	21	0	2	23
−	−	−	−	*B. hofmanni*	1	0	1	2

Taking these two tables it will be observed that the results obtained are strikingly at variance with those reported by Majors Fitzgerald and Robertson. In place of forty out of sixty-seven cases, or practically 60 per cent. of open wounds affording cultures of true virulent Klebs-Loeffler bacillus, we find two out of (approximately) 306, or under 0·6 per cent. Even if we accept the non-virulent bacilli of Klebs-Loeffler type as true diphtheria bacilli, the figure is raised only to a little over 1·0 per cent. The total number of diphtheroid strains isolated affords a percentage far below that of the *B. diphtheriæ* isolated by the Toronto observers.

DISCUSSION.

In a careful bacteriological study of open wounds made at three important Canadian medical centres in England there is complete absence of widespread infection of wounds by *B. diphtheriæ*. The Toronto epidemic of such infection is, we believe, the first recorded among the soldiers of the Allied Powers during the course of this War.

It is well recognized to-day that non-pathogenic diphtheroids are widely spread. Even these, while commoner, are not frequent inhabitants of wounds.

Thanks more particularly to the introduction of the newer methods of antiseptic treatment of wounds, never has there been so extensive and intensive a study of the bacteriology of wounds as during the present War. For the establishment and control of these newer methods repeated cultures have come into vogue, and had diphtherial infection been common in Europe, numerous observers would before this have called attention to the fact. We find, on the contrary, no reports upon the epidemic spread of diphtherial infection. That individual cases occur our own observations clearly demonstrate. What is more, in addition to the two cases here reported, two other cases have been notified as occurring at No. 5 Canadian General Hospital, Liverpool. But upon further inquiry into these cases we learn that in the earlier of the two (Pte. P—— 228808) this was recorded by the Pathological Department of the Thompson-Yates Laboratories of the University of Liverpool as yielding a free growth of staphylococci and "a few apparently typical diphtheria bacilli." With regard to the second case, that from Sergeant W—— 38385, this was one of eight swabs received, and was returned as positive. In neither case were tests made for pathogenicity. The officer in charge of the Ist Western General Laboratory, who reports these facts, states further that owing to the cost of guinea-pigs pathogenicity tests are not made as a routine; occasionally attention is drawn to the fact that diphtheria-like bacilli are not necessarily pathogenic, and he adds: "Only recently an assistant in a neighbouring laboratory had diphtheria-like bacilli present in the throat which, however, were negative to the pathogenicity test." It will be seen thus that diagnosis in these two cases was made simply from the appearance of the mixed cultures obtained from swabs, and that this being the case, the evidence that these two patients showed genuine and virulent diphtheria bacilli in their wounds is far from complete.

That epidemic spread of diphtherial infection of wounds might under circumstances manifest itself is freely admitted. In Major Fitzgerald and Robertson's account of the nurse with the infected finger we have an excellent instance of how this may be brought about. We are, however, of the opinion that the widespread use of eusol, Dakin's mixture, flavine, and other antiseptic solutions in Canadian hospitals in England has reduced the danger of such spread to a negligible amount. As regards the non-pathogenic diphtheroids, indeed, our figures indicate, we consider, the existence of a low grade of local or endemic prevalence. Thus it is deserving of note that wound diphtheroid (I) was the commoner form at Taplow, wound diphtheroid (II) at Orpington, while bacilli of the xerosis type predominated in the Folkestone area. We would not, however, lay too great a stress upon these findings.

ON THE CLASSIFICATION OF THE DIPHTHEROIDS.

It may be asked by those who have not followed the literature: What is the nature of these wound diphtheroids?

In 1888 von Hofmann-Wellenhof of Graz, in Austria, called

attention to the frequent presence in the throat and mouth of a perfectly harmless Gram-positive bacillus of irregular breadth which might easily be mistaken for the true diphtheria bacillus. Loeffler in his original communications had noted the existence of these harmless forms. For years this was regarded as an attenuated strain of the virulent germ, and as such spoken of as *B. pseudo-diphthericus*. With the discovery that this form was incapable of fermenting dextrose and other sugars, and was therefore quite distinct from the Klebs-Loeffler organism, the first name was seen to be inappropriate, and now this form is more generally known as *B. hofmanni*. Slowly, but at an increasing rate, other non-diphtherial organisms have been detected in the air, in water, and in the human body and its passages, often becoming regarded as the cause of one or other condition of disease, e.g., Hodgkin's disease, general paralysis, &c., until it came to be recognized as urgent that the group should be carefully studied, and the members classified.

The first notable attempt at such a classification on any considerable scale was made by Hoag* of Boston in 1907. He made an analysis of the properties of 199 pure cultures of members of the group, including among these 146 growths of what he termed provisionally "organism X" (a diphtheroid which he had isolated more particularly from the insane patients at the Danver Insane Hospital), seventeen strains of the Klebs-Loeffler bacillus, four of Hofmann's bacillus, &c. A still more thorough analysis was made in 1912 by Miss Morse of Chicago.† Her study of 295 different strains following the biometric methods of Theobald Smith and Winslow was so thorough and analytical that even if we are on the eve of a revolution in the method of determining the acidity and alkalinity of media, her results must remain as the basis of the scientific classification of this group. A year later Hine‡ in Great Britain published an article based upon his unpublished thesis of 1906, in which, basing himself upon the study of the biochemistry of seventy-one different cultures of various diphtheroids, he arrived at conclusions very smilar to those of Miss Morse.§

Miss Morse recognized six groups (two groups or sub-groups of *B. diphtheriæ* distinguished by fixed morphological differences, the one less virulent than the other, *B. hofmanni, B. xerosis, B. hoagii,* and *B. flavidus*); Hine recognized five main groups (*B. diphtheriæ, B. hofmanni, B. coryzæ segmentosus* (Cautley), a group of skin diphtheroids, and another of urethral diphtheroids.

Last year Mellon,‖ of Harvard Medical School, published the results of another exhaustive study of the group. Employing as many as ten different saccharides, he makes out no less than seven sub-groups of the diphtheroids, or, including *B. diphtheriæ,* eight. Experience must show whether he is justified in making this extensive subdivision. This is not the place to enter fully into the vexed matter of the specific value of fermentation tests. In connection with this diphtheroid group, as with other groups of pathogenic bacteria, those who have made the fullest and most exact studies are most willing to admit the wide variations that occur even in the fermentative activities of strains about whose allocation there can be no reasonable doubt. Thus, for example, Graham Smith has recorded an epidemic of diphtheria in which many of the cultures isolated fermented saccharose vigorously. On the other hand, it has to be admitted that with regard to specific sugars well defined groups in general show a striking constancy in their action. It is, for example, a perfectly sound rule to lay down that a diphtheroid which ferments dextrose, lactose and dextrine, and fails to produce acid with saccharose, is either *B. diphtheriæ,* or what we would term *B. quasi-diphthericus,* the differentiation between the two being made by the inoculation test. However, the converse does not obtain that all diphtheria bacilli ferment these sugars. In an article just published, Smith of Glasgow throws doubt upon the fermentation of lactose by *B. diphtheriæ.** Only two out of six of his strains, proved by inoculation to be the Klebs-Loeffler organisms, fermented this sugar. Either Glasgow has a special strain of bacilli, or this laboratory an inactive brand of lactose.

And studying carefully the excellent tables compiled by Hoag, Morse and Mellon, we find ourselves justified in selecting for this group the four sugars employed in this investigation. Had we, that is, employed ten, we cannot see that, judged by the experiences of the above-noted observers, we should have at all materially altered our findings. As it is, the permutations and combinations afforded by four variables, or more truly (including virulence) five, are quite sufficient for all reasonable and practical purposes. Species are not so precisely limited. It is well to bear in mind that the separation of forms of life into genera and species is in its essence at most a convention, a convention instituted for the sake of utility, in order to permit the orderly classification of the forms under review. Among these lower forms of life sharply defined species as such do not exist. When, therefore, a classification becomes so minute that in place of being useful it becomes tiresome, the primary object of the convention is defeated. It is contrary to good sense and good practice to elevate a single variation in the fermentation tests into a specific difference. Within the limits of this group the four sugars selected, together with the results of inoculation, or virulence, afford all the particulars necessary for a sound classification. Even these four, in our opinion, are at most helpful, not definitive. Diagnosis, that is, cannot be based upon fermentation tests alone.

Employing these and utilizing the data afforded by the investigations above-mentioned, we recognize the following members of the group:—

CLASSIFICATION OF THE MEMBERS OF THE DIPHTHERIA GROUP, BASED UPON CULTURAL CHARACTERS, FERMENTATION TESTS AND PRODUCTION OF ECTOTOXINS.

	Dextrose	Lactose	Saccharose	Dextrine	Ectotoxins
B. enzymicus (Mellon, 1917)	+	+	+	+	−
B. diphtheriæ (Klebs-Loeffler, 1887) ..	+	+	−	+	+
B. quasi-diphthericus (the authors) ...	+	+	−	+	−
B. hoagii (Morse, 1912)	+	∓	±	∓	−
B. xerosis (Kuschbert and Neisser, 1884)...	+	−	+	−	−
B. flavidus (Morse, 1912)	+	−	−	−	−
B. ruedigeri (Mellon, 1917)	−	−	−	−	+
B. hofmanni (? Park and Beebe, 1895) ...	−	−	−	−	−

Morphologically all the organisms here noted have the peculiar features of the diphtheria bacillus, and may on first sight be mistaken for it. There are a few forms on record which may be mistaken for *B. diphtheriæ,* but ferment sugars with the production of gas. These we do not regard as diphtheroids, but as members of the proteus group, nearly allied. The characteristics of the various sub-groups or species are as follows:—

B. enzymicus.—So-called from the strong tendency exhibited to ferment sugars with the production of acid. All the members of the group ferment at least six of the saccharides employed commonly in bacteriological research; some ferment as many as ten. Growth poor when first isolated; individuals vary greatly in size and appearance.

Included in this group are the strains (*B. hodgkini*) isolated by Bunting and others from cases of Hodgkin's disease.

B. diphtheriæ, cultures greyish white, with no pigment production, slightly moist; characteristics so well known that they need not here be recapitulated.

B. quasi-diphthericus.—The separation off of this sub-group is necessitated by the consideration that bacilli which

* *Boston Med. and Surg. Journ.*, 1907, x, 197.
† *Journ. of Inf. Diseases,* 1912, xi, 253.
‡ *Journ. of Pathology and Bacteriology,* 1913, xviii, 75.
§ In 1906 (*Journ. of Hygiene,* 1906, vi, 286), and later in 1908, in the well-known volume by Nuttall and himself, ("Bacteriology of Diphtheria," p. 161), Graham Smith described and named a considerable number of diphtheroids. He did not, however, make a study of the fermentative activities on a sufficiently extensive scale, so that, willing as we are to credit his pioneer work, it is difficult to place precisely his various species or sub-species. Add to this, by the laws of botanical nomenclature, several of his designations, being trinomial, are inadmissible.
‖ *Journ. of Bacteriology,* 1917, ii, 269.

* *Applied Bacteriology,* edited by C. H. Browning, M.D. London, 1918, p. 60.

do not cause diphtheria cannot be spoken of as diphtheria bacilli until it is shown that they are *potential* diphtheria bacilli, that by passage, &c., they can be made to produce ectotoxins. Until this has been done they must be treated as distinct. In every other respect they are not distinguishable from *B. diphtheriæ*.

B. xerosis forms on blood serum agar whitish or colourless colonies, dry and adherent, growing not very actively, and consisting of large rather thick individuals with clear-cut segmentations. Neisser's granules large and irregular. Common upon the conjunctiva. Does not ferment lactose or dextrine. There has been considerable confusion regarding forms described under this heading. Mellon, from the study of one strain only, describes it as negative to saccharose, while Hamilton includes a maltose fermenter under this name which Mellon would class as *B. flavidus*. That here given is the more commonly accepted sugar formula, though acid is produced so slowly with dextrose that earlier observers reported the fermentation to be negative. Eyre isolated a form from cases of chalazion which he found pathogenic for guinea-pigs, causing local œdema on inoculation. Other observers find it devoid of virulence, and it does not produce ectotoxins.

B. flavidus.—Morphologically and culturally very similar to the preceding, save that with age *the colonies become pale yellow*. Dry adherent growths on blood and serum media. Neisser's granules large and irregular. While not producing ectotoxins, Hamilton found it pathogenic for guinea-pigs (four out of seven strains). Mellon would give this name to organisms "similar in most respects to the Klebs-Loeffler bacillus, but lacking the specific toxin formation of the latter." Morse lays stress on the fact that, unlike *B. diphtheriæ*, it is a weak fermenter, and that "usually" saccharose, maltose and glycerine are not fermented.

The observations of Captain Adams at Folkestone that the strains isolated there, while giving the sugar formula of *B. xerosis*, nevertheless assumed the yellowish colour which is associated with *B. flavidus*, suggest strongly that Hamilton is correct in admitting a considerable variation in the fermentative activities of the former. But in that case *B. flavidus* as such becomes non-existent, save as a variant of the earlier named *B. xerosis*, and all come under the one heading of *B. xerosis*. We are not prepared to make a decisive ruling on this point, and hence, provisionally, record both forms, although registering an opinion that *B. xerosis*, *B. flavidus* and *B. hoagii* form a closely allied series of forms.

B. hoagii.—Under this heading it appears proper to include a very widely distributed group of non-pathogenic diphtheroids growing actively on blood media, and giving abundant moist confluent growths which take on a *salmon-pink or tawny colour, becoming buff with age*. They vary in their fermentative activities; in general ferment saccharose actively, and do not ferment lactose and dextrine. Maltose at times fermented, at times not. Individual bacilli of medium size smaller than the members of the two preceding species, but larger than *B. hofmanni*, thick, solid, barred, or wedged-shaped. Neisser's granules abundant but small.

We are of the opinion that Benham's organism* which he obtained from cases of common cold belonged to this group, and not, as Mellon regards it, to the *B. enzymicus* series, and that therefore, by the laws of priority, his name *B. septus* (1906) should be applied to this sub-group, but both Benham and Graham Smith identified their organisms with Cautley's *B. coryzæ segmentosus*, and doing this report fermentative activities so divergent as to create confusion. Hine's skin and urethral diphtheroids are here apparently to be included, the latter fermenting dextrine, the former not.

B. ruedigeri.—Ruediger isolated this organsim in 1903. It grows heavily on agar and various media, and causes diffuse clouding of broth. It ferments none of the "sugars," although it decolorizes litmus milk, but this without the production of acid (reduction process). It produces an ectotoxin fatal to guinea-pigs, which is not neutralized by diphtheria antitoxin. Rare.

B. hofmanni.—Small, solid, wedge-shaped forms, smaller than *B. diphtheriæ*. No Neisser's granules. Growths colourless. Ferments none of the sugars. Non-toxic.

This table and these descriptions are, we admit, provisional. More has still to be accomplished in the matter of reciprocal agglutination and complement fixation tests before the relationships by these various sub-groups is clearly determined. We give the table tentatively in the hope that it may be of service to others and form the basis for further work.

Comparing this with the table already given of our results, it will be seen that our Wound Diphtheroids (I) come under the category of *B. enzymicus*, our Wound Diphtheroids (II) are *B. hoagii*, and our Wound Diphtheroids (III) are *B. xerosis*.

CONCLUSIONS.

(1) Morphologically and, in the early stages, culturally, diphtheroid bacilli from wounds are, many of them, indistinguishable from *B. diphtheriæ*.

(2) Harmless, non-toxic bacilli may be present in wounds affording cultures possessing the same sugar formula as regards dextrose, lactose, saccharose and dextrine, as does the true virulent Klebs-Loeffler bacillus.

(3) It is not justifiable, therefore, to make a diagnosis of diphtherial infection of wounds, either from smears alone or from stained preparations and cultural characteristics.* The demonstration that the bacilli produce toxins—ectotoxins—i.e., the result of inoculation of broth cultures, is alone capable of proving the presence of infection by the true virulent *B. diphtheriæ*.

(4) By the staining, cultural and fermentation tests, four cases of apparent diphtherial infection have been detected in a careful bacteriological study of 306 cases of open wounds. By the decisive test of inoculation these are reduced to two.

(5) There is a large body of evidence showing that even isolated cases of diphtherial infection of wounds are distinctly uncommon among the wounded overseas, and complete absence of any evidence in Great Britain that these isolated cases have acted as foci for the spread of the infection to other wounded men. No evidence of a widespread infection of open wounds by diphtheria bacilli has been discovered in Canadian hospitals overseas in Great Britain.

(6) Diphtheroid bacilli of various orders, while not common, are, as might be expected, more frequent in open wounds. There is no evidence that these have exerted deleterious effects.

(7) There is a certain amount of evidence that particular species of diphtheroid bacilli characterize particular hospitals.

* *British Med Journ.*, 1906, i, 1023.

* E.g., advice has been received from Canada that a bacteriological examination of the wounds of returned invalids at the time of their leaving the hospital ship on January 10, 1918, before any of the wounds had been dressed on shore, revealed the presence of "bacteria similar to diphtheria bacilli" in fourteen cases. Further information is promised regarding these cases. The wording of the information indicates that inoculation tests had not at that time been performed.

CHRONIC HYPERTROPHIC PULMONARY OSTEO-ARTHROPATHY FOLLOWING BRONCHIECTASIS.

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THE comparative rarity of the clinical picture presented by the following case seems to justify its being recorded.

Private S. R., Regimental No. 865298, 44th Canadian Battalion, single, aged 21, was admitted to No. 16 Canadian General (Ontario) Military Hospital, Orpington, November 15, 1917, complaining of cough and profuse expectoration and weakness.

The family history was unimportant, and no other member has been similarly affected.

The patient had diphtheria at 4 years of age. He states that since 7 years of age he has, at intervals, had a slight cough, but it never gave him any special trouble until the onset of his present illness.

He enlisted in Canada in March, 1916. In June of the same year, while at Camp Hughes, between Winnipeg and Brandon, he contracted a left-sided pneumonia, for which he was confined to bed for six weeks. Seven weeks after the onset of the pneumonia he began to have an annoying cough

with rather abundant expectoration. These symptoms gradually became more marked, and have persisted up to the present time.

He came to England in May, 1917, and went to France in June of the same year. His cough and profuse expectoration had continued throughout the entire year. On July 15, 1917, he developed an acute febrile illness, and was sent to No. 1 Canadian General Hospital at Etaples, where the true nature of his trouble was recognized by Lieutenant-Colonel Gwyn and his associates. During the first week he had a fever which ranged from 103° to 104° F. After remaining there six weeks he was sent to the Norwich War Hospital, where he remained five weeks. Thence he was sent to the Canadian Convalescent Hospital at Epsom. He was then sent to No. 16 Canadian General Hospital, Orpington, on November 15, 1917.

His chief complaint was cough, abundant expectoration, and general weakness. He states that during the past summer the forearms were slightly sensitive on pressure above the wrists, but he has not suffered spontaneous pains in the extremities. He himself had not been conscious of any changes in his hands or long bones until his attention was drawn to them at No. 1 Canadian General Hospital, Etaples, in July, 1917. We consequently have no definite information as to the actual date of these alterations.

Physical Examination.—The patient was tall, measuring 6 ft. 1½ in. Fairly well nourished; weight, 172 lb. There was moderate cyanosis of the nose, ears, and finger-nails. The nose was not globular.

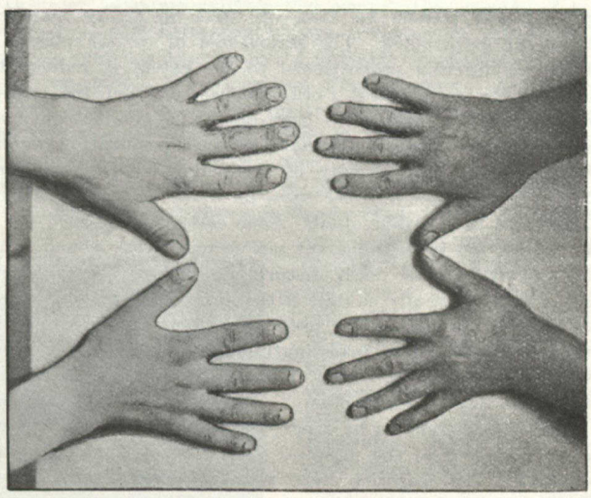

FIG. 1.

Hands on left, those of patient. Weight 172 pounds; height, 6 ft. 1½ in. Those on right of normal man weighing 175 pounds, and height 6 ft.

One was at once struck by the skeletal changes. There was quite marked hippocratic clubbing of the fingers. The nails presented the characteristic "parrot-beak" curving. The fingers were large and appeared elongated. The soft tissues of the fingers were increased, and the phalanges felt thicker than normal. The lower halves of the forearms looked more massive than in a normal individual of the same build and stature. They had lost their normal, graceful tapering as the wrist was approached. The circumferences of both forearms 4 cm. above the tip of the styloid process of the ulna on both sides was 19 cm. 8 mm. The feet were large and the toes moderately clubbed. The lower thirds of the legs appeared definitely thickened and had lost their normal tapering. The circumference of the legs 8 cm. above the tip of the internal malleolus on each side was 24 cm.

Examination of the thorax showed moderate depression above and below both clavicles. There was diminished expansion throughout the lower half of the left side of the chest.

There was no demonstrable impairment of the percussion note over the left lung, but on several occasions a few sonorous musical râles were heard over the lower axillary and subscapular regions.

The tactile fremitus was nowhere changed over the left lung, but there was moderate impairment of the percussion note over the lower axillary and throughout the entire subscapular area. The breath sounds were somewhat enfeebled over these areas. There were numerous coarse sonorous râles which would come and go with coughing. In addition, there were coarse bubbling râles over the subscapular region, where here and there they possessed a somewhat amphoric quality. In some areas the whispered voice sounds were definitely exaggerated. At no time was definite amphoric breathing detected. The physical signs at the left base varied somewhat from day to day, but coarse, moist and sonorous musical râles were constant.

The examination of the cardio-vascular, alimentary, and genito-urinary system was normal.

His cough was at times very annoying, and the expectoration was very abundant, particularly in the mornings when he got up. At this time he would expectorate 60 to 90 c.c. (2 to 3 oz.) in a few minutes. The sputum was collected and measured daily, and generally ranged between 90 and 240 c.c. (3 to 8 oz.). One day it reached 330 c.c. (11 oz.). Postural drainage by having the patient lie across the bed with his body nearly inverted and his head near the floor for twenty minutes daily was carried out, but without much eventual diminution in the quantity of sputum. For the first few days the amount was increased, probably as a result of his getting rid of the sputum which had accumulated in his bronchiectatic cavities. The sputum had a slightly greyish-yellow colour and separated into three layers, a thick mucous layer at the top, a serous layer in the middle, and a greyish-yellow, granular layer at the bottom. It possessed a slightly offensive, sweetish odour. It was negative for tubercle bacilli and elastic tissue.

The patient's temperature ran an afebrile course during his stay in the hospital.

The radiograms of the lungs and skeletal bones were kindly made by Captain Gilchrist, the hospital radiographer. Those of the lungs showed markedly increased mottling and density in the lower lobes, particularly on the left side, although distinctly dilated individual bronchi could not be made out.

Radiograms of the hands, feet, and of radii, ulnæ, tibiæ, and fibulæ were taken. They showed a slight increase of the "bur-like" of the terminal phalanges. All the long bones appear more massive than normal. The shafts of the first and second phalanges, particularly of the hands, are thickened and show very thin layers of subperiosteal new bone formation. The lower ends of tibiæ and ulnæ also show similar thin layers of new bone, although the line of demarcation is not as well developed as in some of the more advanced cases published in the literature.

This affection, of which this patient presents an example in its comparatively early stages, was first described in 1889 by Bamberger [1], who reported a condition of abnormal thickening of the long bones in a patient suffering from bronchiectasis. In the following year Marie [2] described other cases, and gave to it the name by which it has since been known.

Marie's syndrome of hypertrophic osteo-arthropathy is, in the great majority of cases, associated with lesions of the respiratory system. It is commonest in bronchiectasis. Then in order of frequency come pulmonary tuberculosis and empyema. Thayer [3] found it associated with disease of the lungs or pleura in forty-three out of fifty-five collected cases, and Wynn [4] in sixty-eight of 100 in his series. These constitute the cases of chronic hypertrophic pulmonary osteo-arthropathy. It should be emphasized here that it is now generally accepted that hippocratic clubbing of the fingers represents the disease in its mildest form. This has been well demonstrated by Locke [5], who has made the best recent study of the disease. It is supported by the studies of Kessel [6]. They both demonstrate that radiograms of the hands and feet and of the long bones show a "burring" of the terminal phalanges of the former, and almost invariably thin layers of subperiosteal new bone formation somewhere along the shafts of the latter.

The affection is not confined to diseases of the respiratory tract. Cases have been reported in association with chronic diarrhœa, chronic jaundice, hypertrophic cirrhosis of the liver, nephritis, and congenital syphilis.

The cases reported have been, with few exceptions, in the white race. The disease prevails in males. Of seventy-seven cases collected by Alexander, sixty-four were in males and thirteen in females. All ages may be affected, but in the majority of cases the onset is in the third or fourth decade.

In rare instances the disease appears to have been congenital, and Marie believes that it may be inherited.

The consensus of opinion seems to be that hypertrophic osteo-arthropathy is due to a toxic periostitis resulting from the action of circulating toxins, absorbed, in the pulmonary group, from foci of infection in the lungs.

Pathologically, the underlying changes in the soft tissues of the fingers and toes have been generally described as a connective tissue hyperplasia, with capillary dilatation (Kessel). Alexander [7] has reviewed the reports of sixteen complete autopsies. The chief characteristic is a symmetrical deposit of new subperiosteal bone on the shafts of the long bones. The lower ends of the radius and ulna, the metacarpals, the first two rows of phalanges, and the lower ends of the tibia and fibula, are the bones most commonly affected. Other skeletal bones, however, may be involved. In the forearm the new bone usually begins fairly abruptly as a thin layer about 4 in. or 5 in. above the wrist-joint, and forms a sheath covering the lower ends of the radius and ulna as far as the epiphyseal line. In radiograms of well-developed cases this sheath and its line of demarcation from the old bone is very well defined. In the earlier stages of the disease, as in the case here reported, the new bone formation may be in a very thin layer, and the line of demarcation may not yet be recognized. The osseous changes are remarkably symmetrical.

It is usually only in the marked cases that the arthritic features manifest themselves. In some cases there is increase of fluid in the joints, especially the wrists, knees, ankles and finger, due to a subacute synovitis. As a rule the cartilages show no changes. There is little lipping, osteophyte formation, or eburnation of the joints. Generally the cartilages show no changes according to Emerson [8].

Sternberg [9] recognizes three clinical types, which are probably merely three grades of the same condition. (1) The mildest type, in which there is only found clubbing of the fingers, such as is seen in chronic purulent diseases of the lung, and in patients with congenital heart disease. (2) Clubbed fingers with painful thickening of the long bones, especially those of the forearms and lower legs. (3) The third is "Marie's" type, or osteo-arthritis hypertrophica, in which the bone changes are the most conspicuous features, amounting almost to actual deformities.

Symptomatically, the subjective disturbances may be so slight that the patient may not realize that there is anything wrong with his bones until his attention is called to the changes. On the other hand, the forearms may be painful, the pain being increased by pressure. The hands are large, fingers thickened and tips clubbed, and the nails exhibit the "parrot-beak" curving. The feet show similar changes. The lower ends of the forearms and legs are much thickened and have lost their normal graceful tapering. The joints in some cases may be slightly sensitive and somewhat swollen from excess of synovial fluid. In the pulmonary group there may be considerable cyanosis of the fingers and nose, and the latter may be somewhat "globular." In the pulmonary cases there will be the symptoms associated with the lung affection, to which the bony changes are secondary.

From the standpoint of diagnosis there is practically no other condition that closely simulates this disease. In every case of chronic pulmonary disease characterized by enlargement of the hands, feet and the distal halves of the forearms and legs, and accompanied by some degree of pain, hypertrophic osteo-arthropathy should be strongly suspected. The true nature of the trouble can be readily demonstrated by the finding of subperiosteal new bone formation in radiograms of the long bones. The appearance of the hands and feet in acromegaly is quite distinctive. Recognition of the fact that hippocratic clubbing of the fingers in chronic pulmonary diseases is the mildest form of hypertrophic osteo-arthropathy should stimulate us to take radiograms of the long bones in these cases, in order to demonstrate the new bone formation so frequently found in this condition.

The therapy is essentially that required for the treatment of the primary condition, and considerable improvement has been recorded in some cases by effectively following this course.

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THE AFTER-EFFECTS OF WOUNDS OF THE CHEST AND THEIR TREATMENT.

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THE eventual degree of disability of soldiers suffering from wounds is of great importance, not only from the military, but equally from the civilian point of view. In all classes of injury the object to be striven for is such reduction of the disability as will make the patient again fit to be a soldier. Where this is not feasible it is the aim of the physician to reduce the disability as much as possible in order that the patient may resume his civil life with no greater handicap than can be avoided. The seriousness of certain classes of injury is directly proportioned to the extent it reduces the capacity to do physical work, independently of the amount of damage that may have been done. In this category are included those cases which have received penetrating wounds of the chest. The severity of the original injury need not be, in fact is not, in these cases an index as to the eventual usefulness of the individual. Some cases are disabled out of all proportion to the apparent seriousness of the wound, while others with greater local disturbance make remarkable progress and eventually exhibit little or no diminution in power of physical exertion. The present work was undertaken with the twofold object of investigating the after-effects of injury to the chest and of determining the best means of reducing the disability to a minimum.

The observations to be reported are based on seventy such cases admitted to this hospital during the latter six months of 1917. The majority were received direct from France, where they had been under treatment for an average period of four weeks (from three days to fourteen weeks). The cases varied considerably in character. Eleven (15·7 per cent.) had been operated upon for the evacuation of pus in the pleura, while in nine cases (12·8 per cent.) the foreign body had been removed. With regard to these latter, it should be noted that in all except one case the foreign body was merely removed from under the skin. In the exceptional case it had been removed from the left lung close to the pericardium at the time of operation for empyema. In 60 per cent. of the cases there was a history of hæmoptysis, it being of a severe character in one case only. In 66 per cent. there was a history of fluid in the pleural cavity.

On admission to this hospital careful notes were taken as to the condition of the chest. In 28·6 per cent. of the cases no abnormal physical signs could be detected, although in all of these there was clear evidence of penetration. In the remainder the examination revealed conditions as set forth in Table I.

TABLE I.

Collapsed lung	2·9 per cent.
Thickened pleura	38·6 ,,
Fluid	12.8 ,,
Fluid and thickened pleura ...	12·8 ,,
Air	4·3 ,,

In all those cases which had been operated upon in France for empyema a discharging sinus still existed, and in only one of these was a secondary operation necessary. In this case the injury had involved the abdomen, and a subphrenic abscess had developed in the left side, which was drained through a small hole in the pleura. Eventually this opening had to be enlarged to permit of better drainage. Empyema

developed after admission to this hospital in three cases, in all of whom fluid in the chest had been reported from France. In one case only was it found necessary to remove the foreign body from the lung. In all of the cases, except two, the physical signs were quite typical of the condition which was supposed to be present. In both of the cases which presented atypical signs there was increased vocal resonance and tactile fremitus over the abnormal area. All the other physical signs were those which are considered the classical signs of pneumothorax. It was difficult to account for these abnormal findings. In both of these cases there was only a partial collapse of the lung. In the series there was one other case of pneumothorax. There was complete collapse of the lung in that case. At first there was absence of tactile fremitus and vocal resonance. Later there developed slight expansion of the lung and a distinct increase of both of these signs over the normal side.

The progress of the physical signs was carefully noted in relation to the improvement or otherwise of the patient's condition, and in regard to his ability to accomplish physical work. But it soon became apparent that little or no information of value as to this point could be obtained by percussion or auscultation. The most significant finding was the development in a varying degree of a distinct physical deformity, which progressed without any change in the physical signs except those revealed by inspection. This deformity was manifested in various ways. It varied from a simple muscular atrophy with or without pronounced drooping of the shoulder girdle, to conspicuous contraction of the chest wall, with curvature of the spine.

In order to obtain reliable and comparative records of the progress of this deformity it was necessary to adopt more accurate methods than those of ordinary inspection. It was found impossible by observation alone to detect any change of less than ½ in. in the relative levels of the shoulders, and this was particularly difficult in estimating the improvement or otherwise in the condition. Therefore a height gauge was devised. This consisted of an upright or standard with two sliding arms, as shown in fig. 1. The patient was placed in front of this, and the standard (A) was alined with the axis of the spine. The arms (B and B1) were then adjusted in such a manner that the wedge-shaped pointers (C and C1) rested exactly on the acromio-clavicular articulation of each side. On the back of the standard a scale in inches indicated directly the difference in level between the two shoulders.

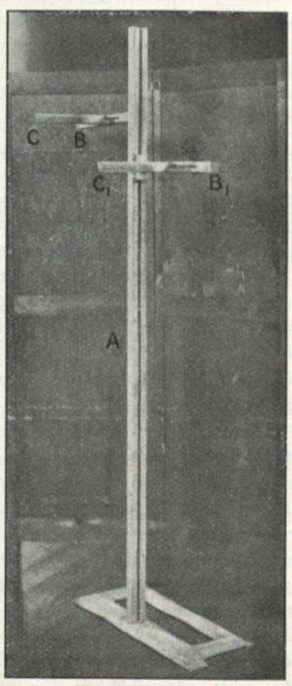


FIG. 1.

It was also difficult to determine the shape and relative size of the two sides of the chest, and any changes which might subsequently occur. Therefore a cyrtometer was employed, and the outline of the chest transferred to a large piece of paper. These outlines were then reduced to half-size by means of a pantograph, and filed with the case sheets.

The deformity frequently appeared very early. The earliest was recorded two weeks after the date of injury. The first manifestation is a muscular atrophy about the points of injury. This may progress in a varying degree, so as to involve all the muscles of the chest wall and the shoulder girdle. It may even extend to the deltoid and muscles of the upper arm of the injured side. As a consequence of this atrophy an early droop of the shoulder becomes apparent. The further deformity follows upon a falling-together of the ribs, which may be finally accompanied by curvature of the spine. At any stage the progress of the deformity may cease.

The determination of the cause of this deformity was recognized as of first importance. In view of the fact that the missile traversed, in all cases, the chest wall, the pleura, and the lung, it seemed probable that the deformity was the result of the injury to one of these.

In so far as could be determined, direct injury to the muscle produced in itself only slight atrophy, which was confined to the single muscle injured. In cases where the ribs were fractured without signs of the involvement of either the pleura or the lung, any deformity which occurred was strictly dependent upon the local condition. If there had been loss of portions of the ribs, or if the fracture was not in proper alinement, a local deformity of greater or less extent naturally occurred; but if there was no loss of rib substance and the fracture was in good position, no deformity ensued. Furthermore, an analysis of the site of the wound showed that it was immaterial whether the injury was above or below the third rib, as there was practically an equal prevalence of deformity in either case. In no case did any general deformity result unattended by signs of disturbance of lung or pleura.

With regard to injury of the lung tissue, it was found that the presence or absence of a history of hæmoptysis gave no indication as to the future presence and degree of deformity. Likewise in those cases in which the foreign body was retained in the lung substance, this did not appear to have any influence on its development. In so far as local collapse of the lung was concerned, in no case did this occur without a history of the co-existence of either fluid or air in the pleura. In fact, there was no evidence that injury to the lung tissue *per se* had any influence on the development of the deformity.

On examining into the degree of disturbance of the pleural cavity, it was found that in 94 per cent. of the sixteen cases where the pleura was free from all evidence of disease, little or no deformity occurred. In one case the patient suffered from an infected bomb-wound just below the middle third of the right clavicle, which had necessitated an extensive incision through the pectoral muscles. This had healed by secondary intention, and the ensuing contraction of the scar had produced considerable deformity of the right shoulder. The general deformity in this case is accounted for by a strictly localized condition.

TABLE II.

Deformity	Pleura free Per cent.	Hæmothorax Per cent.	Pyothorax Per cent.	Pneumothorax Per cent.
Nil ...	... 57	... 39·5	... 7	... 0
Slight	... 37	... 39·5	... 40	... 50
Moderate	... 6	... 6	... 26·5	... 16·6
Conspicuous	... 0	... 15	... 26·5	... 33·3

It will be seen in Table II that there was a progressive diminution in the number of cases exhibiting no deformity, and increase in those which did, depending upon the manner in which the pleural cavity was involved.

The cases of hæmothorax presented two well defined classes, determined by the absence or presence of fluid in the pleura when they came under our observation. The former class comprised twenty-five patients. All of these gave a history of hæmothorax, but in none of them were there signs of fluid after an average period of three weeks from the date of injury. Among these no instance of marked deformity developed. It was at first thought probable that these cases might have suffered from only a small hæmothorax, and this might have accounted for the fact that no deformity developed. But in fourteen of the cases aspiration had been performed one or more times, although only in six of these was the amount recorded. It averaged about 800 c.c. (240 c.c. to 1,800 c.c.). One of these cases was wounded on August 12, 1917, in the left intercostal space in the axillary line. On the 15th 500 c.c. of blood were aspirated. Another 500 c.c. were removed on the 18th, and on the 21st 800 c.c. more of bloody fluid were aspirated. On admission to this hospital on the 29th the physical signs were practically normal. No deformity developed in this case, except slight atrophy of the thoracic muscles of the back. Therefore this could hardly account for the absence of deformity. The latter class comprises eight cases, in each of which fluid was present when the patient was admitted to this hospital. In one of these the injury had occurred a week before. Shortly after admission 500 c.c. of bloody fluid was aspirated and the signs of fluid soon disappeared. This case did not develop any deformity.

In the other seven cases there were signs of a varying amount of fluid in the pleura, after several months had elapsed, since the time of injury. In three of them aspiration had been done some time before. In all seven cases pro-

nounced deformity existed when admitted, and this showed a tendency to increase. It seems, therefore, that the persistent presence of fluid in the pleural cavity plays a conspicuous part in the eventual development of deformity of the chest.

Empyema developed in fifteen of the cases. Of these, seven (47 per cent.) were operated upon within fifteen days of the time of injury, and in none of them did any general deformity follow. In eight cases (53 per cent.), however, the operation was not performed until an average period of six weeks had elapsed. In all of these cases a conspicuous deformity did develop.

There appears, therefore, to be a close connection between the development of the deformity of the chest and the length of time that the pleura is allowed to retain a quantity of fluid, irrespective of whether it be sterile or infected.

Only six of the cases gave a history of pneumothorax. Two of these evidently had a hæmopneumothorax while in France. They were both repeatedly aspirated, and when admitted to this hospital, seventeen and twenty days later, there were no signs of either air or fluid in the pleura, and only slight evidence of thickened pleura. Another case was reported to have had an extensive pneumothorax in France, which necessitated aspiration for relief of the symptoms. When admitted to this hospital, five weeks later, there was a small localized pneumothorax about the site of the wound of entrance. This was situated anteriorly over the inner end of the second rib (R.). There was loss of substance of this rib, and a hernia of the lung about 3 in. in diameter, which eventually disappeared by the use of a firm pad. In none of these three cases did any deformity of an appreciable degree develop.

One of the other three cases gave no history of a pneumothorax, but on admission to this hospital there were signs of a moderate hæmothorax with an extensive pneumothorax (L.) which caused urgent symptoms. Aspiration was performed which gave relief. This was done two and a half weeks after time of injury. The recovery of this case was very tedious but progressive. A moderate deformity developed, which under suitable treatment had practically disappeared at the time of discharge.

The two remaining cases, on entrance to this hospital, were quite normal except for the small entrance wounds, which were healed. One of these cases developed acute dyspnœa with collapse on the first occasion of being out of bed, five weeks after the injury. On examination there were signs of pneumothorax. The symptoms were paroxysmal, occurring in the evening and lasting a few hours. There was no increase at these times in the signs, which showed involvement of the whole right thorax, with complete collapse of the right lung. On the third day aspiration was performed, which relieved the urgent symptoms of dyspnœa and orthopnœa, but made no impression on the physical signs. Repeated aspiration did not effect any reduction of the pneumothorax. The recovery in this case was extremely slow, and the consequent deformity most conspicuous.

The other case gave a history of a right pneumothorax with complete collapse of the lung. There were no signs of pleural involvement on admission to this hospital. He developed an acute recurrence of the pneumothorax six weeks after the injury on being out of bed for the first time. The symptoms were not as severe, nor did the signs, which were confined to the upper half of the chest, indicate such an extensive degree of collapse of the lung as the former case. The most outstanding feature was the asthenia and neurotic symptoms, both of which retarded recovery. On being allowed out of bed again, there was evidence of considerable deformity of the right chest. On suitable treatment, however, there was great improvement, until on discharge it was almost impossible to detect by examination which side of the chest was injured.

In view of the above facts it appears permissible to account for the varying degrees of deformity which may develop in cases suffering from penetrating gunshot wounds of the chest as follows: Those cases in whom there is a simple perforation of the chest, without appreciable and persistent involvement of the pleural cavity, as a rule show some local atrophy of the muscles. The muscles are temporarily splinted, particularly if there is pain caused by respiration, and if a cough is present this splinting is accentuated. Furthermore, if the pectoral muscles or the latissimus dorsi be perforated, and movement of the arm is also considerably restricted, the local atrophy becomes more conspicuous. Thus there may be moderate drooping of the shoulder of the affected side, which frequently develops very early, the result of atrophy of the muscles of the shoulder girdle, apparently due to disuse. But the general conformation of the chest wall is not as a rule altered. A pronounced change in the shape of the chest wall appears only to develop when the pleural cavity is allowed to remain for a considerable period in an abnormal state. In addition to the immobility of the affected side of the chest, which is usually extreme in such cases, there is another factor to be taken into account—namely, the change of the intra-thoracic conditions. When a part of the pleural cavity is occupied by blood (of varying concentration) for some time, organization eventually occurs. This organized material is adherent to both layers of the pleura, and as contraction proceeds compression of the lung and diminution of the volume of the intra-thoracic contents occurs. This is indicated first by elevation of the dome of the diaphragm. When this has reached a certain point other factors prohibit its further extension, and in consequence the bony structures of the chest wall become involved. The ribs begin to assume a more oblique position and come closer together, until evidently the intercostal spaces are greatly diminished in width. Consequent with this collapse of the chest wall the drooping of the shoulder becomes much more pronounced, and if the contraction continues beyond a certain point scoliosis of the dorsal spine develops with the concavity towards the side of the injury. In some cases of extensive and persistent pneumothorax a similar sequence of events occurs, even without such involvement of the pleura. In these cases the extensive collapse of the lung over a prolonged period allows carnification to occur, so that when the air in the pleura is eventually absorbed the lung is incapable of expansion, and therefore the surrounding structures must contract to obliterate the potentially vacant space.

It was found that apparent deformity occurred more frequently and to a greater degree when the right side of the chest was injured. This was evidently due to the rôle played by the diaphragm. In right-sided lesions the elevation of the dome of the diaphragm was strictly limited by the liver, which acted seemingly like a cork. Beyond a certain point it could not go, while on the left side, although naturally limited, the degree of intra-thoracic space which it could occupy was much greater than on the right side.

The treatment of this deformity was based on the principle that prevention would be more fruitful of results than correction after it had developed. Two points were of prime importance: first, the prevention and correction of the muscular atrophy; and second, to increase the power of expansion of the affected lung. It seemed reasonable to suppose that the muscles could be developed by avoiding or overcoming the disuse. This turned out to be the case. It was more difficult to promote the expansion of the affected lung. At first the usual blow-bottles were employed. These, however, developed the side of the unaffected lung more than the affected one. When the blow-bottles are used the intra-pulmonary pressure is uniformly increased. Therefore the increased expansion would occur where the resistance was least—namely, in the healthy lung. As a result the healthy side became larger, while the affected side became relatively smaller, and the deformity more apparent.

It therefore suggested itself that it was important to splint the healthy side and to force the affected one to do more work. In order to accomplish this a series of exercises was adopted as follows:—

(1) The sound side of the chest is splinted against the back of a chair with the arm of this side extended as far as possible and grasping a rung. Then the patient is instructed to take deep slow inspirations, meanwhile pressing the healthy side against the back of the chair, in order to prevent expansion of the sound lung. In consequence the injured side tends to expand more fully (five minutes). (Fig. 2.)

(2) Dumb-bell exercises with a 4-lb. dumb-bell in the hand of the affected side, and a 2-lb. one in the hand of the unaffected side.

(*a*) Arms raising sideways and bending under to armpit and over to shoulder (five minutes).

(*b*) Lying on the back; arms raising from side to the vertical and lowering to the horizonal above the head (three minutes).

(3) Ladder exercises. The arm of the affected side is fully

extended above the head and the highest possible rung of the ladder grasped firmly. The patient is then instructed to take deep slow inspirations, meantime pulling on the rung of the ladder with the arm of the affected side (three minutes). (Fig. 3.)

It soon became apparent that the sooner the exercises were started the better. Therefore, as soon as a patient had been out of bed for a few days and was capable of walking about without conspicuous distress, the first exercise was started, and as he gained strength the others were added. It was found that usually at the end of the tenth day of exercise a patient would be on the full schedule.

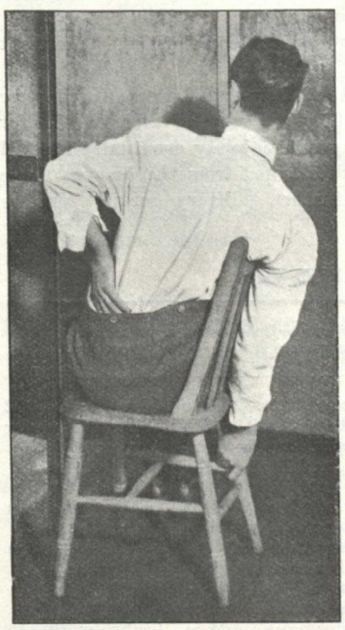


FIG. 2.

An essential part of the exercises was firm encouragement. The object of them was fully explained to the patient. On first commencing the course he was allowed to drop out and rest if he became at all exhausted. Such symptoms as pain and slight breathlessness were explained as being of no serious moment, and the former almost essential for recovery. It is very important that the physical instructor be intelligent and interested in the cases individually, and be under the direct supervision of a medical officer. Also he should realize that the patients are in a curative stage, which may be marred by too strenuous progress. When the patients became strong enough they were given general physical training in combination with the special exercises in order to reduce their "hospitalization" as much as possible.

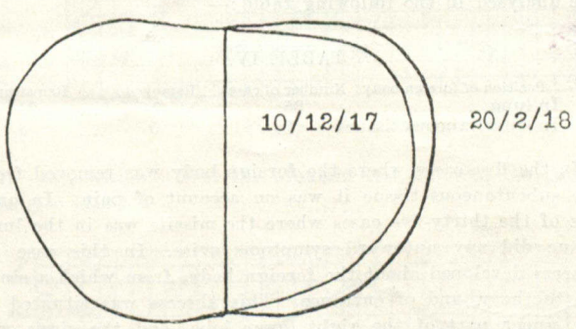
The result of the use of these exercises was very satisfactory. In those cases which had atrophy of the muscles only, re-development was rapid and complete, while in those with more gross deformity the improvement, although conspicuous, was not necessarily complete. There were a few cases in whom the deformity had progressed to an advanced degree before the exercises could be begun. In these further deformity was arrested, and a slight improvement occurred; but the bony changes were so pronounced that it was not considered possible to change them more than to a limited degree.

The early commencement of exercise in cases of empyema was of particular value. The patient was encouraged to get out of bed as soon as possible after the operation, and when the thorax was still draining he started his exercise. At first the discharge would increase, but after a short time this would gradually become less, the drainage tube would be pushed out until eventually the sinus would close. During this time the expansion improved, the deformity and shoulder droop were reduced, and finally the two sides of the chest would be equal in size and movement.

FIG. 3.

A few typical cases are set forth in Table III in order to show the progress that usually occurs. It will be seen from these cases that there is a progressive diminution in the atrophy of the muscles and the degree of shoulder droop until the two sides are practically equal. This improvement is further demonstrated by the comparative outlines of the chest walls of those cases which are shown in Charts 1 to 3.

CHART 1.

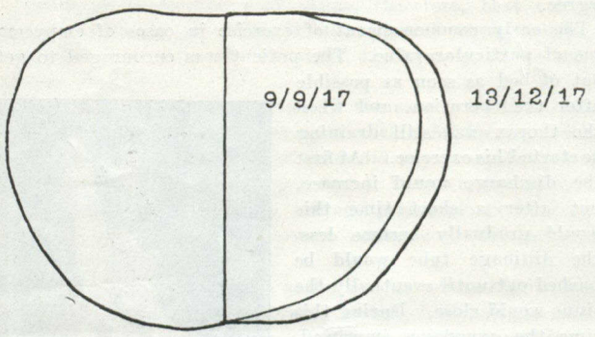


Pte. A. J., 41157. Left hæmothorax. Outline of Chest Wall before and after a course of Special Physical Exercises.

TABLE III.

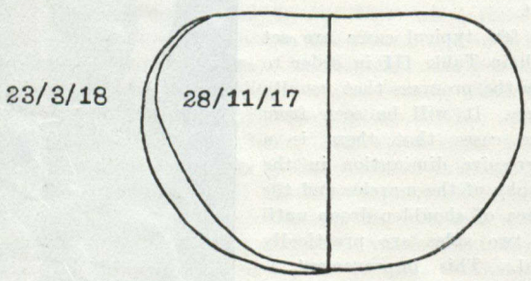
Name	Date	Special notes	Muscular atrophy on side of injury	Difference in sides of chest	Shoulder drop	Spinal deformity
Pte. A. J., 41157. Hæmothorax (L.). ...	26.8.17	Wounded				
	12.9.17	—	Latissimus dorsi and intercostals	Slight	Slight	None
	28.9.17	—	Increasing	1 in.	Increasing	—
	22.11.17	—	—	2 in.	½ in.	Moderate
	6.12.17	Special P.T.	—	—	—	—
	10.12.17	—	—	2 in.	½ in.	—
	20.2.18	—	Slight	*Nil*	⅛ in.	Slight
	2.3.18	—	Very slight, about scar only	—	⅛ in.	,,
Gnr. J. T., 21509. Pyothorax (L.). ...	1.8.17	Wounded				
	9.9.17	Special P.T.	Pectoralis major and latissimus dorsi	2 in.	1½ in.	None
	10.10.17	—	Less	1⅛ in.	¾ in.	,,
	20.11.17	—	Slight	⅜ in.	⅛ in.	,,
	13.12.17	—	Very slight	¼ in.	¼ in.	,,
Pte. R. E., 233681. Pneumothorax (R.). ...	15.6.17	Wounded				
	26.7.17	—	Pectoralis major, and latissimus dorsi, and intercostals	—	—	—
	28.8.17	—	Progressive	—	—	—
	2.10.17	—	Unchanged	—	Slight	—
	28.11.17	—	,,	1¼ in.	—	—
	7.1.18	Up for first time.	,,	—	Slight	—
	14.2.18	Special P.T.	—	—	1½ in.	Slight
	2.3.18	—	Much less	—	¾ in.	Very slight
	23.3.18	—	Very slight	*Nil*	⅛ in.	Unappreciable

CHART 2.



Gnr. J. T., 21509. Left pyothorax with operation. Outline of Chest Wall before and after a course of Special Physical Exercises.

CHART 3.



Pte. R. E., 233681. Right pneumothorax. Outline of Chest Wall before and after a course of Special Physical Exercises.

The effect of the retention of the foreign body in the lung was carefully followed. In forty-four cases (63 per cent.) there was clear evidence of retention of the missile. These are analysed in the following table:—

TABLE IV.

Position of foreign body	Number of cases	Removed	Remaiinng
In lung	35 ...	1 ...	34
In subcutaneous tissues	9 ...	5 ...	4

In the five cases where the foreign body was removed from the subcutaneous tissue it was on account of pain. In only one of the thirty-five cases where the missile was in the lung tissue did any untoward symptoms arise. In this case an abscess developed about the foreign body, from which a sinus led to the wound of entrance. This abscess was situated in the upper part of the right lower lobe, and the sinus was directed downward and backward. The cavity did not completely drain, as periodically the discharge would cease, and there would be coincident rises of temperature. It was therefore considered necessary to remove it. It was localized by X-rays, and under nitrous oxide anæsthesia long forceps were easily introduced into the cavity through the sinus, and the foreign body, which was oblong in shape, was seized at one end and readily removed until it reached the skin, where a slight enlargement of the opening was necessary. After this the patient made an uninterrupted recovery. In all of the other cases the presence of the foreign body in the lung exerted no untoward influence on the progress of the case.

The length of time that the patients were in hospital before returning to some form of duty or discharge from the Army naturally varied within wide limits (from one to twelve months), the average being four and a half months. The period of stay under our care averaged three months, depending on the condition present, and in nearly every case this was in proportion to the deformity.

The disposal of the patients on the completion of treatment is set forth in Table V.

It will be seen that out of fifty-eight cases which were discharged from hospital fifty-two were considered fit for some form of duty, and the great majority eventually for full duty. Only six cases were discharged from the Army. These were considered unfit for further military service for the reasons given in Table VI.

TABLE VI.

Name	Reasons for discharge from the Service	Present occupation
Pte. J. W. L.	Chest in good condition. Totally blind in right eye, with considerable pain, due to gunshot wound, and deaf in the right ear	Munitions, 52 hours per week.
Pte. C. K. ...	Chest in fair condition. But he had pronounced debility	In hospital in Canada.
Pte. H. G. ..	Extensive destruction of the left pectoral muscles at the time of injury. Inability to use left arm	In hospital in Canada.
Pte. W. C. ...	Spondylitis deformans. Age 51	Light work, 45 hours per week.
Pte. W. T. B.	Pronounced deformity of chest, with displacement of the heart	Farming, 28 hours per week.
Pte. E. W. S.	Pronounced deformity of chest, with displacement of the heart	—

Of these cases, therefore, only two were invalided from the Army on account of conditions directly attributable to the intra-thoracic condition.

The after-history has been determined so far in thirty-nine of the cases discharged. Examination of Table V shows that, of the thirty-four cases retained in the Army who have been traced, eighteen (53 per cent.) are doing full duty; seven (20 per cent.) have been lowered in category; two (6 per cent.) remain in Category B as on discharge from hospital; five (15 per cent.) are still in training at command depots; while two (6 per cent.) are not available for duty at present. The present occupations and length of work per week of five cases who were discharged as permanently unfit are given in Table VI.

It is apparent that injury to the chest is not necessarily a conspicuous factor in invaliding soldiers from the Army. Even when they are discharged from the Army on account of the results of such an injury, they are still capable of doing a considerable amount of work each week in a civilian occupation. Amongst those cases which are not discharged

TABLE V.

Disposal	Number	Number traced 3 months after discharged	PRESENT STATUS OF THOSE TRACED						
			B. E. F.	A. 3	B.	D. 1	In hospital	P. U.	Totals
Furlough I	1	1	—	1	—	—	—	—	1
Furlough II (D[1])	47	29	9	7	7[4]	4	1[1]	1[2]	29
B.	4	2	—	—	2	—	—	—	2
Convalescent hospital ...	1	1	—	1	—	—	—	—	1
Auxiliary hospital	2	1	—	—	—	1	—	—	1
Trans. to other hosps. ...	2	0	—	—	—	—	—	—	0
Remaining in hospital ...	7	0	—	—	—	—	—	—	0
Permanently unfit	6	5[3]	—	—	—	—	2[3]	3	5
Totals	70	39	9	9	9	5	3	4	39

[1] In hospital for removal of F. B. from subcutaneous tissue of back.
[2] Sent to Australia for "change."
[3] Two cases were invalided to Canada for further treatment other than for the intra-thoracic condition.
[4] One case is likely to be raised in category.

from the Army as permanently unfit there is a good percentage who eventually return to full duty with little or no impairment in the degree of physical exertion which they are able to accomplish.

CONCLUSIONS.

(1) Deformity of the chest wall is a very important disabling after-effect of gunshot wounds of the chest.

(2) This deformity follows most frequently prolonged involvement of the pleural cavity.

(3) The early and persistent evacuation of fluid from the pleural cavity, either by aspiration or by operation, is of great importance in preventing the development of the deformity. Especially is this so in cases of hæmothorax.

(4) The early use of special exercises is beneficial in preventing or overcoming this deformity.

(5) The prognosis in this condition is exceptionally good under suitable treatment.

REPORT ON THE EXAMINATION OF THE SPUTUM FOR ALBUMIN IN PULMONARY TUBERCULOSIS AND CHRONIC BRONCHITIS.

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No. 2 Canadian Mobile Laboratory.

THE following report is based upon an investigation of 243 cases under treatment at Moore Barracks Canadian Hospital, Shorncliffe.

Numerous observers during the past few years have demonstrated that albumin occurs in the sputum in a large percentage of cases of tuberculosis, but its value as a diagnostic test has been questioned. That it occurs in certain cases of tuberculosis, and not in others, and that positive and negative tests are obtained on the same case at different times has been clearly shown. The reaction itself is due to sero-albumin, which only appears as a result of alveolar inflammation as opposed to inflammation of the bronchi. Pneumonia gives a positive test until the crisis or lysis begins, when it becomes negative, rapidly in the former, more gradually in the latter.

Moore Barracks Canadian Hospital accepts not only severe cases of pulmonary tuberculosis, but also borderline cases shading into those diagnosed as chronic bronchitis. Because of the wealth of the material at hand it was decided to conduct a series of tests, and, if possible, to definitely ascertain the value of the reaction.

Technique.—To 5 c.c. of sputum, add 20 c.c. of normal saline and five or six drops of acetic acid. Shake thoroughly and filter. Test the filtrate by boiling or with nitric acid for albumin.

Altogether 580 tests were done, and it was found convenient to report each test as positive, negative, or trace. All tests were done on twenty-four-hour specimens.

The cases examined may be divided for simplicity into four groups :—

(1) Simple chronic bronchitis, fifty-seven.

(2) Cases with clinical signs hardly definite enough to justify a diagnosis of tuberculosis, but sufficiently marked to be called suspicious, i.e., borderline cases, seventy-three.

(3) Cases with signs so marked that they may be regarded as tuberculosis, although bacteriological examination has always been negative, i.e., clinical tuberculosis, seventy-one.

(4) Cases in which sputa always showed tubercle bacilli, forty-two.

Of the fifty-seven cases in Group 1, fifty-six were found invariably negative for albumin, although as many as six tests were often done on the one case on successive days. The other case showed a trace of albumin coincident with a rise in pulse rate, and this case was just being transferred for observation as a tuberculosis suspect at the time of the test, so that it properly belonged in Group 2.

Of the seventy-three borderline cases, only nine were negative for albumin, the remaining sixty-four showing either positive or trace. Owing to the great difficulty of following a military case through the many transfers which are customary, it is impossible to report how many of these sixty-four have since shown tubercle bacilli, but ten cases were followed closely for two months, and it is significant that five of them showed the bacilli within that period.

Other observers have stated that 75 per cent. of borderline cases with albumin in the sputum later show tubercle bacilli. It seems remarkable that many cases positive one day frequently showed but a trace the next, and sometimes none on the third day, only to become positive on the fourth day. As this variability was noticed in twenty-eight of the seventy-three cases, the reliability of the test might have been questioned, but an explanation was found, and it is with this interesting finding that the article now concerns itself.

Supposing a case were known to be tuberculous, what would the test show? To settle this question the forty-two cases in Group 4 were selected. Of these thirty-seven gave a positive test, but five gave a negative. If, then, a true case of tuberculosis could thus be negative, of what use was the test? Upon examining the clinical charts of these negative cases, *a very definite correspondence was noticed between the temperature and the result of the test.* In each of the five cases the sputum had been collected on days upon which the temperature was either normal or subnormal. Looking then at the charts of the thirty-seven positive cases, it was seen that the sputum had been taken on days when there was a rise in temperature. A patient with tuberculosis was then examined for albumin on each of seven successive days, and it was seen that as the temperature rose so the albumin gave a more intense reaction, and as the temperature fell the reaction became less and less marked (see Chart 1).

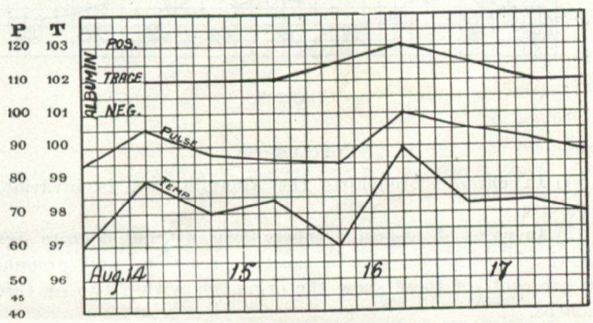

CHART 1.

In cases without fever the albumin test followed the pulse-rate (see Chart 2).

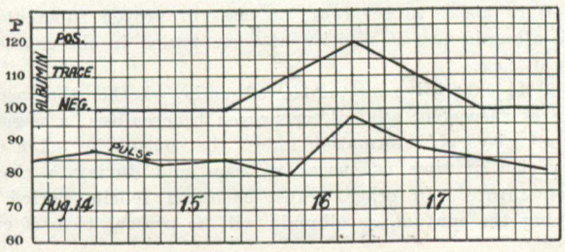

CHART 2.

These observations would seem to show that a definite correspondence existed between the temperature and the presence of albumin in the sputum. According to the heat-centre and visceral hyperæmia theories, the cause of an abnormal rise in temperature in infectious diseases is due to the circulation in the blood of bacterial toxins; hence the albumin test became positive when toxins were liberated into the blood-stream—that is to say, when there was an increased focal reaction in the lung.

Whether the appearance of sero-albumin in sputum is due to the increased local circulation reactively established by the irritation of the infection, or due to a toxic increase in the permeability of the alveolar epithelium, cannot be stated. Undoubtedly the pulse-rate is increased in the same manner as is the temperature, and this correspondence of increased pulse-rate with the appearance of albumin may be seen in some of the charts.

The next step was to investigate the seventy-one cases of Group 3. The mere absence of organisms in the sputum is no reason for not considering well-marked cases to be tuberculous. Of the seventy-one cases nineteen were invariably positive; and in fifteen of these nineteen cases the sputum had been taken during a period of elevated temperature. In twenty-eight other cases of the seventy-one the sputum had

been taken during a period either of normal or subnormal temperature and pulse. In only one case of the seventy-one could it be shown that a negative result had occurred coincidentally with a raised temperature. The remaining twenty-three of the seventy-one cases each gave a variable result, i.e., being one day positive, and another day negative. It was almost invariably found in any given case that when the temperature was normal or subnormal the reaction for albumin was negative, and that as the temperature rose the albumin reappeared. This was seen clearly in twenty of these twenty-three cases, in each of which the sputum was examined daily over a period of from five to eight days. In only three cases was this correspondence not to be observed.

Moreover, in three cases running afebrile courses the same striking correspondence between albumin and pulse existed.

Does this relation of temperature to the test apply in the cases of suspected tuberculosis? A re-examination was made of the charts of the cases in Group 2, and the same relation was found to hold good. Chart 3 is an example.

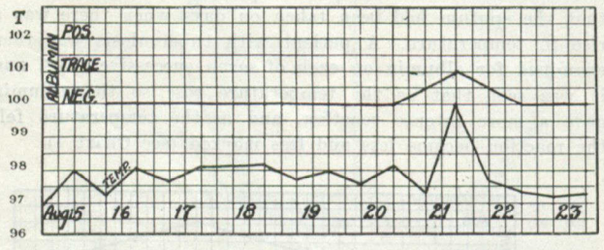

CHART 3.

CONCLUSIONS.

(1) In chronic bronchitis the albumin test is invariably negative.

(2) In cases of suspected tuberculosis without definite signs about 87 per cent. give a positive reaction, and *probably* 60 per cent. of these show the organism within two or three months.

(3) In cases of clinical tuberculosis 70 per cent. will show albumin if the sputum be taken during an elevation of temperature, but albumin is nearly always absent from sputum collected when the temperature and pulse are normal or subnormal.

(4) In about 98 per cent. of cases of proven tuberculosis, the albumin test is positive at some period in the course of the disease.

(5) In examining sputum for albumin, whether the case be one of suspected, clinical, or proven tuberculosis, a negative result gives no information unless the sputum be taken over a period of time on successive days and during a rise of temperature. In other words, choose a febrile period for taking the sputum, as albumin will be present then if ever.

DELAYED TETANUS.

By HARRY MORELL, Captain C.A.M.C., Officer in Command District Laboratory, M.D. No. 5, Quebec, Canada.

DELAYED tetanus is rather an unusual type of the disease which might result from an incomplete neutralization of the toxin by the immunizing dose of tetanus antitoxin. There is an extension of the period of incubation and an absence or a modification of the classical symptoms as generally described under tetanus. The following case is quoted in which it is shown that the incubation was slow and the manifestations of the disease delayed for almost three months:—

No. 234968 Private C. E. F. was admitted to the Military Hospital, Quebec, from the Clearing Depot on December 2, 1917. This man had just returned from overseas and had been sick for the past forty-eight hours. He presents the following history: On September 6, 1917, he had his left arm amputated 2 in. below the shoulder-joint for a shrapnel wound received in action about one week before. He states he was given an injection of tetanus antitoxin within three hours after being hit, and that the wound healed kindly without any unusual symptoms. At the present time the stump looks healthy, with a linear cicatrix about 2 in. in length, which is discharging very slightly. There is no rigidity or spasm in the muscles of the stump, nor is there any pain in this region. A culture of pus from the wound shows pyogenic cocci only. He says that two days ago a slight headache developed, accompanied by nausea and persistent vomiting, which has continued, also he has pain and stiffness at the angle of the jaws, which is gradually becoming worse.

The patient is a fairly well-nourished man, slightly pale. Heart and lungs normal, pulse 115, temperature 99°, respirations 36. Urine negative.

The jaws are tightly closed, impossible to open them even for nourishment; any sudden noise or irritation, as when spoken to, causes the whole body to become rigid and tense. These spasms, though severe, do not cause opisthotonos. There is a slight convergent strabismus and spasm of the eyelids. His mind is clear, he being able to give information regarding himself perfectly, except for the difficulty experienced in making himself understood on account of the severe spasms. The paroxysms persisted and became more aggravated, and death suddenly occurred from heart failure during a convulsion thirty hours after admission. Temperature just before death was 103·4° F. No post-mortem was made.

In commenting on this case it might be interesting to review the causes which may have to do with the late appearance of the disease after infection. It is usually stated that the incubation period of tetanus is about two weeks, but this stage may be lengthened, as it is known that the bacilli may remain for some time inert before producing toxins. This may be due to (*a*) condition of the tissues infected; (*b*) the virulence of the bacilli; (*c*) the amount of soluble toxin secreted; (*d*) the path of infection; and (*e*) the amount of antitoxin injected.

Below is a brief statement on the behaviour of the *Bacillus tetanus* in the tissues and the development of its toxin, which may explain why the period of incubation and the symptoms of the disease may be delayed for a considerable time.

The most suitable soil for the growth of the *B. tetani*, which grow anaerobically, is a lacerated, dirty wound, though it is impossible from the appearance of any particular wound to say whether or not it is infected with tetanus bacilli, and in healed and sealed wounds there is created an absence of oxygen, which condition is required for their growth. Again, it is held that the tetanus bacilli grow more favourably in the presence of aerobes such as the *Staphylococcus aureus*. The latter, using up all the available oxygen, produces a more suitable nidus for the anaerobic *B. tetanus*, and it is here the bacilli will grow most luxuriantly, giving off their secretion products into the surrounding tissues. This product, the toxin, or ectotoxin, is one of the most powerful poisons known, and it has an affinity for the nerves of the cerebro-spinal system.

Not even in the most severe and fatal cases of tetanus are the bacilli found in the blood. They are confined to the local lesion only. Another thing—spores alone, or tetanus bacilli without spores, die in the tissues, and there is evidence that the bacilli with spores may remain a considerable time shut up in the body before producing toxin.

The immunity conferred by an injection of antitoxin lasts a short time—about two weeks—or only so long as the toxin secreted by the bacillus is neutralized by this injection of antitoxin; for, though the toxin is neutralized by the antitoxin injection, it does not necessarily cause the death of the bacilli, which may continue to manufacture toxin.

To neutralize all free toxin formed, and also to provide an excess of antitoxin to neutralize the toxin as rapidly as it is produced, several successive doses of antitoxin should be used. It is therefore essential that a second, third, and fourth subcutaneous injection should be given to all wounded men; and, in order to anticipate the total disappearance of antitoxin from the body, the second injection should follow the first at an interval of seven days, or as soon after as possible. The third and fourth injections must also follow at the same intervals of time.

PROCEEDINGS OF CLINICAL SOCIETIES OF THE C.A.M.C.

REGULAR MEETING OF THE ETCHINGHILL CLINICAL SOCIETY.

April 10, 1918.

The Treatment of Chronic Gonorrhœa.

CAPTAIN A. B. JAMES: Infection of the epididymis was one of the hardest things to deal with, and our present treatment left hard nodules, which took considerable time to resolve and caused frequent reinfection of the urethra. He recommended that instead of expectant treatment epididymotomy be done on every case as soon as signs of inflammation were present. For superficial infection of the prostatic duct and for ulceration and granular condition of the verumontanum he had obtained good results by direct application of silver nitrate 15 per cent. through the cysto-urethroscope. Chronic gonorrhœa might be classified into two classes bacteriologically: (1) Those in which there was a pure gonococcal infection, and those in which the original infection was complicated by secondary organisms, and (2) those in which the infection was purely secondary; in the latter condition autogenous vaccines might prove of value, though his results had not been very satisfactory. He was not satisfied with the general treatment of acute and chronic gonorrhœa by through and through irrigations, and thought that possibly anterior injections and posterior instillations through a catheter might be of more value. Besides attention to the genito-urinary tract the general health of the patient had to be considered. Syphilis and anti-syphilitic treatment hindered the cure of chronic gonorrhœa.

Captain G. H. J. Pearson: On looking over the records of this hospital for the last three months, it was found that out of 521 patients discharged as cured 101 patients, or 21·11 per cent., admitted as acute had become chronic cases during their stay in hospital. There might be some doubt as to when a case became chronic, but on examining the records it was found that in a very large percentage of cases the symptoms began to diminish between the fortieth and sixtieth day of the disease, and might even become entirely negative. In those cases which were cured no further symptoms appeared, but in cases that became chronic an acute exacerbation of symptoms started about this time, so that a graph of the pus content in the discharge and both urines resembled the temperature curve of relapsing typhoid fever. He had not yet satisfied himself of any means of prognosis that would inform one whether a resolving attack of acute gonorrhœa would go on to resolution or whether it would become chronic.

The course of a chronic gonorrhœa was one of frequent relapses, acute exacerbations following upon diminutions of symptoms. Chronic gonorrhœa may be defined as a gonorrhœa of complications. In his series of cases prostatitis was most frequent, next being littritis, then epididymitis, polypus-urethritis, cowperitis, cystitis, and pyelitis. He was not at present taking into consideration systemic complications. It was also a localized disease, and it was necessary for an accurate diagnosis of the location of the lesion to be made before treatment could be intelligently applied. In every case admitted to the hospital as chronic, and in those cases admitted as acute when the typical relapse syndrome indicating the change from an acute to a chronic stage appeared, a careful urethroscopic examination of the whole of the urethra should be made. If this was impossible recourse must then be had to some other method, of which he found Wolbarst's the most accurate. In checking up this method with the urethroscope the site of the lesion was found to be fairly accurately determined, but no information was gained as to its character. In detailing this method the speaker emphasized the fact it was impossible to determine by macroscopical examination whether the material expressed from the prostate and vesicles was pathological. A careful microscopical examination was necessary to decide this.

In concluding the speaker warned against discharging patients with gleet. Many such cases relapsed with positive smears, and a large percentage, on being apparently ready for discharge with gleet, show positive results after the administration of a provocative vaccine.

Captain J. D. McDonald gave a short paper on irrigations.

The use of irrigations as a routine treatment of acute and chronic gonorrhœa is the most important weapon in our armamentarium for attacking this infection.

Internal treatment or vaccines alone will not cure the disease. Experience has shown that in the vast majority of acute cases the disease has reached the posterior urethra by the end of the second or third week, no matter what mode of treatment we follow. In 90 per cent. of cases the prostate gland and vesicles have become more or less involved. Direct extension along the urethra and ducts is only one of several routes of infection by which the gonococci reach the epididymis and prostate. A chronic urethritis practically always means a chronic posterior urethritis, and nearly all relapse cases show posterior involvement.

Acute primary cases which are not seen early enough for "sealed-in" treatment may, in some instances, be cured by anterior lavage, but the great majority of these patients will require posterior irrigations before a cure is effected, and there are many advantages and practically no danger in instituting this treatment from the first, provided the antiseptic is intelligently chosen and carefully administered. A medical officer to superintend irrigations in venereal hospitals would be beneficial.

The anterior urethra should be carefully irrigated before the solution is allowed to pass into the bladder. Irrigations are not so effective in long-standing chronic cases, but their use is nevertheless important along with whatever treatment is chosen for the complications.

A germicidal irrigation does not cure gonorrhœa directly. Its chief benefit is to set up a hyperæmia of the mucosa whereby the organisms imbedded in the sub-epithelial and glandular tissues are encouraged to come to the surface. It likewise tends to promote drainage of the involved prostate gland and vesicles. He had inspected the urine passed immediately after an irrigation, and in some cases had found masses of vesicular content, fibrin and prostatic cells in patients who have not, as yet, received prostatic massage.

The character and strength of the antiseptic solution to be used will depend upon many considerations, the stage of the disease, the age and susceptibility of the patient, &c. Strong germicidal solutions produce inflammation of the mucosa, destroy the protective powers of the tissues, and often lead to secondary infection. An astringent irrigation in early acute cases may defeat the object aimed at. There are a few cases in which a bichloride solution may be beneficial; it is more likely to do harm. The simple antiseptics, permanganate of potash, boric acid and the organic silver salts used alternatively in mild solutions will give satisfactory results. The maximum strength which he prescribes for permanganate is 1 : 5,000 and ¼ of 1 per cent. of protargol. Weak solutions used frequently give better results than the strong solutions used once or twice daily.

ADMINISTRATIVE NOTES.

THE C.A.M.C. AND THE MILITARY HOSPITALS COMMISSION.

"THE Committee of the Privy Council, on the recommendation of the Prime Minister, advise that—as in future officers and soldiers of the Canadian Expeditionary Force will, until they are struck off the strength or discharged, be cared for and treated in institutions administered and controlled under the direction of the Militia and Defence, and will pass under the care of the Military Hospitals Commission only upon their being struck off the strength or discharged, the said Commission shall hereafter, for the purpose of better indicating its scope and functions, be known as the 'Invalided Soldiers Commission.'" *Report of the Privy Council of Canada, approved by His Excellency the Governor-General, February* 21, 1918.

The controversy between the Department of Militia and the Military Hospitals Commission is now at an end. Only two courses were open; either for the Government to leave the task of caring for the sick in the hands of the Department of Militia and Defence, as it now has done; or the Military

Hospitals Commission should take full control of returned invalids, appoint, and control medical staffs on a civilian basis. But even in this latter course the Government would not have been absolved from its responsibilities, since it is a party to the Geneva Convention, which specifically forbids the handing over of these military functions to a civilian body.

The functions of the C.A.M.C. can only cease when the returned soldier is discharged from the service. After that point he may be taken over by the Hospitals Commission, or by any other civilian body. The returned soldier is still as much a soldier as before he became a casualty; he is in receipt of public pay; he is maintained by the public through the Government. The Government has towards him certain obligations which end only with his final discharge from the service. As the patient is still a soldier, and still liable for further service on recovery, he cannot be turned out of hospital for misconduct as in civil life, nor can he be asked, or permitted, to sign a waiver releasing the Government from its obligation to him.

Formerly there were three authorities dealing with military patients in Canada. These were: The Medical Department of the Militia; the Military Hospitals Commission; the Director of Medical Services Invalids. These, it is true, all reported direct to the Adjutant-General. They dealt with two separate classes of patients, namely, those who had not gone overseas, and those who had returned from overseas.

The Military Hospitals Commission was a name applied to a body of men scattered throughout the Dominion. They had not met since September 7, 1916. The affairs of the Commission were in the hands of the President, Director, and Secretary, none of whom were qualified medical men or officers holding commissions. It was unlikely that these three non-professional civilians should develop towards themselves the loyalty of the medical and military professions, as well as the sympathy of the men who form those professions.

The C.A.M.C. is a military body. The Military Hospitals Commission was a civilian body. The obedience of a military body is to the King alone, and to his authority as exercised through his Ministers. That authority cannot be delegated to any body of civilians. The Government may disband the military body, in which case the members would become civilians, and their relation to the Government would then be governed by civilian contract. Orders must come through the Adjutant-General. If a civilian body should intervene, the chain of responsibility would be broken, and the military body would then become a number of civilians without a recognized obedience.

The C.A.M.C. could not operate under a civilian body, even if it would. It is governed in its methods by the Geneva Convention, which is the best known document in international law. So recently as 1906 this memorable Convention was ratified by no fewer than thirty-five of the world's sovereign Powers. It is explicitly stated in Article 10 that the military sick and wounded of the subscribing countries shall be cared for solely by military authority. The conditions under which civilian assistance can be legally employed are specified. It must be placed under military authority; the belligerents intending to use it must notify the enemy Power; it must remain during the whole of its employment under direct military control. In face of all precedents and legal requirements, it is impossible for a civilian body to take upon itself the performance of military duties.

Field Service Regulations issued by the General Staff govern all military operations. In Section 97 it is clearly specified that civilian medical units will be required to adhere to the Service Regulations which govern the constitution, personnel, and equipment for war of corresponding units in the Army. They will, if accepted for service, come under the order of the military authorities, and be incorporated with the medical units of the Army in such a manner and for such purposes as the Commander-in-Chief may determine. Military hospitals in Canada have precisely the same status as military hospitals in the field, and are subject to identical restrictions under the Field Service Regulations.

A civilian body can exercise no authority over the soldier patient so long as he remains a soldier. The soldier owes obedience to the military authorities alone, and there is no other power that can discipline him for military offences. If he were a civilian in a civilian hospital he could be expelled for offences against the regulations of the institution, but until he is discharged from the service he must be cared for in sickness as well as in health. The man is a soldier until he is discharged. He is a soldier, but he is also a patient. A military body alone like the C.A.M.C. can deal with him as a soldier and treat him as a patient.

The Government has now formally installed the C.A.M.C. in its proper functions. It has never yet failed in its duty to the Government. It will not now fail.

CORPS NEWS.

Honours and Awards.

Decorations and medals presented by the President of the French Republic:—

Légion d'Honneur: Croix d'Officier to Major-General G. L. Foster, C.B., and Croix de Chevalier to Colonel G. E. Beauchamp.

The Military Medal for bravery in the field has been awarded to No. 33320 R.S.M. A. P. Disley.

Promotions.

Colonel (Temp. Surgeon-General) G. L. Foster, C.B., to be Temp. Major-General.

Temp. Lieutenant-Colonel J. G. Adami to be Temp. Colonel.

Temp. Captains to be Temp. Majors: W. T. Ewing; J. E. McAskill, M.C.; F. E. Watt; N. C. Sharp; R. G. Armour; A. A. MacKay.

Temp. Major H. L. Harris to be Temp. Lieutenant-Colonel.

Temp. Captain (Acting Major) W. C. Laidlaw to be Major.

Temp. Captains (Acting Majors) R. J. Gardiner, M.C.; G. W. Hall; H. W. McGill, M.C., to be Temp. Majors.

Lieutenant-Colonel H. M. Robertson to be Temp. Colonel.

Struck off Strength.

Being returned to Canada for duty: Col. W. Webster, D.S.O.; Lt.-Col. J. J. Fraser, D.S.O.; Maj. G. F. Boyer; Maj. H. P. Wright; Capt. H. B. Rogers; Maj. R. M. Luton, M.C.; Capt. R. H. Ker; Capt. T. A. Watterson; Capt. W. H. Taylor; Col. F. S. L. Ford, C.M.G.; Capt. M. M. Crawford; Qr.-Mr. and Hon. Capt. W. Taylor; Maj. J .W. Shaw; Maj. C. E. Fortin; Col. G. E. Armstrong; Maj. F. T. Cadham; Maj. C. Woollard; Capt. K. G. Mahabir; Capt. E. H. Young.

Being retained in Canada: Col. A. Primrose; Maj. W. Bapty; Capt. J. W. Welch; Capt. A. B. Chandler; Capt. V. Bourgeault; Capt. L. C. Charland; Capt. G. E. Clerk; Capt. A. E. Gordiner; Surg.-Gen. J. T. Fotheringham, C.M.G.; Maj. H. G. M. Nyblett; Maj. T. L. Butters; Maj. G. C. Hale; Maj. L. W. MacNutt; Capt. G. G. Clegg; Capt. W. B. MacDermott; Capt. S. O. Rogers.

Being returned to Canada, permanently unfit for general service: Capt. A. Mathien; Qr.-Mr. and Hon. Lt.-Col. J. Hood.

Having resigned their commissions: Lt.-Col. T. B. Futcher; Lt.-Col. R. J. Blanchard; Qr.-Mr. and Hon. Capt. R. H. Nichols.

Being invalided to Canada for further medical treatment: Capt. I. W. Dickson; Capt. J. F. McQuay; Capt. J. O. Todd; Capt. W. E. Brown; Lt.-Col. J. G. Gunne; A. E. Henry; Lt. L. M. Jones.

Having died of wound, April 5, 1918: Capt. J. Carmichael.

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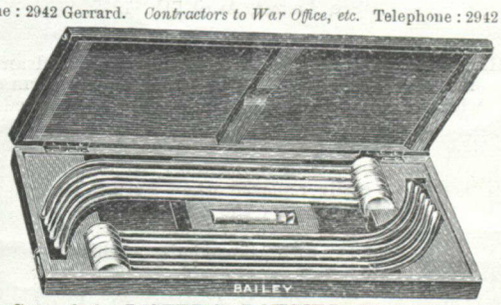

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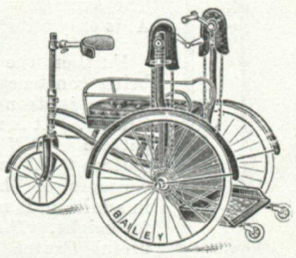

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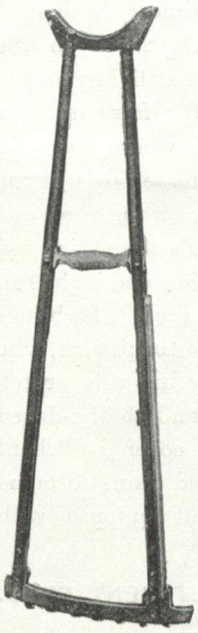

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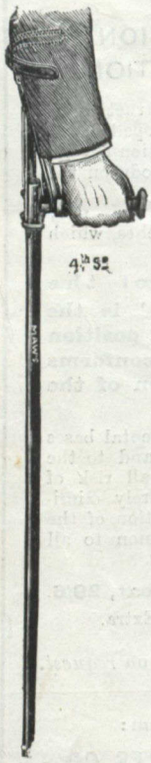

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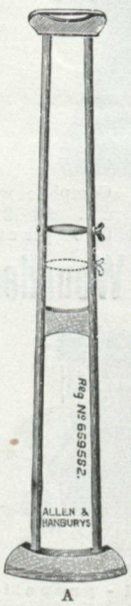

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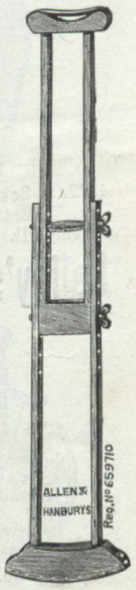

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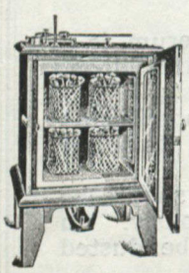
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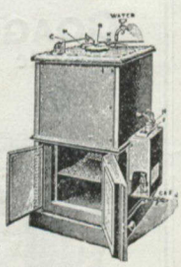
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