

**The Hunterian oration on the treatment of wounds in war : delivered before the Royal College of Surgeons of England on February 15, 1915 / by Sir W. Watson Cheyne.**

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Hunterian Oration  
ON  
THE TREATMENT OF WOUNDS  
IN WAR

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W. WATSON CHEYNE




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The Hunterian Oration  
ON THE  
TREATMENT OF WOUNDS  
IN WAR

*Delivered before the Royal College of Surgeons of England on  
February 15, 1915*

BY  
SIR W. WATSON CHEYNE, BART., C.B., F.R.S.  
LL.D. EDIN.  
PRESIDENT OF THE COLLEGE.

*Reprinted from THE LANCET, February 27, 1915*

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# The Hunterian Oration

ON THE

## TREATMENT OF WOUNDS IN WAR.

GENTLEMEN,—It is now nearly 122 years since the death of John Hunter, and since that time 67 orations have been delivered in his memory, most of them dealing with his life and work. Although I have not read these orations it did not seem likely that there was much left for me to say, but after perusing his works I thought that there might still be something fresh in a consideration of his scheme of life and disease in the light of our present-day knowledge. When, however, this war began so many other more pressing interests arose that I began to doubt whether such an oration would really be of interest, and therefore I gladly fell in with the wishes of some of the more warlike of my colleagues, and shall devote the greater part of this hour to the consideration of a very important subject—viz., the treatment of wounds in war.

### JOHN HUNTER: HIS WAR EXPERIENCE.

John Hunter was always trying to solve puzzles. He never met with a point which he could not understand but he tried to find out its meaning, and his museum is an indication of the multifarious



things in which he was interested and of the many facts which he collected with regard to them. At the same time he had that great characteristic of true genius, a vivid imagination, and he was always weaving theories to explain his puzzles and modifying or adding to them as seemed necessary. In this way he built up his great scheme of disease which is full of ingenuity and interest. It does not, it is true, occupy any important place in the teaching of the present day, but the reason for that is that he had so few really basal facts to theorise on.

Among the many puzzles that we have to deal with there is none more urgent or important, especially at the present time, than the treatment of wounds in war. It is a puzzle which has exercised the minds of medical men since the world began, and it is still unsolved. And yet the solution is urgent, both out of gratitude to those who risk their lives for their country and also for the sake of the country itself. To attempt with all our strength to solve this puzzle is a matter of common gratitude, for we owe it to those brave men who risk their lives for our safety and well-being to minimise that risk as much as possible; and it is also a matter of national importance, because the more soldiers we save, and the sooner those who are able can be returned to duty, the greater is our strength.

John Hunter himself had some experience of war, and wrote an article on gunshot wounds which is of great interest, especially as regards the influence of the velocity of the bullet on the nature of the wound. There is no definite record in his writings as regards his war service, but Major Howell, of the Royal Army Medical Corps, has collected a few facts concerning it. According to

him John Hunter accompanied a British expedition to Belleisle in 1761, in which, in the attempts to land a force on the island, there were some 500 wounded men on whom Hunter was enabled to make his observations. His war experience was somewhat increased in the following year, as he went to Portugal for a few months. His connexion with military surgery did not, however, cease at that time, for he remained intimately connected with the army for many years in that he drew his half-pay regularly. In 1786 he returned to the active list of the army. In 1790 he became head of the Medical Department jointly with a physician, Sir Clifton Waitringham. In 1793, some months before his death, he became sole head of the Medical Department of the Army, and according to Howell he was really the first medical director-general of the army. It is interesting in passing to note, as showing the tendency of his mind, that during his service at Belleisle he studied the coagulation of the blood, and when he came home from his army service he brought with him 200 specimens of beasts, lizards, and snakes, which formed the foundation of his museum. A good many of his views on inflammation and on the treatment of wounds were also formed at that time.

#### TREATMENT OF WOUNDS IN RECENT WARS.

The history of the treatment of wounds in war would form a very interesting topic, but I shall only say a few words with regard to the treatment in recent wars. During the past all sorts of methods of treatment of wounds, whether in peace or in war,



have been employed, but very little real advance was made till the Listerian period, and therefore our present interest in these matters only concerns recent wars.

The first war in which any attempt at Listerism was made was the Franco-Prussian War in 1870-71, but Lister's views had not made any great progress at that time, and the methods employed were very feeble and inefficient. The wounds were sometimes washed out with carbolic lotion, and oily solutions of carbolic acid were also employed as dressings, as well as other antiseptics such as acetate of alumina and permanganate of potash. Open wound treatment was also used in some hospitals, but the results were bad. On the whole, there was no great improvement as regards sepsis on this occasion. The statistics of a number of surgeons in this war give a mortality of 50·5 per cent. for amputations, and of 48·6 per cent. for resections of joints.

In the Russo-Turkish War in 1877 some more definite attempts were made to carry out the Listerian methods; but only the work of one or two individual surgeons is of any use for our purpose. In this war all those surgeons who tried Listerism emphasise the difficulty of getting the wounded for treatment at a sufficiently early period, which was generally laid down as within 12 hours after the injury. I need only refer to the work of Reyher, a Russian surgeon who had visited Lister's wards in Edinburgh, and who attempted to carry out his methods as thoroughly as he could. He also emphasises the difficulty of getting the patients and of carrying out the treatment during the first 12 hours, and therefore he had only a comparatively small number of such patients, whom he terms "primary antiseptic cases." In his

statistics he stated that his mortality in cases of injuries of joints which came under observation within 12 hours and were treated conservatively was 13 per cent., while in those which were brought in later than 12 hours and in which no thorough disinfection could be made it was 61.5 per cent. As regards compound fractures coming under observation within 12 hours the mortality in primary antiseptic cases was 18.1 per cent., while in those which came under observation later it was 35.3 per cent. The mortality of all the cases treated primarily—that is to say, within 12 hours—including compound injuries of joints, compound fractures, primary resections of bones, and primary amputations, was 6.1 per cent., while that of similar cases which came under observation later than 12 hours was 32.1 per cent. Apart from the delay in getting the patients from the field, the disinfection of each case by the method he employed took some time, and therefore he always took the worst cases first. Reyher's method consisted, in cases of bad wounds of joints, in laying them open, thoroughly washing them out in every direction with 1:20 carbolic acid lotion, free drainage, and antiseptic dressings. In addition, some surgeons—for example, Fischer—recommended that if the wounds were badly soiled these parts should also be treated with strong chloride of zinc lotion.

The next war to which I need refer was the Chino-Japanese War (1894-95), and there also in the Naval Department, which is the only side I know, attempts were made to carry out Listerian treatment. The treatment consisted in washing out the wounds with  $2\frac{1}{2}$  to 3 per cent. carbolic lotion, disinfecting the skin, extracting such foreign bodies as were easily accessible, and the application either of



antiseptic dressings such as sublimate gauze and carbolic gauze, or of absorbent cotton-wool. As in most cases the wounds could not be thoroughly disinfected in the time at their disposal the surgeons filled them up with iodoform. The result was that nearly all the wounds suppurated, and as an explanation it was pointed out that time did not permit of anything like a thorough disinfection of the wound, and that these wounds were irregularly torn, leaving irregular spaces in which organisms could lie and escape the action of the antiseptic, while the surrounding tissues had lost their resisting power and organisms could multiply readily in them. In this war the average time for the healing of a shell wound was  $2\frac{1}{2}$  months.

In the South African War, so far as I know, no thorough attempt was made to disinfect the wounds; indeed, in most cases no special treatment of the wounds was found to be necessary, owing to the fact that for the most part they were small. The majority of these wounds did well if they were allowed to scab over. There were comparatively few large wounds; those which did occur suppurated, and the ordinary troubles which are taking place now were also met with then. It is true, I do not remember to have seen a case of tetanus, but I saw several cases of acute spreading gangrene.

The last great war was the Russo-Japanese War, and by that time antiseptics had been more or less given up, and here we have an example of the so-called aseptic treatment combined with the imperfect use of antiseptics. The wounds were not handled nor washed out with antiseptics, but they were dusted over with a powder of salicylic and boracic acids and dressed with sterilised

gauze. The report of the result runs as follows:—

The wounded, when admitted to hospital, were found to have all their wounds inflamed in a somewhat advanced stage—the bruised tissues were already sloughing off and a reactionary inflammation was already developing around the lips of the wounds. The larger and still open wounds were in most instances covered with a dark grey slough and no signs of firm and red granulations were to be seen.

#### LESS VIRULENT SEPSIS OF WOUNDS.

If we review these wars we see that, with the single exception of Reyher, no real attempt at the disinfection of wounds has been carried out. Nor has sepsis been conquered; all large wounds suppurate and sometimes slough, and various septic troubles arise. It is true that such septic conditions as phagedæna, pyæmia, &c., with their terrible mortality, are not so frequent as they were before the Listerian era, but otherwise the results are very much the same. In my opinion the explanation of these improved results is as follows. The very bad results in former days were, I have no doubt, due not so much to infection of the wound at the time as to transference of infective material directly from one patient to another by the surgeon and attendants at the dressings. In former days, when the process of infection was not understood, case after case was dressed with the same instruments, which were often not cleaned at all or only rubbed with a cloth or rinsed in water; the surgeons did not even wash their hands after every case. Now we know that if the virulence of a pathogenic organism has diminished during culture the best way of restoring its virulence is by passing



it through a series of animals, and further, the virulence of a virulent organism can often be much exalted in the same way. I believe that many of the tragedies in pre-Listerian times arose from the continued transference of increasingly virulent organisms from patient to patient by the surgeon or the attendants. One result of Lister's teaching is that, apart from strict aseptic work (and by that I mean work which ensures asepsis in a wound quite apart from whether antiseptics are used or not), everyone who has to deal with wounds takes care, or ought to take care, by disinfecting the instruments before being used for a fresh patient and avoiding infection of dressings, &c., not to carry organisms from one patient to another. My view is that the chief explanation of the less virulent sepsis which is present in these wounds to-day and to which surgeons point with considerable self-satisfaction, and indeed most that has as yet been gained from modern methods of wound treatment in the case of war, is the result of this simple cleanliness rather than of improved treatment of the wounds themselves.

Before I go any further let me make clear what I mean by sepsis. In speaking of sepsis and septic wounds I refer to the conditions (suppuration, cellulitis, septicæmia, pyæmia, osteomyelitis, and so on) brought about by the ordinary pyogenic organisms. Whether the amount of disturbance caused is much or little, a wound in which these organisms are growing freely is a septic wound. In the present war, I fancy, attention is chiefly concentrated on the foul smell of the wounds and on the occurrence of tetanus and acute spreading gangrene rather than on the suppurative condition. Now, foul smell in a wound does not mean anything much worse than a septic wound

without a foul smell. The odour is due to the presence of some organism (generally a saprophyte) which produces foul-smelling gases, and though they may increase the amount of toxins absorbed they are easily got rid of by irrigation, free drainage, &c. Tetanus and acute spreading gangrene, again, are independent diseases which happen to get into the wound along with soil, and are to a certain extent independent of the question of sepsis, although they seldom occur in wounds which are not also septic. Further, these diseases, though very terrible, are comparatively rare.

As regards the present war, I do not suppose we can know accurately what the proportion of tetanus is until statistics are made up at the end of the war; but in a note issued to the medical staff in December it is stated that about 0·2 per cent. of the wounded had been attacked by tetanus among the troops in France, and that some further cases had developed after the arrival of the wounded in this country. In recent wars the number of cases of tetanus has averaged less than 1 per cent. of the wounded (varying from 1·2 to 0·26 per cent.). The proportion of acute spreading gangrene is somewhat greater, but we may take it that at most only some 3 per cent. of the wounded will probably be affected with these diseases. Tetanus and spreading gangrene are very terrible diseases, and hence, no doubt, the reason why undue prominence is being given to them; but what I am trying to work out is how best to deal with the other 97 per cent. of the wounded so as to avoid the much more common and often very serious sepsis. Incidentally I think it will be found that in concurrence with the disappearance of the septic diseases the proportion of cases of tetanus and acute spreading gangrene will also diminish.



## CONSIDERATION OF METHODS OF TREATMENT.

Now in considering the prevention and treatment of septic infection of wounds it seems to me that there are theoretically three ways in which we may oppose the attacks of the parasitic invaders: 1. To strengthen the natural protective forces in the body to such an extent that they may be able to resist and destroy the invading organisms. 2. To destroy the organisms after they have broken through the natural defences of the body and have established themselves in the injured part or the body generally. 3. To prevent the growth of or to destroy the organisms at their point of entrance into the body before they have had time to establish themselves there.

*The Strengthening of the Natural Defences.*

The first point raises the very difficult question of immunity and the action of toxins introduced into the body by the surgeon—the so-called vaccines. These questions are much too abstruse for me to go into to-day, if indeed I were competent to do so, and besides they are very far from being worked out; indeed, the theories of this year may very probably not be the theories of two or three years hence. I may, however, say a few words as a clinician on the way in which the matter so far strikes me in reference to the question under consideration.

In former years the use of vaccines was advocated as a prophylactic measure, a certain amount of immunity being produced, or the existing amount of immunity being increased, by setting



up a mild attack of the same or of a closely allied disease. This was the process of inoculation and later of vaccination against small-pox, the latter being produced by setting up a mild attack of a similar disease (if not the same disease), viz., cow-pox, and the value of this measure is universally acknowledged except by a few cranks. The first to extend the process to bacteric diseases was Pasteur, who by the previous injection of organisms, weakened as regards their virulence, was able to induce a considerable amount of protection against the assaults of living and more virulent bacteria of the same kind. Thus he was able to vaccinate chickens against chicken cholera, and sheep and cattle against anthrax. At the present time antityphoid inoculations are being very largely employed and, in the opinion of those best qualified to judge, with great advantage. Prophylactic inoculations have also been employed against cholera and against plague. These attempts to raise the immunity of an animal before infection, and thus to enable it to resist the infection better than one that has not been vaccinated, are thoroughly logical and most promising, and they seem to me to be the proper sphere of vaccine work. It must, however, always be remembered that there is no such thing as absolute immunity and that the increased immunity afforded by the vaccines can always be broken down by a sufficiently large dose of the bacteria.

Of late the attempt has been made on a gigantic scale to employ vaccines not merely as a prophylactic measure, but also in the treatment of disease (these vaccines being composed of the dead bodies of the bacteria with their toxins). This is quite a different principle, however, from that on which vaccines were first introduced, and when it

is proposed to rely on this treatment for the recovery of those wounded in war the matter requires very careful consideration. I have always felt rather sceptical as to the possibility of raising the immunity by this plan in cases where the disease is actually in progress. The fact that the disease is present shows that the natural immunity of the body has been more or less overcome, and the general view is that this has been brought about by toxins produced by the invading organisms and absorbed into the system. If this be true, the question very naturally presents itself, How can this immunity be restored by the injection of more toxins of the same kind? I can see no essential difference between the absorption of toxins from a wound and the injection of the same toxins from a bottle. If the quantity absorbed from a wound has broken down the resisting power of the body, how can it be restored by the subsequent injection of more toxins from a flask? I know that bacteriologists try to defend their position, but the arguments put forward in its support are purely theoretical and very obscure.

What support is there from clinical experience in favour of the employment of vaccines for treatment as apart from prophylaxis? Just think how many millions of vaccine injections have been made in the course of the last few years, and in how very few cases we can definitely recognise an immediate and marked improvement, as we ought to do if the treatment is to be justified. Think, also, how often we are in doubt whether such improvement as occurs in the course of the treatment is due to the vaccine or is a natural result of the actions of the body. Think again in how many cases (the vast majority, indeed) there is no apparent



action at all. I have used vaccines extensively (employing the services of bacteriologists for the purpose, so that I should not feel that I had not been carrying out the treatment properly), and I have in only two or three cases seen any result which I should not have expected without their use. I have seen lesions getting well in one part of the body and yet, while still under vaccine treatment, fresh lesions breaking out in other parts of the body, and I have also seen bad and even fatal results follow the use of vaccines. To follow out this matter would, however, lead me far from my subject matter to-day, and all I would say as regards the place of the first method in the case of wounds in war is that while I would welcome vaccine injections as a prophylactic measure, I think they are very broken reeds to trust to once the organisms have established themselves in wounds.

#### *Destruction of Organisms in the Body.*

Let me now refer very shortly to the second point, of which the chief outcome is chemotherapy, the principle of which is to destroy the organisms by drugs after they have established themselves in the body.

Intermediate between (1) and (2) we have the use of antitoxic sera. Here antitoxins are introduced into the blood which destroy or neutralise the toxins of the bacteria, and the latter, when deprived of their weapons, soon fall an easy prey to the defensive arrangements of the body. The typical example of this is antidiphtheritic serum, which, if given early enough, leads to very rapid arrest of the disease in a way which is not seen in



vaccine therapy. In the case of tetanus the anti-tetanic serum seems also to be very beneficial in some cases, if used immediately after infection.

As to the direct destruction of bacteria by chemical substances or chemotherapy, we have imperfect examples of this in the treatment of malaria by quinine and of syphilis by mercury, and still more definitely in the treatment of syphilis by salvarsan. Whatever may be the value of salvarsan as regards the complete cure of syphilis the immediate effect is most striking and is evidently the ideal to be sought for in the medical treatment of any infective disease. Unfortunately, this form of treatment has not as yet been extended to the infective diseases with which we are at present concerned. If it were it would solve all our difficulties, and it would not be necessary for us to discuss the brutal methods which I felt it to be my duty to recommend at the meeting of the Medical Society last November<sup>1</sup> and which I am afraid I must again to a certain extent emphasise to-day. I sincerely hope that Professor Ehrlich, who, whatever may be thought of German Kultur in general, is the great pioneer in this work and to whom it would be difficult to find a successor, will still be able to go on with his work and will not be crippled in health or opportunity by this war. I may be prejudiced, but I look on Professor Ehrlich as the greatest medical asset that the world possesses at the present time.

### *The Disinfection of Wounds.*

We are thus left with the only method of dealing with these conditions which we possess at the

<sup>1</sup> THE LANCET, Nov. 21st, 1914, p. 1185.

present time—viz., to attempt to destroy or prevent the growth of the organisms responsible for septic diseases before they have established themselves in the wounds, an attempt which we may speak of shortly as the disinfection of wounds.

#### LISTER'S METHODS.

You may remember that in my paper at the Medical Society last November I traced the history of the disinfection of compound fractures in Lister's work, and I may shortly repeat what I said.

His *first* plan was to introduce impure liquid carbolic acid into the wounds, stir it up with the blood, and leave it there, painting a little of the acid on the surface of the blood clot from time to time. The result of that plan was the complete revolution of surgery; his compound fractures behaved like simple fractures, there was no inflammation, suppuration, or sloughing, and none of the septic diseases such as phagedæna, erysipelas, pyæmia, &c., which were so common in his wards up to that time. What also struck Lister as most extraordinary, and what he was always remarking on, was that tetanus also disappeared, although it had been previously quite common in his wards. He had no idea until many years later that tetanus was an infective disease, but he frequently remarked that suppuration was somehow or other concerned with its onset because he had had no cases since he ceased to have suppuration in his wounds. Had the effect of undiluted carbolic acid been to cause extensive sloughing and to favour the growth of pathogenic bacteria, as some of our workers in laboratories tell us is the case, Lister's



experiments would have failed and been abandoned and the revolution in surgery might not even yet have taken place.

The *second* stage, after Lister had given up the use of the undiluted carbolic acids in wounds, was to wash out compound fractures very thoroughly with 1 in 20 carbolic lotion, a catheter being attached to the syringe and passed into all the recesses of the wound, so that no part should escape the action of the antiseptic. It was found, however, that the results were not so uniformly good as in his original method, especially if the wounds were much soiled, and so his *third* plan was, in addition to washing out the wound with 1 in 20 carbolic lotion, to clip away the soiled tissues and apply undiluted carbolic acid to those parts. This is the plan which I have used for years and which has proved very satisfactory. Under the present circumstances in the field, however, I suggested a *fourth* plan—viz., in addition to clipping away the soiled parts, to apply the undiluted carbolic acid to the whole surface of the wound, opening it up if necessary.

My main idea in making this suggestion was in order to ensure that the whole surface of the wound should be subjected to the action of the antiseptic, and that no recesses should escape, as might very easily be the case if the wound were only syringed out. A further idea was that the carbolic acid might, so to speak, "pickle" the tissues and so prevent the growth of micro-organisms in them till such time as the defensive action of the tissues had come fully into play. That the procedure is a severe one and open to several objections I readily admit; the great objection, to my mind, being the risk, in the case of large wounds, of absorption of the carbolic acid to a disagreeable and even dangerous

extent. At the same time, considering the evils of sepsis, this risk, which is not really very great, is worth taking if no better way can be found. Whether the plan can be modified in the light of the facts which I shall bring before you to-day is a matter which only experience can decide.

#### DIFFICULTIES IN DISINFECTION OF GUNSHOT WOUNDS.

Some surgeons take a hopeless view of the disinfection of gunshot wounds and think that disinfection is impossible of attainment. That it is quite possible and comparatively easily obtained in accidents in civilian practice is a fact which cannot be denied. Why, then, should gunshot wounds be so hopeless? I think the idea is probably founded on experiments by Lagarde and others carried out a good many years ago. In these experiments it is stated that in gunshot wounds in animals, where the bullet is travelling at high velocity, particles of gunpowder may be driven into the tissues which form the sides of the wound to as great a depth as 17 millimetres and presumably bacteria might also be driven in to the same extent, in which case no amount of syringing out of the wound with antiseptics could affect them. I cannot argue this matter fully here, but I may say that the experiments, so far as I read them, are not convincing and I am not prepared to accept them without fresh and careful repetition.

A further reason given is that the sides of the wound are so deprived of vitality that they must slough. But dead tissue in a wound does not slough if the wound is aseptic; indeed, we constantly put dead substances into wounds, such as ligatures of



all kinds, pieces of bone, &c., and they do not separate if they are aseptic. In many accidents in civil practice the tissues are equally badly contused, and yet if disinfected early and thoroughly the wound follows an aseptic course and the bruised tissues do not slough. Sloughing of bruised tissues is due to infection of these tissues. Anyone who followed the course of the bullet wounds in the South African War and remembers how frequently they healed without sloughing or suppuration will, I think, doubt the soundness of the view that gunshot wounds must slough and that bacteria are driven into the tissues to such an extent that sepsis must occur.

A third point which is being urged just now is that almost immediately after infection the infective organisms may be found in the blood of the heart. This may be true as regards guinea-pigs and bacteria which produce general diseases, but I want some further confirmation of it in regard to man and local diseases such as those we are dealing with. Even if it were correct in the case of man that some organisms do find their way from the wound to the heart very quickly, it is not these silly young Cupids that one has to fear in the case of septic wounds; they very quickly suffer the fate of unrequited love. It is the slim old bacteria that establish themselves in the wound, dig themselves in, and then proceed to pour out their toxins, that one has to guard against.

I quite realise, however, that there are many difficulties in carrying out the thorough disinfection of wounds in war, but I cannot believe that disinfection of these wounds is impossible, and I will not believe it till I have tried thoroughly myself and have failed.

In my paper at the Medical Society I especially

referred to two great difficulties which stood in the way of any thorough disinfection of the majority of gunshot wounds. The first was the large number of cases which may come under treatment at any one time. Sir Anthony Bowlby has rightly laid great stress on this point in his interesting paper in a recent number of *THE LANCET*.<sup>2</sup> In November I could only suggest that the cases should be sorted out, and that the compound fractures and joint injuries should be dealt with first and as soon as possible, leaving the others to take their chance as regards disinfection.

The second point which I emphasised was the length of time which might elapse between the receipt of the injury and the patient's arrival at a suitable place where thorough disinfection could be carried out, and the consequent failure of any attempt at disinfection owing to the growth of bacteria in the wound in the interval which elapses between its infliction and the reception of the patient at the dressing station or field hospital. With regard to this point I made one or two tentative suggestions, but they were very feeble, though they showed in what direction my mind was working. I said that we had been trying at Chatham to make soluble bougies or suppositories containing carbolic acid which might be pushed into wounds and delay the sepsis, or that, as an alternative, we might push in swabs soaked in iodine and leave them there; but I made no definite suggestion, for the simple reason that I had not worked it out and had no definite facts to go upon.

<sup>2</sup> *THE LANCET*, Dec. 19th, 1914, p. 1427.



COMMITTEE OF INVESTIGATION: NATURE OF THE  
PROBLEM.

I have, however, taken up this problem very seriously since that meeting, and at the suggestion of Sir Arthur May, the Director-General of the Naval Medical Service, have formed a little committee consisting of Fleet-Surgeon Bassett-Smith, the well-known bacteriologist in the Naval Medical Service, Mr. Arthur Edmunds, who has worked with me for years, and who is also attached to the Royal Naval Hospital, Chatham, and myself. I may say that I have been most fortunate in the choice of my coadjutors; they are both men with great scientific knowledge, most industrious, and most ingenious. As far as I am concerned, it has been a great delight to me to go back to laboratory work and experiment again. The work has been done under the auspices of the Naval Medical Service, and the Director-General has given us every assistance that we wanted. It was done partly in the laboratory of the Royal Naval Hospital, Chatham, and partly in Dr. Bassett-Smith's laboratory at the Royal Naval College, Greenwich. We have to thank Sir Arthur May and also the staff at the Chatham Hospital for their most cordial help, and especially Staff-Surgeon Dudley, who has charge of the laboratory there. To-day I propose, with the consent of the Director-General and of my colleagues, to make a preliminary communication on our work, and to mention some of our experiments, and I hope you will remember that though I speak, what I say is the result of our joint work and not of my own alone. The more detailed report of the work, which is by no means completed as yet, will be published in the next number of the *Naval Medical Journal*.

The problem which we set ourselves was whether it was possible to introduce an antiseptic into a wound soon after its infliction which would remain there, diffuse in the blood and tissues, and inhibit the growth of the bacteria till such time as the wound could be thoroughly disinfected.

I think I can make the meaning of the problem clear if I give you an illustration, and as we are dealing with war I shall make it a warlike one. The enemy has established a battery at a certain point not accurately known, but evidently in connexion with a definite field or wood; that battery is inflicting, or is likely to inflict, great damage on our forces, and we must try to destroy it if possible. Our gunners proceed to throw shells over the suspected area, searching it thoroughly from side to side and from front to back; but it may quite well happen that they may plough up the whole field without injuring the battery or the gunners at all, because the latter are hidden away in some quarry or ditch and thus escape the shells. Just in the same way, we may syringe out a wound with antiseptic lotions without rooting out the bacteria, for they may be lying safely protected by a piece of bone or tissue or blood clot, and that is the reason why I advised opening up the wounds if necessary and applying the antiseptic methodically to the whole surface of the wound. And just as a field may be spoilt uselessly by the guns, so the syringing may damage the tissues without accomplishing its object, and may only enable the bacteria to get a firmer hold.

Now I suppose we all dream about various things at times—at any rate, I know that I do—and I have often thought that if I were writing a sixpenny romance on war I would make our gunners use shells containing some anæsthetic substance



heavier than air which would diffuse along the ground and search out and anæsthetise the enemy, however well they were hidden. They and their guns could then be carted away at leisure. How furious it would make my noble and illustrious namesake if he found that his best troops were carted off the field and woke up to find themselves prisoners of war without a scratch on them !

Now I think that something of this kind would be the best way of attacking the bacteria in these wounds—that is to say, instead of syringing out the wound, which if done in a hurry or incompletely is futile—to introduce an antiseptic into the wound and leave it there to diffuse over the whole wound and inhibit the growth of the bacteria till the patient can be brought to the field hospital. It was with that idea in my mind that I spoke of bougies or iodine in November, and that is the problem which we set ourselves to solve.

#### ACCOUNT OF INVESTIGATIONS.

In working out this problem we had to consider various points. For example, we had to devise a method of estimating the diffusibility of antiseptics in blood clot and their action on the bacteria present in or on that clot. We soon found that their diffusibility and activity varied much according to the medium in which they were present and various other circumstances.

This led us to the question of the form in which the antiseptics should be used in wounds, and we then had to test the action of a variety of antiseptics in various media so as to find one suitable for our purpose.

Again, we had to study in what strengths these

antiseptics could be introduced into and left in wounds, and further, we had, as far as possible, to test the action of the antiseptics which seemed most suitable for our purpose, in animals and in man. This last part of our research is still very incomplete, but we have learned a good deal about antiseptics which we did not know before, and therefore I hope this short preliminary communication on our work will not be without interest to you. At the same time, I wish you to understand thoroughly that it is really preliminary. All sorts of lines of research are still occurring to us, and I would not say anything about it just now were it not that the matter is very urgent and that we have arrived at a point when it is necessary to test our results on actual wounds. Further, we shall no doubt have the benefit of various criticisms.

#### *Media and Antiseptics.*

I may, in the first instance, refer to the medium in which the antiseptics should be introduced into wounds in order to delay the growth of bacteria till the wound can be properly attended to. An essential point is that the antiseptic should remain in the wound and not escape from it at once; it is not a transitory action but a more or less continued one that is required. Hence it seems evident that antiseptics in a fluid form will not answer the purpose, for they will run out of the wound almost at once, and their effect will only be momentary. For this reason, therefore, watery, alcoholic, or oily antiseptic solutions were discarded, however efficient they might be from an antiseptic point of view. This left us with various pastes or ointments,



and powders. As regards the latter, it would be very difficult to introduce powders into the recesses of a wound, and besides some of the most efficient antiseptics do not occur in the form of powder. Hence we chose pastes, and we have made a large number of experiments with the view of deciding what would be the most suitable basis with which to combine the antiseptic. I will show you presently an example of the behaviour of antiseptics according to the bases with which they are combined, and will make some remarks on this point, but in the meantime I may say that, as far as we can judge at present, the most suitable basis from every point of view is one consisting of six parts of lanoline to one part of white wax. I may say that in the preparations which I shall now show you in reference to the question of diffusibility of antiseptics the latter were combined in varying proportions with this base unless I state the contrary. We have, however, also tested the diffusibility and activity of several antiseptics in liquid or solid form.

The following were the chief substances tested: Carbolic acid. Tricresol (o.m.p. cresol, as Martindale labels it). This consists of the three cresols—ortho-, meta-, and para-cresol—which have very nearly the same boiling point and pass over together in the distillation of coal-tar products. Various proprietary substances which are used by surgeons in which the tricresols or allied substances form the active agents, but are mixed with other products of distillation and with varying quantities of soap so as to form an emulsion. Such were izal, cyllin, hycol, and lysol. Liquor cresolis saponatus (or English lysol made with pure redistilled tricresol, Martindale). Bichloride of mercury. Iodine. Salicylic acid. Salicylic and boric acids (1 to 3), a

powder much used in the Russo-Japanese War. The double cyanide of mercury and zinc. Paraform. Turpentine. Various essential oils, especially oil of origanum, oil of cinnamon, and oil of eucalyptus. Alcohol. Various colloidal substances (mercury, silver, gold, selenium). Balsam of Peru, friar's balsam, and Dr. Mencière's embalming fluid.

We have tested their diffusibility and inhibitory power as regards growth, and also the antiseptic power (i.e., the power of actually killing the bacteria) in blood clot and also on nutrient agar. As a matter of fact, we find that the diffusibility and antibacteric power of most of these pastes are much the same in nutrient agar as in blood clot, and for demonstration purposes agar is far more convenient. Hence, on the present occasion, I shall show you some of our agar preparations.

#### *Description of Methods.*

Speaking generally, the plan which we have ultimately adopted as regards agar, is to place the antiseptic paste to be tested on the bottom of a Petri dish underneath a slab of nutrient agar and to paint the upper surface of the agar with an emulsion of bacteria of various kinds according to circumstances. We were then able to judge of the diffusibility and activity of the antiseptic by observing the growth or absence of growth of the bacteria which we had planted. Now a comparative test is only of value if all the conditions are exactly the same, and I think we have ultimately worked out a satisfactory method. We always use the same quantity of the paste by weight, either half a gramme or one gramme as we wish. This is placed on an ordinary microscopical cover-glass, either  $\frac{3}{4}$  or 1 inch in diameter, which is applied to the centre of the under surface of the slab of agar. In this way the antiseptic is applied to the same definite area ( $\frac{3}{4}$  or 1 inch) of the agar in all cases. Where fluids have been tested they have been put into a small paraffin cell con-



taining pieces of filter paper and always in definite quantities.

The slabs of agar must also always be of exactly the same thickness, and here we had our greatest difficulty. We began by pouring the agar into a Petri dish, till, as far as we could judge, we had got the proper depth of agar, and then allowed it to solidify and turned it out into another Petri dish in the centre of which the paste was laid. After all, however, this was only guesswork; the table might not be level and one side of the agar might be thicker than another, and besides we could not always be certain that we had put the same amount of agar into each dish. This difficulty has been overcome in a very ingenious manner, and though when two or more men work together it is not usual to refer to any one man's share in particular, still in this instance the arrangement is likely to be very useful in similar experiments in future, and therefore I think I ought to say that it was devised by Mr. Edmunds, and I shall speak of it as Edmunds's cell. (Fig. 7.)

To make an Edmunds's cell you take two square pieces of glass, a brass ring of known thickness (we generally have used one  $\frac{1}{4}$  inch thick), the ring being incomplete in one part, and two or three broad paper clips. First sterilise a glass plate in the flame and then lay it down on a dish, then similarly flame the interior of the brass ring and lay it down on the glass, then flame the other piece of glass and lay it over the brass. Bind these together by the paper clips and you have a cell with an opening at one part through which the melted agar can be poured and left to solidify. When the agar has solidified the cell is laid down flat, the clips removed, the upper glass plate and the brass ring lifted off, and then we have the slab of agar lying on the lower glass plate. The cover-glass with the paste is now placed on the centre of this slab, with the paste next the agar, and then the lower part of a Petri dish is inverted over it, the whole turned upside down, and with a little manipulation the slab is transferred to the dish. A thin emulsion of the bacteria to be employed is previously made and is now brushed over the whole surface of the agar with a camel's hair brush. Finally, a little fluid agar is run round the edge

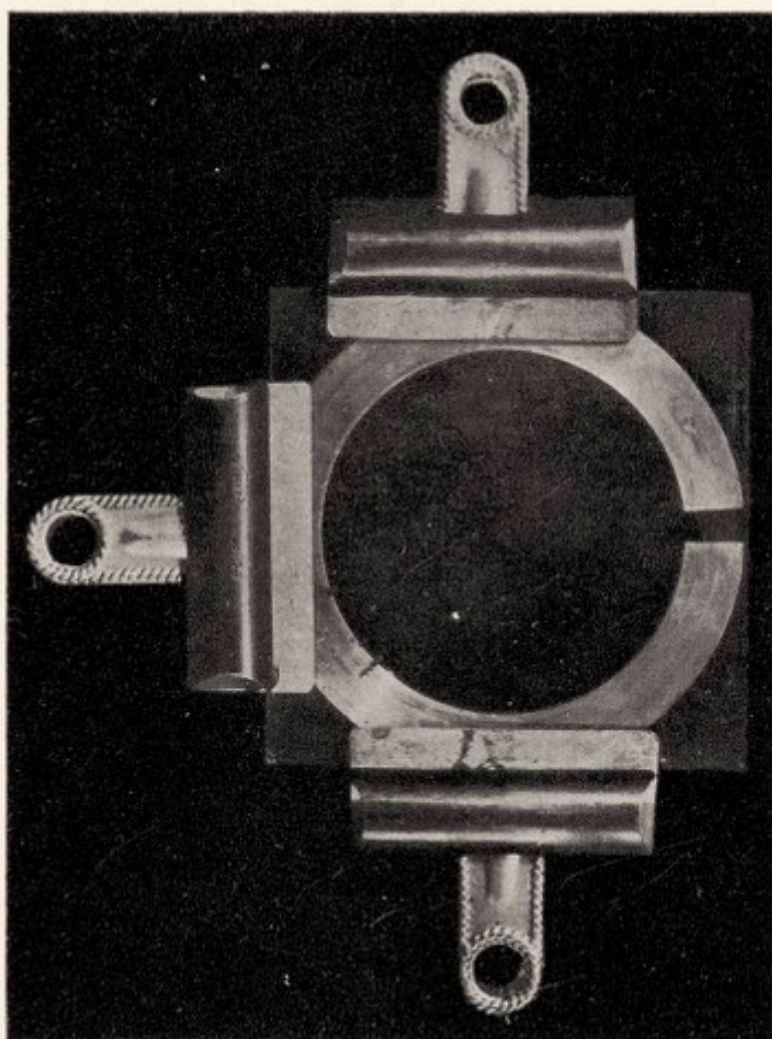


FIG. 7. The Edmunds Cell





of the slab, partly to fix it to the dish and partly to prevent the escape of vapour should the antiseptic to be tested be volatile.

As regards bacteria, we have chiefly employed the ordinary pus organisms, the staphylococcus pyogenes aureus, but we have used micrococcus prodigiosus and also bacillus subtilis so as to study the effect on spores. It will be very interesting when we have time to study other organisms. The Petri dish thus prepared is placed in an incubator at the body temperature and observations made from time to time.

### *Results of Experiments.*

I shall now show you some of the results, and first we will take a series in which the surface of the agar was brushed over with an emulsion of staphylococcus pyogenes aureus, which will show you the effect of various antiseptics on the growth of these organisms, the antiseptics being incorporated in the lanoline and wax base.

The first specimen which I show is a control where everything has been done as I have said, except that no paste has been applied, and you will see that the whole surface of the agar is pretty uniformly dotted with colonies of the staphylococci. (Fig. 2.)

As a marked contrast with this I show you next a plate where a paste containing 30 per cent. of cresol has been used, and you will see the large clear area in the centre where no growth has occurred and the very narrow fringe of small colonies around the edge of the agar. The central space is clear because no bacteria have grown there, and the extent of the clear space indicates the diffusibility and the activity of the various antiseptics when present in this particular basis (lanoline and



wax). I shall have a good deal to say presently about the significance of this clear space and also about carbolic acid and tricresol, and I shall therefore leave this and the allied antiseptics to the last and show you, in the first instance, the action of various other antiseptics. I may, however, show you a series of the carbolic acid specimens from 5 per cent. up to 30 per cent. (Fig. 8) so as to illustrate the value of the method, and you will see that as the strength increases so the effect in arresting the growth also increases. In this series only half a gramme of the paste has been used so as to show the contrast of the various strengths better, but in the specimens which follow the amount has been one gramme.

#### *Iodine.*

In the meantime I shall pass on to other antiseptics, and in the first place I show you various specimens of the effect of iodine, which is so popular at the present time. I here show you plates where the paste contained 2 per cent. and 6 per cent. of iodine. (Fig. 1.) There was no use in going higher because even these pastes cause marked irritation of the skin, and when we reach 10 per cent. the paste left on only for  $2\frac{1}{2}$  hours caused almost complete destruction of the skin, so that iodine of that strength is clearly unsuitable as an application in wounds. Here you see that the iodine has not diffused at all, and that luxurious growth has occurred over the whole area just as in the control dish. I would especially call your attention to the plate where 6 per cent. iodine paste has been used, where you see that the growth is actually more luxuriant over the iodine than else-

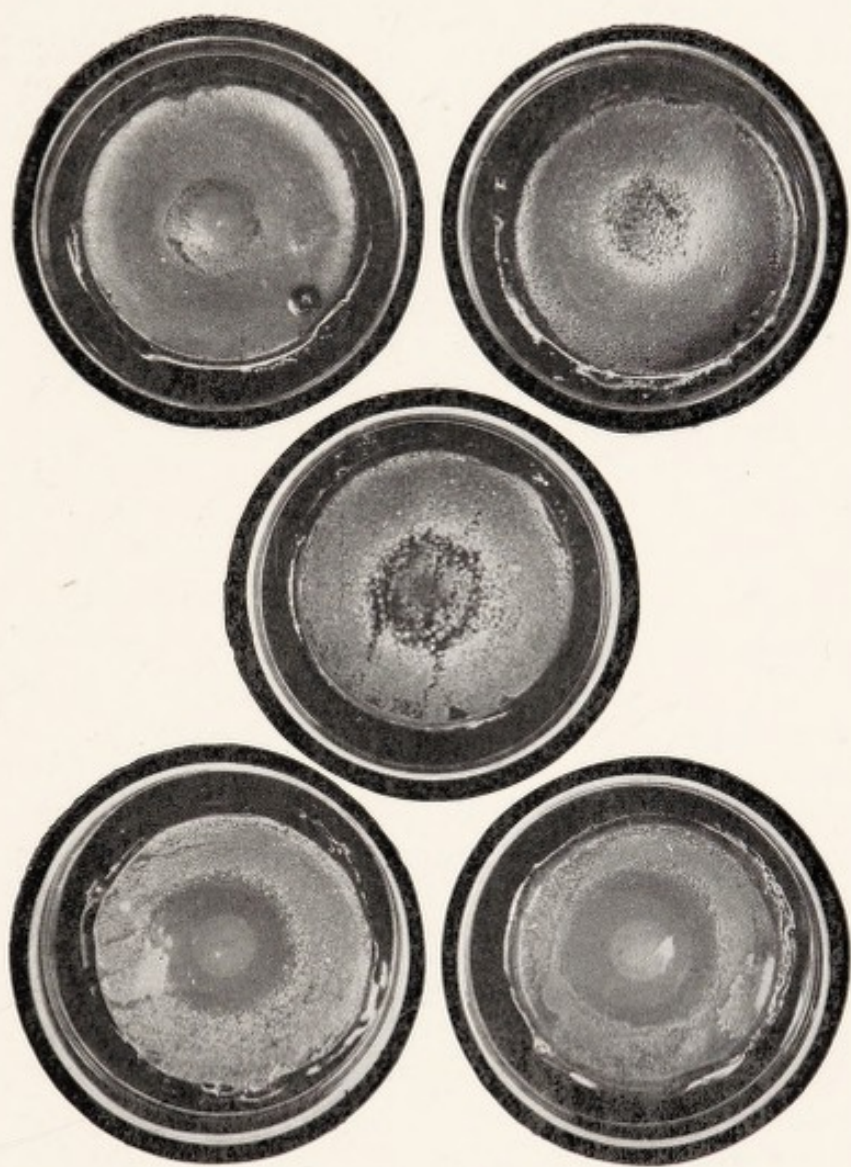


FIG. 8. Carbolic Paste—5 % 10 % 15 % 20 % 30 %





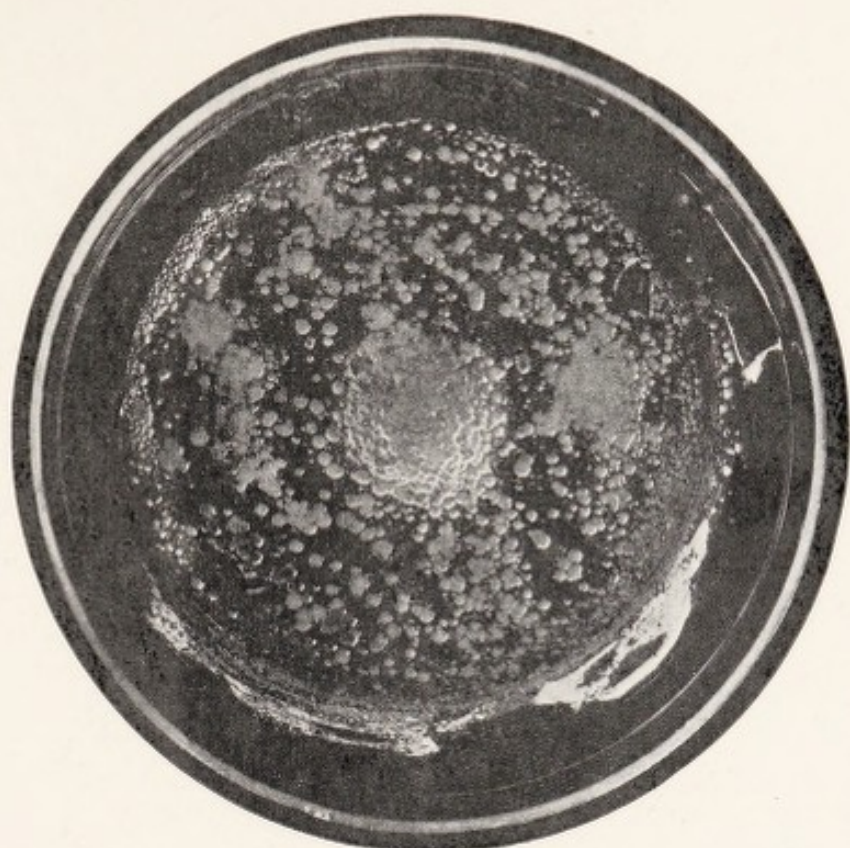


FIG. 1. Iodine Ointment 6 %



FIG. 2. Absolute Alcohol





where. At first sight you might think that the organisms painted over the surface had run down and collected in the middle of the slab, but as a matter of fact the centre of these slabs of agar is the highest point on account of the cover-glass and ointment placed behind them. In these specimens the solid iodine has been mixed up with the lanoline and wax basis, and that might be the reason for its failure, and therefore we have gone further into the matter.

In the next plate which I show the iodine was mixed with iodide of potash in the ordinary proportions so as to aid its solution, but here also there is still no action. Again I show you a specimen where the ordinary tincture of iodine of the British Pharmacopœia has been used without any ointment basis, pieces of filter paper being saturated with the tincture and applied in the same manner as the paste, but still growth has occurred.

I must say that these results have surprised me very much, as I was always under the impression that iodine was quite a useful antiseptic though I knew that it was not so good as was generally supposed. However that may be, it certainly does not show the diffusibility and activity which many other substances do, and I am afraid that we must therefore come to the conclusion that iodine is useless for our purpose. Certainly the clinical results in wounds in war, so far as they have come under my notice, coincide with these experimental results, for I have had several very septic cases which I have been surprised to learn afterwards had been freely treated with iodine soon after their infliction and shortly before I saw them.



*Alcohol (on Filter Paper).*

Some disbelievers in iodine have, I understand, expressed the opinion that any good effect of the iodine solution was due to the alcohol, but I show you here a plate where absolute alcohol has been used and where uninterrupted growth has gone on. (Fig. 2.) This is interesting, because it is not uncommon to see needles, &c., especially hypodermic needles, "disinfected" with methylated spirit.

*Other Antiseptics Tested.*

*Paraform*, 5 per cent. in paste (Fig. 3).—Here the result is good; there is a clear area beyond the cover-glass of  $\frac{2}{5}$  to  $\frac{3}{5}$  inch in extent. Immediately outside this area the colonies are large. As you will note, this is a small percentage of paraform, but I doubt if anything stronger could be employed in a wound, if indeed this percentage would not be too strong.

*Double cyanide of mercury and zinc*, 10 per cent. in paste.—This shows no action. Dry cyanide powder placed under an agar slab also causes no inhibitory effect, but if the powder is moistened with a little water, as was done in this next specimen, the inhibitory effect is very marked. I confess that I do not as yet understand this, but we are going into the matter. It is possible that there may be some dissociation of the double cyanide, but we shall see. In the meantime, however, I would warn those who wish to use the double cyanide in wounds that they must not put it into a lead tube, for the lead is rapidly attacked and cyanide of lead is formed which is poisonous.

*Bichloride of mercury*—(Fig. 4) 0.2 per cent. in paste (= 1 in 500). Here we see a clear area beyond the cover-glass varying from  $\frac{1}{8}$  to  $\frac{1}{4}$  inch. Note that the colonies are large up to the edge of the clear area.



FIG. 3. Paraform 5 %

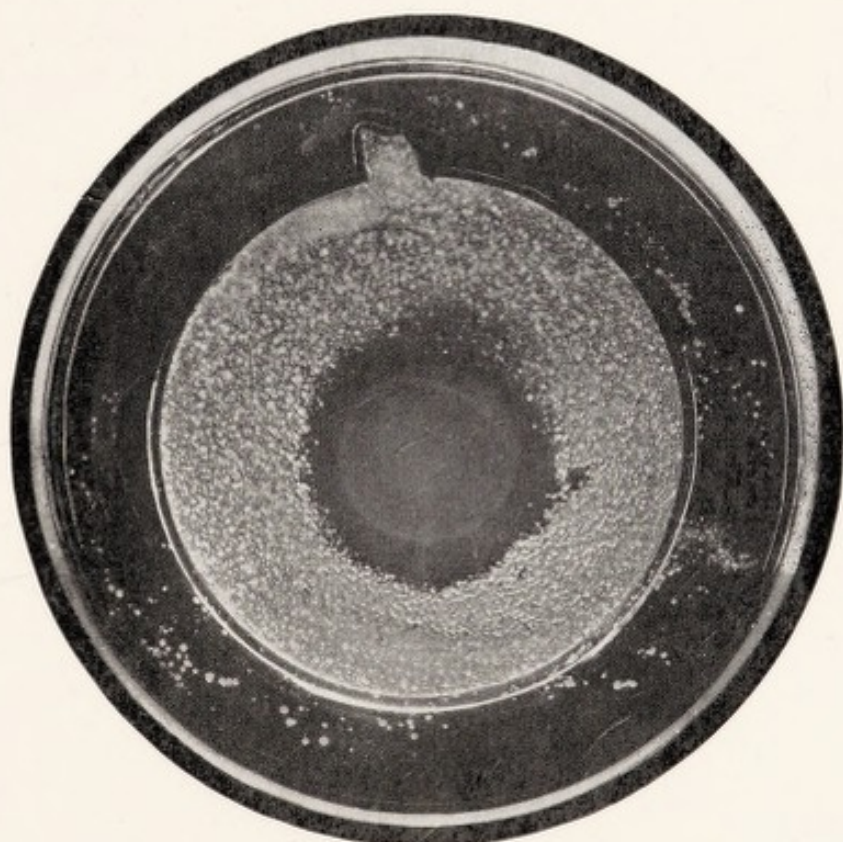


FIG. 4. Corrosive Sublimate Paste 0.2 %





In the following specimens the antiseptic was combined with the lanoline and wax paste in the proportion of 20 per cent.

*Salicylic acid*.—Over the area of the cover-glass the surface is fairly clear, but shows scattered colonies. Free growth extends quite up to the cover-glass.

*Japanese powder* (Salicylic acid 5, boric acid 15, lanoline and wax base 80).—This plate shows very little inhibitory action, no doubt because the percentage of salicylic acid is too small and the boric acid is inert.

*Oil of turpentine*.—Free growth, no inhibitory action.

*Oil of origanum*.—The centre is clear, but in the immediate neighbourhood colonies are dotted all over, but it is comparatively clear for about  $\frac{1}{2}$  inch. Free growth beyond.

*Oil of cinnamon*.—Very good,  $\frac{3}{5}$  to  $\frac{4}{5}$  inch clear area outside the area of the cover-glass.

*Oil of eucalyptus*.—No interference with growth.

*Izal*.—Colonies right up to and overlapping the area of the cover-glass.

*Cyllin*.—Somewhat larger clear area, but separate colonies are found right up to and overlapping the area of the cover-glass.

*Hycol*.—Better. Comparatively clear for about  $\frac{3}{16}$  inch from the cover-glass, but scattered colonies to within  $\frac{1}{8}$  inch of the centre.

*Lysol*.—Clear area about  $\frac{1}{4}$  inch beyond the cover-glass.

*British Lysol* (Fig. 5).—(Liq. cresol. saponat.—Martindale). 20 per cent. paste. Large clear area; quite good.

*Friar's balsam (pure)*.—Free growth. No inhibition.

*Balsam of Peru (pure)*.—Clear circle  $\frac{3}{8}$  inch beyond centre.

*Dr. Mencièr's embalming solution (pure)*.—Free growth. No inhibition.

*Colloidal mercury, selenium, copper, and silver*.—No inhibitory effect.



We may now pass on to *carbolic acid and tricresol*. I have already shown you a series of dilutions of carbolic acid in small quantities, but I may now show you a 20 per cent. paste of carbolic acid (Fig. 6) where one gramme has been used, and then a 30 per cent. one. I may also show you a similar series with tricresol. You see that the results are practically the same with tricresol as with carbolic acid, and they are quite constant.

#### *Significance of Clear Area.*

Let us now study these preparations a little more carefully, and especially the meaning of this clear space. In the first place, it indicates that no growth has occurred in that area, and not only so, but that there never has been any growth, or at any rate not since a very short time after the preparation of the slide. In other words, the antiseptic has been able to diffuse so rapidly that it has checked the growth of the bacteria which were sown on the surface before they had formed colonies visible to the naked eye or even under a low power of the microscope. If one examines such a plate under a low power of the microscope, say with a 2-inch lens, 3 hours after inoculation, one can already see the colonies quite distinctly towards the periphery of the agar, but none can be detected towards the centre, in the area which will subsequently remain clear. In rather less than 5 hours after the preparation of the plate the colonies can be perceived with the naked eye. This will give you some idea of the extraordinary rapidity with which these organisms grow. From this we learn that at some period of time within 3 hours after the prepara-

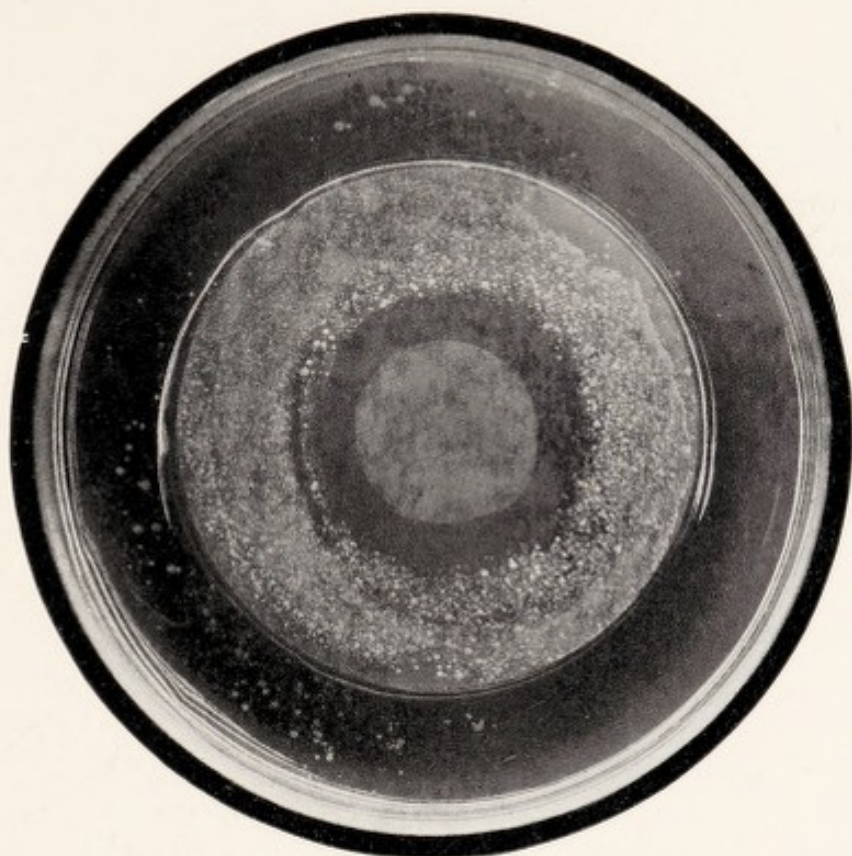


FIG. 5. Lysol Paste 20 %

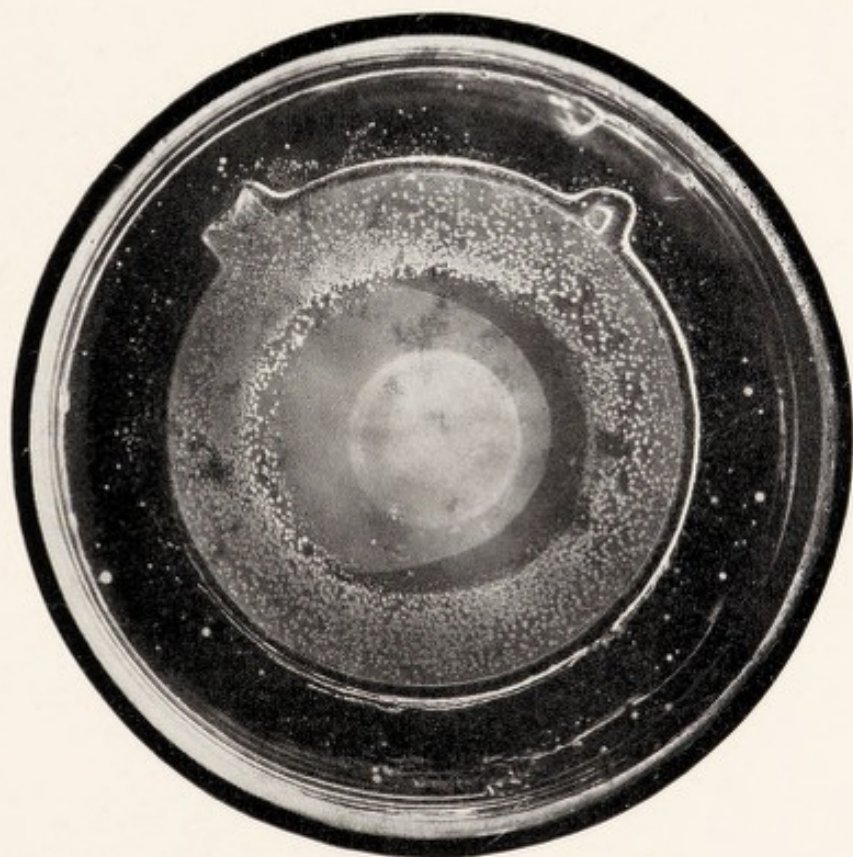


FIG. 6. Carbolic Acid Paste 20 %





tion of the plate, and probably a good deal less than that, the antiseptic has penetrated through  $\frac{1}{4}$  inch of solid agar in sufficient amount to arrest the growth of the bacteria; indeed, seeing the extent of the clear area, it must have penetrated to a greater distance than  $\frac{1}{4}$  inch. Thus you see the value of this clear space as an index of the diffusibility and activity of an antiseptic, and from the series of specimens already shown you see how differently the various substances which we have tested act.

There is another point which I wish you to note in this preparation (the carbolic acid or cresol plate)—viz., that the colonies at the edge of the clear area are quite small and that they increase in size as they lie further away from it. From this it is clear that the antiseptic did not cease to penetrate at the end of two or three hours. It is true, it only got through in amount sufficient to check growth before colonies had formed in the area shown by the clear space, but it continued to come through to a greater and greater distance, and as it came through it arrested the growth of colonies which had already become visible. All antiseptics, however, do not act in this way. Contrast the appearance of the paraform slide and several of the others which I have already shown. There you will see that the colonies at the edge of the clear centre are large—indeed, sometimes as large as any outside, showing that there was no continuance of the diffusion of the antiseptic; evidently the full amount came through quickly and the full effect was obtained in the first three hours. The continuance of the diffusion is a very important point and one in favour of cresol and carbolic acid. I think we may therefore conclude that when carbolic acid or cresol is combined with this base a certain amount is



stored up and only parted with slowly, whereas in other cases there is no such storing up, the anti-septic passing through quickly and exercising its full effect at once. We are inclined to think that it is the wax to a greater extent than the lanoline which holds up the carbolic acid, because the clear area is larger where the basis is lanoline alone than with the lanoline + wax base. I shall, however, show you immediately a series illustrating the effect of different bases, and you can note this point.

#### *Evidence of Death of Bacteria.*

Now another question naturally arises in looking at these barren areas. Are the bacteria, which are planted on the surface, still alive, or have they been actually killed, and, if so, how soon are they killed? You will always find that in cases where 20 per cent. or more carbolic acid or cresol is employed, if you make a cultivation from the centre of the plate over the cover-glass area 24 hours after the commencement of the experiment, no growth takes place, showing that the bacteria have died. We have spent a good deal of time in going into this matter.

In order to ascertain precisely what happens we have drawn a series of circles,  $\frac{1}{4}$  inch apart, on a piece of paper. These circles have been numbered from the centre, 1, 2, 3, &c. The Petri dish is placed on this paper so that the centre of the cover-glass is over the centre of the circles. The 1-inch cover-glass occupies circles 1 and 2, and then we have the further circles 3, 4, 5, and 6 at  $\frac{1}{4}$ -inch intervals from the edge of the cover-glass. At certain definite intervals of time cultivations have been made from the centre and from various circles around with the following results.

During the first three hours there is no evidence

of death of the bacteria even at the centre, so that the absence of growth up to that time is purely an inhibitory effect. After that time one begins to get evidence of the death of the bacteria, in the first instance in the centre, then in No. 3 and No. 4. Here I show a specimen at the end of five hours, where you see that the growth from the centre is only slight, in No. 3 moderately luxuriant, and in No. 4 quite active. Next I show you a specimen from the same experiment  $9\frac{1}{2}$  hours after its commencement. Here there are very few small colonies at the centre, a marked diminution in No. 3, and normal growth at Nos. 4 and 5. We have generally found that the central area is sterile after six to ten hours, and No. 3 becomes sterile next day and sometimes also No. 4. In one case cultures were taken 6 days after 30 per cent. cresol ointment had been applied, with the result that the centre, No. 3, and No. 4 were sterile. The line between Nos. 4 and 5 also appeared to be sterile at first, but after three days a few colonies appeared in the tube inoculated from that point. Note that the areas 4 and 5 show visible colonies, so that most of them had also died, and the few bacteria which survived had so suffered in health that it took three days before they had recovered sufficiently to grow. It is interesting to note that a cultivation taken from the centre of the 6 per cent. iodine plate three days after the experiment began grew luxuriantly. We have not had time as yet to test this point with other antiseptics or other bacteria, but it will be very interesting to do so.

One other point arises in connexion with these clear areas. Is the hindrance to growth permanent or does the antiseptic ultimately disappear? Cresol and carbolic acid are both volatile, and it



was interesting to see whether a time would come when the medium could again be inoculated with success. To test this we have taken dishes where carbolic acid, cresol, and formalin have been used, and after 21 days we have inoculated the clear space with fresh bacteria, but no growth occurred.

#### *Effects of Different Bases.*

I have already said that the results differ considerably according to the base with which the antiseptic is combined. We have made many experiments on this matter with which I need not trouble you, but I show you here a series of 20 per cent. carbolic pastes in five different bases. You will see that the greatest diffusion is obtained with pure lanoline and the least with a paraffin base, the latter being only half as great as the former. The lanoline when mixed with carbolic acid is, however, too diffuent, and besides, it is much more pungent and would irritate the wound and the skin. The addition of wax to it lessens its activity by about one-quarter, but it does not irritate the skin and only requires the introduction of a little more into the wound to obtain the same effect. The greatest diffusion in the carbolic series is obtained with undiluted carbolic acid and the same is the case with cresol.

#### *Imitation of Conditions of a Wound in War.*

We have also tried in various ways to reproduce the conditions of a wound in war as far as possible. I may show two experiments.

Take a flattened flask (this was done as it shows better in the epidiascope than an ordinary one), introduce into it

nutrient agar with which staphylococci have been thoroughly mixed. When it has set, punch a channel down it and introduce down that channel a piece of gauze or lint which has been soaked in the cultivation of bacteria. Then, by means of a syringe or pipette, put small quantities of cresol or of carbolic ointment into the agar in various directions and place the flask in the incubator.

As you will see in this experiment done five weeks ago and in which 30 per cent. cresol ointment was used no growth has taken place anywhere, while the control vessel shows active growth.

I also show you two similar vessels of gelatin done on Jan. 20th in which micrococcus prodigiosus was used and a piece of ordinary lint which was lying about the laboratory was put in and in the one in which 20 per cent. carbolic paste was used you see no growth. (We have since repeated the experiment with a massive blood clot and precisely the same result has been obtained.)

### *Spore-bearing Bacilli.*

So far I have been speaking of experiments with non-spore-bearing bacteria, and especially with staphylococcus pyogenes aureus, but before I leave this part of the subject I may mention that we have also tried similar experiments with the spores of bacillus subtilis, and I show you one with 20 per cent. carbolic paste which shows a clear area as in the experiments with staphylococci. Tests have been made as to the vitality of the spores; for example, cultivations were taken from the centre, from space No. 3 and from space No. 4, 12½ hours after the commencement of the experiment. On the following day there was no growth from the



centre, but there was growth from No. 3 to a certain extent and quite copiously from No. 4. After a further 24 hours in the incubator there was still no growth from the centre, but on the third day slight growth was evident which presently became quite copious. Apparently, though the spores had not been killed, they had been damaged, and took some time to recover their natural activity. We have not yet had time to pursue this matter so far as with staphylococci, but some interesting points as to the action on spores have been observed and are worth following up.

#### *Scope of Investigations.*

So much for a short sketch of our experiments with agar. I hope you understand thoroughly what their scope is. This is not a method to test whether a particular antiseptic will or will not kill bacteria, or in what concentration or after what length of time it will do so. For that you have the Rideal-Walker and various other methods, but these only deal with naked bacteria with which the antiseptic comes into immediate contact. The method which I have now shown you is, I think, a far more practical one because it enables us to study the action on bacteria at a distance and in different surroundings, as we have to do in connexion with the treatment of wounds. This method, which I believe is new, opens up quite a fresh line of study, and I fancy that, in following up the points raised by it, we shall have enough to occupy all our spare time while this war lasts. And it is quite possible that we may come across some better antiseptics or some better method of applying them in the course of our study.

The explanation of the diffusion is partly osmotic pressure and probably partly volatility of the antiseptic. Another thing also happens which affects diffusibility—viz., combination of the antiseptic with substances in the surrounding medium. This is probably the explanation of the result with iodine, which, though an active antiseptic when free in the presence of naked bacteria, has a marked tendency to combine with a great variety of substances which diminish or destroy its antiseptic qualities. Hence the reason why it does not diffuse, as an antiseptic, in blood and agar. (We have since found that one iodine plate prepared as above and covered with starch paper shows no starch reaction after 24 hours.)

#### *Experiments on Blood.*

Although I have been showing you agar experiments, we have done a number of similar experiments with blood clot—indeed, all our earlier work was with blood. In most of our experiments the blood was received into a long cylindrical vessel and allowed to clot. The clot is then turned out into dishes and cut in slices about half an inch thick, like a Swiss roll, and treated in the same way as I have already mentioned. In some cases a very thin layer of agar has been run over the surface of the clot, so that the colonies of the bacteria can be more readily seen than in the clot itself. I need not take up your time by narrating the experiments, but the results so far as we have gone are very much the same; certainly they are quite the same with the carbolic and cresol pastes and with iodine. The arrest of the growth of the bacteria and their subsequent death occur in blood



clot as in agar, and the clot, where it is penetrated by the antiseptic, becomes firm and hard and unsuitable for the growth of bacteria. If a thick mass of blood clot is placed in a beaker and the carbolic or cresol pastes mixed up with it it becomes a solid mass, and bacteria do not grow in it. A somewhat similar effect is produced by mixing blood with the double cyanide of mercury and zinc powder, but in one case which was tested micrococci were growing on the surface. Iodine in the form of a 6 per cent. paste does not check the growth of organisms in blood at all.

#### EXPERIMENTS ON ANIMALS.

We have not done much in the way of experiments on animals, because it was necessary to become pretty thoroughly acquainted in the first place with the general behaviour of antiseptics as regards diffusibility and activity, and that has taken up most of the time at our disposal. We have, however, done some experiments and can now take up the matter more systematically.

It is by no means easy to devise suitable experiments on animals, especially on guinea-pigs, which up to the present were the only animals at our disposal; and further, we have not, so far, got a very virulent organism which produces local suppuration in guinea-pigs without at the same time, in most cases, also setting up a general septicæmic disease. Guinea-pigs also have no subcutaneous tissue, so that the skin has to be raised so as to introduce the infective material, and when the wound is closed this material flows into the tissues beyond the region of the wound; in fact, it is practically a subcutaneous injection; or if a fluid

is used, it runs out over the skin and may reinfect the wound at a later period. We shall, however, manage to overcome these difficulties.

The best organism that we have tried as yet is the bacillus pyocyaneus, which sets up suppuration and sloughing locally, but at the same time is very apt to get into and grow in the blood. We have, however, got some results with this organism which indicate that we are working in the right direction. To take one series, pieces of lint soaked in a virulent emulsion of bacillus pyocyaneus were introduced into subcutaneous pockets in seven guinea-pigs:—

(a) Control. The inoculation was followed by severe suppuration; the animal rapidly lost weight and was killed in seven days. Bacillus pyocyaneus was present in the wound.

(b) Tricresol paste (30 per cent.) was introduced into the wound *immediately* after infection. No suppuration for four days, and the animal gained weight; then began to lose weight and slight suppuration occurred. Wound opened and cleaned out, and lint removed; rapidly got well. Bacillus pyocyaneus found in the wound.

(c) Carbolic acid paste (30 per cent.) introduced *immediately* after infection. Same result as in (b), but no bacillus pyocyaneus found.

(d) Tricresol paste (30 per cent.) introduced *15 minutes* after infection. Almost continuous gain in weight; no suppuration for four days. Recovered. Bacillus pyocyaneus not found in wound.

(e) Carbolic acid paste (30 per cent.) introduced *15 minutes* after infection. Gain in weight and no suppuration for four days; then slight suppuration, but no bacillus pyocyaneus found. Recovery.

(f) Tricresol paste (30 per cent.) introduced *half an hour* after infection. Rapid loss of weight, suppuration, and necrosis. Animal killed. Bacillus pyocyaneus found.



(g) Carbolic acid paste (30 per cent.) introduced *half an hour* after infection. Rapid loss of weight, suppuration, and necrosis. Animal killed. *Bacillus pyocyaneus* found.

As regards tetanus and spreading gangrene, somewhat similar experiments have been performed with some highly infected earth which Dr. Bassett-Smith was able to produce through the courtesy of Dr. Dudgeon, of St. Thomas's Hospital. The control animal died in three days from spreading gangrene, and *bacillus aerogenes capsulatus* was present in large numbers. The others died from tetanus from the third to the seventh day, but there was no gangrene, though both tetanus bacilli and the *bacillus aerogenes capsulatus* were present.

These experiments are being continued, but so far it seems as if the 30 per cent. pastes carbolic acid and tricresol prevented suppuration (*B. pyocyaneus*) for four days at least, longer than we required, while although tetanus appeared to be unaffected the action of the gangrene-producing organism was apparently checked. By the additional use of antitetanic serum it seems that the occurrence of tetanus may also be prevented. In no case was there any acceleration of the infection by the treatment. Further experiments will be reported later.

#### OBSERVATIONS ON MAN.

Looking over the specimens that I have shown you it will be seen that there are several antiseptics which evidently have considerable value from the diffusion point of view and which it might be worth while investigating in the case of

wounds in war. Such are carbolic acid, tricresol, lysol, corrosive sublimate, paraform, oil of cinnamon, double cyanide of mercury and zinc, salicylic acid, and balsam of Peru. Of these, in all probability, paraform would be too irritating, while if much corrosive sublimate were left in a wound it might be absorbed in serious amount; they might, however, be of use for later dressings. It is clear, however, that the whole subject must be carefully worked out at the front. In the meantime, taking everything into consideration, it seems, so far as we have gone, that tricresol or carbolic pastes should be tried first in the strength of 20 per cent.

In connexion with the use of these pastes in wounds we tested their effect on the skin, and as Mr. Edmunds has a delicate skin and a considerable expanse of it, he was deputed to wear the various pastes for 24 or 48 hours. The 20 per cent. carbolic or cresol pastes did not cause any redness or irritation of the skin, but greater strengths left a reddish area, and it was evident that any greater strength would probably prove unsuitable. The cresol paste also seemed more irritating than the carbolic acid. We also tried various iodine pastes; the 2, 4, and 6 per cent. pastes caused marked redness and irritation of the skin after 24 hours, and this did not pass away for several days. We could not induce Mr. Edmunds to wear a 10 per cent. iodine paste for more than  $2\frac{1}{2}$  hours, and that burned a hole in the skin which took some time to heal. From that experience and from the failure of iodine pastes in the experiments with agar and blood clot it is evident that this antiseptic is of no value for our purpose.

Having decided on the paste, we tried to get some fresh wounds on which to try it. Unfortunately for our purpose, though fortunately other-



wise, during the last three weeks there have been no fresh naval wounded at the Chatham Hospital, and hence we have not had the opportunity of testing it on actual war wounds. We have, however, had several cases from which we could form some idea as to the action of the paste in wounds. The following was the first case in which we tried the paste:—

1. The patient was a man who shot himself in the face and head. The bullet entered just in front of the mastoid process and ran upwards and forwards and came out at the inner side of the forehead near the middle line. In its course it broke up the upper jaw and malar bone, leaving a large cavity full of pieces of bone, passed through the eyeball tearing it to tatters, and smashed up the lower and anterior walls of the frontal sinus. The fracture of the frontal bone extended into the nose, where also the dura mater was torn, but there were no cerebral symptoms at first. The remains of the eyeball were removed, and one small, quite loose fragment of bone from the supraorbital region. The 20 per cent. cresol paste was then freely introduced into the whole track and cavity of the wound. The patient lived four days and died of his intracranial injuries, but during that time there was no inflammation, or sloughing, or suppuration from the wounds; they were quite aseptic, and no bacteria could be found in pieces of blood clot examined on the second and third days. On the second day a cultivation was made from the end of the drainage-tube where it projected beyond the wound, and only six colonies of cocci were obtained. Naturally one would have expected some growth from that part, and it is surprising that it was so little. He developed symptoms of meningitis and died on the fourth day. On post-mortem examination suppurative meningitis was found, but there was no suppuration anywhere in the external wound where the paste had been introduced; indeed, although it communicated with the nose and with the tear in the dura mater, the blood clot was lying in it without any decomposition.

I may mention one other case which is also very instructive.

2. The patient had a bad crush of the thumb, practically destroying the vitality of the terminal phalanx and laying open the phalangeal joint. It was a machinery accident and the parts were very much soiled. Carbolic acid paste (20 per cent.) was at once squeezed into the wound and over the dirty skin before his admission to the hospital. When he arrived at the hospital an energetic temporary surgeon proceeded to clean up the wound and thus spoil the observation, but he was caught in time; the parts were dried and more paste was put in. The wound remained quite quiet, no pain, no suppuration, no temperature or constitutional disturbance. We know what a mess such a wound would have been in under ordinary circumstances—stinking, inflamed, swollen, and probably a good deal of constitutional disturbance. At length on the tenth day the surgeon who had charge of the case wanted to see what the condition of the terminal phalanx was, and so he set to work and cleaned out the blood clot and the skin. He found the greater part of the terminal phalanx dead but not smelling, and he applied ordinary dressings. Two or three days later inflammation set in and suppuration spread up along the tendon sheath. He therefore removed the end of the thumb and opened the sheath. My own belief is that had the wound been left alone the infection would not have occurred, the dead tip would have dropped off, and healing would have taken place without any infection. At the same time the result was very remarkable and encouraging.

Four days ago we had an accidental pistol wound of the buttock with fairly large wounds of entrance and exit. Carbolic paste was introduced, and so far there is no sign of inflammation or suppuration.

#### BEARING OF RESULTS ON TREATMENT OF WOUNDS.

So much for the facts which we have to bring before you. What are the chances of attaining our object? Recall what that object was: to find some



means of averting sepsis in a wound for some hours, or at most a day or two, till thorough disinfection can be carried out. Nothing more. Now we have learned from laboratory experiments that quite a number of antiseptic substances are able to penetrate agar and blood clot to a distance of  $\frac{1}{4}$  to  $\frac{1}{2}$  inch and still retain sufficient antiseptic power to prevent the growth of organisms, and that this penetration takes place in less than three hours. We have learned in guinea-pigs in the case of the virulent bacillus pyocyaneus—quite a different class of organism in its relation to the guinea-pig from the pyogenic cocci in their relation to man—that the development of infection can be delayed for four to five days by these pastes provided the paste is put in early, within 15 minutes, and that when the wound is cleaned out at the end of that time healing rapidly occurs. From the first observation on man we learn that after one application of one of these pastes to a wound which has not been badly infected no signs of infection have occurred in that region for four days. From the second observation we find that no suppuration or other sign of infection occurred for ten days, although a great part of the tissue bordering on the wound was actually dead, and this was a much dirtier wound than the other.

I cannot but think that these facts point to the possibility that this part of the puzzle as regards the treatment of wounds in war can be solved satisfactorily, and that the danger caused by the delay in getting the cases to a place where proper attention can be given to the wounds can be reduced if not entirely removed.

I think the stage has now been reached when the matter must be worked out more thoroughly on

man, and this can only be done at the front. I am afraid I shall not have the opportunity of doing so myse'f, unless there were a naval action in the Channel. So far, where the actions have been farther north, we have only got the wounded at Chatham a day or two after the injury. Indeed, the only way of getting at the naval cases at an early stage would be to go on board a destroyer or cruiser, but I confess I do not fancy knocking about the North Sea in a destroyer on the off-chance of having a scrap with the Germans. I hope, however, that the plan will be tried by those on board ship, and also by the army at the front. I need hardly say that we shall be only too pleased to show our work and impart our ideas to anyone who is going to work at this subject at the present.

I cannot help thinking, though it is perhaps only a hope, that by this plan we may attain more than a temporary arrest of sepsis, that in some cases we may even attain complete disinfection of a wound, rendering further measures unnecessary, but this, again, can only be worked out at the front. I doubt, however, if these problems will be solved by haphazard work of individual surgeons. Had I the authority I would set aside a small section of the front line with its own line of communications and its base hospital for the thorough study of the whole problem, and appoint a committee of a few men to investigate the subject and to follow up the cases. I say a small section of the front, because one would not want to be overwhelmed with wounded. I need hardly hint that if such a committee were appointed I should like to be one of the members.



## CONCLUSION.

I must apologise to you for having taken up so much of your time to-day, but the subject of the treatment of wounds in war is one which has been a hopeless puzzle for centuries, and anything which can in any way, however slight, help to solve that puzzle is well worth the closest consideration. I have also to apologise for having brought you here to-day to hear a Hunterian oration and yet not giving you any oratory or saying anything about Hunter's work, but I am sure that if he had been alive to-day he would have been just as anxious to solve this puzzle as any of us are.



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## Treatment of Wounds in War.

IN Sir WATSON CHEYNE's recent Hunterian Oration<sup>1</sup> he gave a preliminary account of investigations which were being carried on by a committee appointed by the Medical Department of the Navy to investigate the question of the immediate treatment of wounds in war. At that time a variety of antiseptics were being examined, among others salicylic acid, but the results obtained with that substance were not sufficiently definite to warrant any special reference to it in the oration. A more detailed account of the investigation, will, however, be published immediately in the April number of the *Journal of the Royal Naval Medical Service*, from which it appears that salicylic acid is likely to prove a valuable agent in the treatment of these wounds. Experiments on guinea-pigs with highly infected earth containing large quantities of tetanus bacilli and also of the bacillus aerogenes capsulatus have yielded, shortly, the following results. All control animals died in 30 to 36 hours as the result of infection with the latter bacillus, but those which lived longer as the result of various methods of treatment developed tetanic symptoms. Where the earth was mixed before inoculation with a powder of equal parts of salicylic acid and boric acid (called for shortness bor-sal) no illness resulted. The majority of the animals, in which 5 to 15 minutes after the infected earth was rubbed into the wound the latter was filled up with bor-sal powder, recovered; but where the bor-sal was made into a paste with gum tragacanth, the results were not good, possibly, for one reason, because the amount of bor-sal introduced was smaller. Where, after infection with the earth, the wound was in the first place filled up with bor-sal powder and half an hour later with cresol paste (20 per cent.) all the animals recovered and the wounds healed without suppuration. Where bor-sal powder was applied first and antitetanic serum was injected afterwards, all but one of the animals recovered. The committee recommend provisionally that the wounds should be thickly powdered with bor-sal powder, and that the 20 per cent. cresol paste should then be introduced into all the recesses of the wound as soon as possible after the infliction of the injury, and in cases where the wound is soiled with earth antitetanic serum should be given. Steps are being taken to distribute dredgers containing one ounce of bor-sal powder, and tubes with long nozzles containing half an ounce of 20 per cent. cresol paste, to all the ships in the navy, and in case of landing parties each man will be provided with these as well as with the first-aid dressings. The preliminary treatment can be carried out in a very short time and, except in abdominal and thoracic injuries, by anyone who has been instructed, and it is hoped that it may prevent serious infection during the interval which elapses before the wound can be more thoroughly disinfected. If a large number of wounded are received at one time, the orderlies could renew the powder and paste and bandage while the surgeons are attending to the most urgent cases. The more careful disinfection will consist in cleansing the wounds, removing foreign bodies, such as pieces of clothing or shell, which may be easily accessible, washing out the wounds with 1-20 carbolic lotion, thoroughly drying them, and then powdering them again with bor-sal, and putting in fresh cresol paste; in the case of large wounds a few interrupted stitches will prevent the antiseptic escaping too quickly. A wound so dressed may not require further dressing for a considerable time. These recommendations are, of course, only provisional, and may be varied as the result of experience or of the investigation of other antiseptics, but in the meantime the above suggestions seem worthy of a thorough trial. Those who are interested in the matter will find full details in the forthcoming number of our Service contemporary.





## DIRECTIONS FOR THE USE OF BOR-SAL POWDER AND CRESOL PASTE.

In the case of a wound at the front the first thing is, of course, to stay the bleeding as much as possible, and then to powder the whole surface thickly with the bor-sal powder. The cresol tube is then introduced into the wound and small quantities of the contents are squeezed into it in various directions, endeavouring as far as possible to leave small portions of the paste scattered over the whole area of the wound, not more than 1 in. apart. Some of the paste should also be smeared over the skin around the wound, and after a final dusting with the bor-sal powder the emergency dressing is applied. This can all be done quite quickly, and then the patient can wait till such time as the wound can be more thoroughly attended to.

*When the patient arrives at the advanced dressing station, the treatment depends on circumstances.*

(1) If a large number of wounded have to be attended to, patients who have been treated in the above manner can wait, unless a good many hours have elapsed since the injury. In that case the orderlies should inject a little more paste into the wounds and powder them and apply a fresh antiseptic dressing while the patient waits his turn. In the case of wounds which have not been treated, the orderlies should apply the powder and paste at once.

(2) If it is a large or complicated wound, *e.g.*, a compound fracture, it will be well in the first instance to clean and disinfect the skin, preferably with 1 in 20 carbolic lotion, then wash out the wound with peroxide of hydrogen and 1 in 20 carbolic lotion, remove pieces of clothing or accessible pieces of shell, clip away any badly soiled tags of tissue and arrest the bleeding. The wound being dried and held open it can now be powdered with bor-sal and some cresol paste left in various parts of the wound. If it is widely open it may be well to put a few interrupted sutures in to bring the edges somewhat together and prevent the escape of the antiseptic, and finally apply antiseptic dressings.

(3) If it is not a large wound, if the clot seems solid and if it has been well powdered and plenty of paste introduced into it in the first instance, it is quite possible that sepsis may not occur and if that seems likely all that need be done would be to squeeze a little fresh paste and dust some bor-sal powder over the surface and the skin around and apply a fresh antiseptic dressing.

These wounds will probably not require further dressing till they arrive at the base hospital.

*Subsequent Treatment at the Base.*—Should the wound be free from sepsis or inflammation on arrival at the base hospital it should not be opened up or syringed or otherwise interfered with. Some fresh paste, diluted if necessary, may be applied over the surface and the skin, and a fresh antiseptic dressing put on.

If, on the other hand, there are signs of sepsis the wound must be opened up and drained, and otherwise treated according to the experience of the surgeon.









