

**The Bradshaw Lecture on**

**The Treatment of Wounds**

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## THE TREATMENT OF WOUNDS

Mr. President and Gentlemen - In taking as the subject of the Bradshaw Lecture a critical examination of the present views and methods of treating wounds, I do not think that I need say anything by way of apology for my choice. It is one of the great advantages of lectures such as these that they afford an opportunity not only of introducing new views and observations but also of weighing the theories and practice current at various periods, and of considering how far they accord with definitely ascertained facts and how far we are following the right lines. In a subject such as medicine, where knowledge is still very imperfect, there is a constant oscillation in the views which are current from time to time, and a constant swing of the pendulum of medical opinion in one or other direction, sometimes very extreme and far beyond what is justified by the facts of the case. One has constantly to be on one's guard not to be carried too far by this swing – on the one hand not to discard too hastily the results of previous research and experience, and on the other not to overlook what seems to be sound in the new work. Nowhere is oscillation of opinion more marked at the present time than in the views founded on experimental and chemical pathology, and more especially in connection with the new science of bacteriology and the relation of bacteria to the living body. And when the wish was expressed to me that I should take up the subject of the treatment of wounds at the present time, I was the less reluctant to do so, seeing that as regards that matter we are just now in one of those extreme oscillations. Whether this swing has gone too far or not is the point which I purpose to consider in this lecture, and it will therefore be advisable in the first place to recall as simply as possible the essential points which relate to the treatment of wounds and to the avoidance of the infective disasters which are ever ready to occur when the attention of the surgeon is relaxed, and in the second place to examine the current views and details of practice with the object of seeing how far they meet the requirements of the case.

What first put Lister on the track of his epoch-making work was the consideration of the behaviour of a subcutaneous wound as compared with an open one, and his aim from the very first was to place an open wound as far as possible under the same conditions as a subcutaneous one. In the open wound two sets of noxious agencies come into play. In the first place, it is exposed to a variety of mechanical and chemical irritations from the dressings, air, &c., and in the second place to the entrance of infective agents. The surface of the wound, for instance, comes in contact with dressings and is mechanically irritated by movements, &c. And in the attempts to get a wound to heal it may also be irritated by various chemical substances intentionally applied to it, with the result that instead of healing rapidly the tissues are kept in a constant state of irritation, exudation goes on and cells accumulate in the part, the original tissue at the surface is destroyed, and its place is taken by granulation tissue. It is true that if irritation of this kind is but slight, healing will nevertheless take place readily, but if it be excessive it may be markedly delayed or actually prevented.

Even where an open wound is stitched up, and thus, as far as these mechanical and chemical causes of irritation are concerned, is converted into a subcutaneous one, very serious troubles much more grave than those alluded to above may arise, due to the entrance of various forms of bacteria into the wound and their growth either in the discharges present in it or in the tissues themselves. It is in reality to these organisms

rather than to the other agencies to which I have referred above that the essential troubles in connection with open wounds are due. Apart from the growth of bacteria, it would be quite easy to minimise the other sources of irritation so that little, if any, delay in healing should result, and in the absence of micro-organisms none of the serious troubles which affect the health or life of the patient or of the part, and which so often used to follow open wounds, would arise. These troubles are practically entirely due to bacterial infection, which occurs as soon as the skin is broken or so injured that it is deprived of its vitality, and the essence of the problem of the treatment of wounds is how to avoid such infection. It was this problem that Lister attacked, and though the main principle on which he proceeded from the first was to prevent as far as possible the entrance of bacteria into wounds, he laid much stress on the avoidance of undue irritation of the latter in the process. In fact, his ideal was so to alter the conditions in an external wound as to approach as closely as possible to those in a subcutaneous one. The question for review, then, is how far this ideal is, or can be, attained, and what are the best methods to adopt for this purpose.

- (1) In the first place, let us consider the question of the exclusion of bacteria from wounds. Lister began by trying to kill the bacteria before or when they came in contact with the wounds, and for this purpose he had recourse to the use of various chemical substances belonging to the class now known as antiseptics. In his earliest work, which had to do with compound fractures, the wounds being already soiled and infected, the method he adopted was to apply undiluted carbolic acid to the wound, with the view of destroying the organisms which had already entered it before the patient came under the notice of the surgeon, and then in order to prevent the access of fresh bacteria he made a paste with the blood contained in the wound and the undiluted carbolic acid, which must have effectually prevented the further entrance and growth of micro-organisms. This original plan was very soon modified, and the constant efforts which he made to improve his methods in the direction of less irritation of the wounds, with at the same time efficient exclusion of bacteria, will be found detailed in his collected papers.

When I became House Surgeon to Lord Lister in Edinburgh in 1876, it occurred to me to test the discharges of the wounds which were under his treatment to see how far the desired result – viz. the exclusion of bacteria – was really attained. At that time it was easy to examine this matter very thoroughly, because in the case of practically every operation a drainage-tube was inserted and was retained for from four to eight days, and as long as the tube was present the dressing was changed daily. At that time the modern methods of staining bacteria had not been introduced, and I had, therefore, to devise methods of cultivation in various fluid media. These methods need not be detailed here, but the results so obtained were very definite and entirely coincided with those obtained in after years by simpler and better methods of cultivation and also by suitable staining of the discharge. The results practically came to this – that, as a rule, in wounds treated by Lister's methods no organisms were found in material taken from the interior of the drainage tube during the first few days, but that afterwards one began to find micrococci in a certain proportion of the cases, especially if the dressing had been left unchanged for more than twenty-four hours, or if old epithelium had been allowed to accumulate under the dressing. Suppuration, however, did not necessarily occur, even when these organisms were present. I therefore assumed that they were innocuous organisms, either of a special kind or else

the common pyogenic organisms deprived of their infective power by the antiseptics employed. I also came to the conclusion that they spread into the wound under the carbolic gauze dressing by growing in the epithelium, for I found that they were present in the old epithelium at some distance from the edge of the wound in larger numbers and at an earlier period than in the wound itself. It was thus evident that bacteria either did not get into the wounds at the time of the operation, or if they entered they found themselves under such conditions that they were unable to grow, but that at a later period of the case they might spread in, presumably under the protection of the superficial layers of the epithelium, even though the part was covered by a carbolic gauze dressing. After the drainage of wounds was to a large extent given up, it was not so easy to test this matter thoroughly, because when the first dressing was changed, usually after a week, the wound had healed. If, however, for the purpose of investigation one dresses such wounds early, one obtains a negative result as regard the presence of bacteria in their interior. Further, where in cases where as the result of leaving too large a cavity or from some other cause serum accumulates in the wound, one may find on evacuating it even after a week or more that it does not contain organisms. As a practical fact, therefore, we may take it that organisms do not grow in wounds treated by strict Listerian precautions.

But can we say that living bacteria do not gain access to wounds at the time of operation and are not present there in a living state when the wound is closed? It is quite probable that in the earlier methods of treatment, such as the application of undiluted carbolic acid, the bacteria were all destroyed, and no living organisms were left in the wound. But that can hardly be the case in the later developments of the Listerian method, especially in the plan which is so much the fashion now – namely, the so-called aseptic method. No doubt the entrance of living organisms during the operation from external objects such as the skin, the instruments, the ligatures, &c., can be prevented, but their entrance from the air cannot. We know that air in a state of motion is full of dust, and if we expose plates covered with nutrient jelly to such air we find that various spots of growth appear on the surface, their number and the character of the organisms which composed them varying according to the length of time the plates are exposed, to the place where the exposure is made, and to the moisture of the atmosphere. Why, then, are these organisms not found in the discharge contained in the wound after twenty-four hours?

This raises a very wide question. If organisms do not, as a rule, grow in a wound when the only loophole for their entrance is the air, why is it that they so constantly grow in wounds when no antiseptic precautions have been taken, and where other loopholes have therefore been left open? This depends, in the first place, on the kind of organism which enters. If plates covered with nutrient jelly are exposed in an ordinary dry atmosphere, the great majority of organisms which develop are moulds or various kinds of bacilli. As a matter of fact, the chief living contents of the dust of the air are spore-bearing organisms, for non-spore-bearing organisms, such as the micrococci, cannot withstand drying and soon lose their vitality when deprived of moisture. We may therefore assume that the fungi and bacilli which are ordinarily present in the atmospheric dust are unable to grow in the living tissues of man; in other words, are not pathogenic in man, at any rate under the conditions present in a wound treated by strict Listerian methods.

The chief habitat of the pyogenic cocci so far as infection of wounds is concerned is the skin of the patient, or the operator, or discharges from wounds which may be present in the neighbourhood of the seat of operation. Where, therefore, the skin of the patient and the hands of the operator are thoroughly disinfected, and where precautions are taken which prevent further contamination, the probabilities are that there are many wounds into which no pyogenic cocci have entered and where the only organisms which fall in are non-pathogenic to man. Nevertheless one does find cocci closely related to the pyogenic ones and sometimes actually belonging to that class in atmospheric dust, especially where the air is moist, and in a prolonged operation it is highly probable that organisms of that class also fall into the wounds and yet they do not grow. Hence, we must consider the other possibilities.

Early in the development of bacteriology it was shown that pathogenic power was a property which varied very markedly and which could be impaired by a variety of comparatively slight causes; among others, the use of various antiseptic substances in a dilution short of that required to kill micro-organisms was found to diminish their pathogenic activity. For example, among the various ways in which the virulence of the anthrax bacillus can be diminished or “attenuated”, as the French expression is, one is the action of weak solutions of carbolic acid on the organisms for varying periods of time. Hence, when, as already stated, I found micrococci in the discharges from wounds which were following an aseptic course, in the old days of carbolic gauze and the freer use of carbolic lotions, I thought that the explanation might be that the virulence of the organisms had been diminished by the action of the carbolic acid., and the same may have been the case with cocci coming from the air in the old days of the carbolic spray. This, however, though a plausible explanation, did not seem to me on more careful consideration to be altogether sufficient to explain the facts. On thinking further over these matters it occurred to me to inquire whether the number of bacteria which entered the body at any one time was of importance and whether this might explain the improved results of those who had not fully adopted the Listerian treatment but who, nevertheless, tried to be as cleanly as possible – that is to say, who introduced as few bacteria as possible into their wounds. The fact already demonstrated by Lister that, in order to produce putrefaction in blood clot in glass vessels, it was necessary to add a definite, though small, quantity of putrid material, and the statement that good results were obtained by simply washing the hands and skin with soap and water, in operations on the peritoneum especially, seemed to make it worth while to try a few experiments on the subject. The result showed that the number of bacteria which initiate the disease is in certain cases of paramount importance, and this now become one of the fundamental bacteriological facts. In only very few cases was a single bacterium able to start disease; in most instances several were necessary, while in some large numbers were required. Thus in the case of anthrax and mouse septicæmia one bacterium was apparently sufficient to start the disease in guinea-pigs and mice respectively, while in the case of rabbits several anthrax bacilli were required. In the case of tetanus no result followed the introduction of less than 1,000 bacilli into rabbits. With somewhat larger doses a local titanic spasm of the limb inoculated occurred from which the animal recovered, while larger numbers caused death, till 40,000 and over killed the animals in two days. In the case of pyogenic cocci in rabbits the numbers required to produce disease were very much larger, something like 100 to 300 million being required to produce an abscess, and 1,000 million to cause death. The results, of course, vary with the species of animal tested; in other words, with the susceptibility of the animal to a particular organism.

Among other conclusions arrived at the following may be mentioned as bearing on our subject: (1) The pathogenic dose of a virus varies inversely with the predisposition of the animal to the disease in question; and (2) in animals not very susceptible to a disease, the severity of the affection varies directly within certain limits with the amount of the virus introduced in the first instance. The same facts apply according to the virulence of the organism. Where the organism is in a high state of virulence a smaller number will be required to produce the effect in a suitable animal than where the virulence is what we may term normal; and conversely, if the virulence is diminished a large number of organisms will be necessary. As regards the pyogenic organisms in man, I came to the conclusion that man was not a particularly susceptible object for the growth of these organisms, and that, therefore, a considerable number were required to produce a pathogenic effect.

Thus we have three reasons why wounds treated on Listerian principles are found to be free from organisms, even although it is certain that organisms of some kind or other do enter during the operation: (1) No pathogenic organisms are admitted at the time of the operation; this is probably so in most instances. (2) If pathogenic organisms do enter they may be so few in number that they cannot obtain a footing. (3) The pathogenic organisms which enter may have such slight virulence, either naturally, or acquired as the result of the action of the antiseptics with which they come in contact, that they cannot overcome the resisting power of the body. As a matter of fact, the organisms which usually enter during a carefully performed Listerian operation are either non-pathogenic bacilli or the ordinary micrococcus epidermis, which has only very slight, if any, pathogenic power.

(2) Let us now refer in the second place to the effect on the tissues of the methods employed to prevent bacteric infection. In the treatment of wounds we must not concentrate our whole attention on the exclusion of bacteria. We must also avoid irritation of the tissues exposed in the wound as far as possible. I have already referred to this matter and to the results which may follow as regards the healing of wounds from too great irritation. The question here is how far the measures necessary to prevent bacteric infection do or need interfere with healing. In the earlier development of the treatment no doubt wounds were considerably irritated by the antiseptics employed, and though that did not go so far as to interfere seriously with healing it led to excessive effusion of serum and necessitated the constant use of drainage-tubes, and, therefore, frequent changes of dressings. Since, however, the carbolic spray has been given up, drainage-tubes have been found to be unnecessary unless in exceptional cases. As a matter of fact, as we have managed matters of late years, no carbolic acid comes in contact with the wounds, and the few drops of sublimate solution which may get in on the fingers, &c., are at once precipitated by the blood and rendered inert.

Apart from interference with healing, excessive irritation of a wound has another bad effect, in that it diminishes the resisting power of the tissues, and thereby may enable organisms to take root which otherwise would have been unable to do so. At first sight, in accordance with recent views on the importance of the serum in connection with resisting power, one might think that an increased flow of serum as a result of the irritation of the wound would be a good thing, but in my opinion the important seat of the resisting power of the body is in the tissues. In the Wightman lecture delivered last May I discussed the defensive arrangements of the body, and showed

that they resided in the main in the tissues, and that an extremely important point in connection with the subject was the local differences in the resisting power. I instanced, for example, the different behaviour of the tubercle bacillus in the various bones and joints of the body, and similar differences exist in the case of the pyogenic organisms, according to the part of the body into which they are introduced. Thus we know that if pyogenic organisms enter joints, or bursæ, or lymph spaces they produce much more violent effects than if they are introduced into the peritoneal cavity or into the subcutaneous areolar tissue.

That the living tissues have the power in some way or other of disposing of bacteria was quite early recognised by Lister. He frequently referred to this point in his lectures, and showed specimens of urine free from growth which had been obtained simply by cleansing the orifice of the urethra and then passing the urine into sterilised flasks with precautions against the entrance of dust, thus proving that bacteria could not spread along a healthy urethra. He also pointed out the influence of the tissues in preventing the growth of bacteria, as exemplified by the results of operations performed in situations where bacteria cannot be excluded. For example, in operations for hare-lip and cleft palate union by first intention is the rule, provided the tissues are not handled roughly, even though the wounds are bathed with saliva containing large numbers of bacteria.

Now when we have said above that non-pathogenic bacilli or only slightly virulent cocci, or only cocci in small numbers may get into wounds under Listerian precautions, but under these conditions cannot grow, this failure to grow must clearly be due to the action of the living tissues, for under any of these circumstances growth would occur if the tissues were dead; while the tissues are alive, therefore, they have the power of opposing the growth of bacteria and actually destroy them under favourable conditions.

This action of the tissues in destroying bacteria can be seriously interfered with in various ways in the course of an operation, such as by severe handling and bruising, by the excessive use of antiseptics, or even by washing the wound with plain water, which causes the cells to swell up and lose their vitality, and which is about the worst thing that one can introduce into a wound from this point of view. If under any of these circumstances scrupulous care be not taken to prevent the entrance of pathogenic bacteria into a wound, and if they do enter in any considerable numbers, they can grow more readily and produce more violent effects than in wounds which have been more carefully treated. The experience of years, however, shows that the minute traces of antiseptics which may get into wounds during a properly-performed Listerian operation have no appreciable effect in retarding the healing of the wound or in interfering with the resisting power of the tissues.

As a result of the foregoing considerations we see that there are two great points to be kept in mind in treating wounds – namely (1) the exclusion of bacteria, especially of pathogenic organisms, as far as possible during and after an operation; and (2) avoidance of irritation of the surface of the wound so as not to interfere with healing; nor with the power of the tissues in preventing the growth of any bacteria which may have entered. These are the two essential principles which Lister laid down, and which his immediate pupils have tried to follow. It is interesting, indeed, to see how Lister, beginning by making the exclusion of bacteria from wounds his main aim, and

having apparently attained this object, devoted increased attention to the avoidance of irritation of the wounds by the means employed to keep out the bacteria. In fact, in the later period of his work his main efforts were directed to the search, not for more efficient antiseptics, but for equally efficient antiseptics, which would be as little irritating as possible to the wound. It is always the tendency, however, of pupils to out-Herod their masters, and thus many of those who took up Listerian treatment went to the extreme of deluging their wounds with carbolic acid and disregarded Lister's second postulate; they thus became well acquainted with the poisonous and irregular action of the antiseptics employed, while at the same time they did not always succeed in avoiding infection. Indeed many, thinking that everything necessary was done if only carbolic acid were employed, forgot the most elementary precautions especially the cleansing of the hands and the avoidance of reinfection of the hands during the operation, and the result was that sepsis occurred and was often, indeed, more severe than if no antiseptic had been employed, owing to the diminution of the resisting power of the tissues as the result of the irritation of the antiseptic. Curiously enough, many men at the present day who have not been intimately acquainted with Lister's own work think that that was Lister's treatment, and that there is, therefore, some fundamental antagonism between the Listerian principles and the so-called aseptic treatment of the present day. From this extreme travesty of Listerian treatment the pendulum has swung completely round to the other extreme, and the surgeon's efforts have of late been largely directed to avoiding the contact of antiseptic chemical agents with wounds and to injuring the tissues in that way as little as possible. In fact, in the hands of the extremists this point has been carried as far beyond the mean as the abuse of antiseptics was in former days.

As far as I can judge, what led to this swing of the pendulum was, firstly, the excessive use of antiseptics with unsatisfactory results of which I have just spoken; secondly, the constant statements as to satisfactory results obtained by ordinary cleanliness; thirdly, the slow action of antiseptics in destroying spores and their consequent inefficiency under certain conditions; fourthly, various statements as to the difficulty of disinfecting the skin – that is to say, of entirely eradicating the bacteria – which have led many to look on it as a hopeless task; and, fifthly, an exaggerated belief in the resisting power of the body.

The first of these points I have just referred to. As regards the second, the opposition to the strict Listerian treatment arose in the first instance and chiefly from surgeons whose operative work dealt essentially with the peritoneal cavity. When, however, these surgeons had to operate on the tissues in other parts of the body they encountered a discouraging amount of suppuration. This is explained by the difference in resisting power in different tissues; evidently the peritoneum has a special power of dealing with bacteria when they are not present in too great numbers or in too virulent a condition.

As to the third point, doubt has arisen as to the efficacy of chemical antiseptics in destroying bacteria, and this is probably a reaction from the idea that antiseptics are instantaneous in their action, which was, of course, the only justification of the use of the spray. Koch was the first to test this matter definitely, and the chief point brought out by his researches was the great difference in the resisting power of actively-growing bacteria on the one hand and of spores on the other. In the case of the former, if the antiseptic solution can obtain free access to the organisms, it is only a matter of

seconds, or at most of a very few minutes, before they are completely destroyed, provided the solution is sufficiently strong. In the case of spores, on the other hand, the time is much longer, but in any case 1 in 20 carbolic lotion kills them in twenty-four hours. Where bacteria are surrounded by albuminous material the antiseptic coagulates the albumin, and this coagulum may prevent the penetration of the antiseptics, especially of the mercurial preparations, and thus protect the bacteria in the interior for a long time, Carbolic acid, however, can penetrate this coagulum and even under these circumstances will, as a rule, lead to complete destruction of the bacteria and their spores in twenty-four hours. It is well to recall these facts, for the extremists seem to forget that antiseptics can do what is asked of them and that heat is not the only way of destroying bacteria. It is not really necessary to try to devise elaborate methods of sterilizing materials such as catgut by heat, or to discard the use of valuable articles such as marine sponges, because they are spoilt by boiling. Immersion in suitable antiseptic solutions for the appropriate length of time will be thoroughly effectual in these cases.

As regards the fourth point, I believe that the extreme aseptic views have sprung up to a large extent from the statement that it is practically impossible to disinfect the skin. I confess that these statements puzzle me very much, bearing in mind the uniformly aseptic results which we have for years obtained without the use of gloves – results which have not and cannot be improved upon. In the absence of organisms from our wounds, and the aseptic course they pursue, it is difficult to believe that the skin has not been thoroughly disinfected. Some time ago I went over all the various points in the technique to see how far we were working under bacteria-free conditions, and the ordinary methods of disinfection of the skin seemed quite satisfactory, except in a few situations such as the axilla and the perineum. My plan was to disinfect the skin with antiseptics in the ordinary way, and then to flush the part carefully with sterilized water so as to remove the antiseptic; then to scrape the skin so as to obtain the epithelium and to implant that into tubes of suitable material. The conclusion I arrived at was that there was no difficulty in disinfecting the skin except in the situations I have mentioned. In the case of children, and in parts of the body where the skin was thin, the disinfection seemed to be thorough and rapid. I was, therefore, at first very much surprised at the statements as to the difficulty of disinfecting the skin. These statements rest on a different method of testing the matter than that which I adopted – namely, a piece of the whole thickness of the skin is taken instead of a mere scraping of the surface, and it is assumed that the organisms lie in the deeper layers of the epithelium and in the sweat and sebaceous glands, and thus escape the action of the antiseptics. It is very difficult, however, to believe that organisms inhabit the sebaceous and sweat ducts and glands without causing trouble; besides we must also assume that these canals differ from others, such as the healthy urethra, along which organisms seem unable to penetrate for any distance. It may also be pointed out that this method of testing the matter is more open to the risk of contamination than that of taking the epithelium alone, and also that much depends on the methods of disinfection employed. I believe it is essential to employ carbolic acid for the disinfection of the skin. It mixes with the fatty material and penetrates through the epithelium in a way that no other antiseptic does. Mercurial solutions are very inefficient as they do not mix with fatty material, and thus do not penetrate the epidermis. Even after washing the skin thoroughly with etherial soap the mercurial solution collects in drops like water on a duck's back, while carbolic lotion wets the skin uniformly. In many of the experiments mercurial preparations have apparently

been the antiseptic employed. In any case, however, I would maintain that my method of experimentation is the better test and more in accordance with the practical technique.

Fifthly, these views as to the inefficiency and harmful action of antiseptics have coincided with an increased belief in the resisting power of the tissues to bacteric invasion, and in the minds of some it has seemed of even greater importance to try to keep up or to increase the resisting power of the tissues than to destroy the bacteria. The importance of this point was early realized by Lister and has not been lost sight of, and there is no doubt that every care must be taken to interfere as little as possible with these protective agencies. It is, however, really a question of relative importance, and I believe that where we have to do with an operation through unbroken skin the most important part is to prevent the entrance of bacteria. Experience amply shows that this can be done as far as is necessary without materially damaging the resisting power of the part. On the other hand, where the operation is performed in regions such as the mouth, where bacteria are present and cannot be excluded, while fresh contamination should of course be avoided, the chief reliance must be placed on the resisting power of the tissues, and everything which may, to any extent, diminish that must be avoided. At the present time the subject of resisting power is still in the stage of development, and in any case ample clinical experience has shown us that we must not place too great reliance on this factor.

Let us now see how far the methods of wound treatment at present adopted meet the requirements of the case. Of late, many surgeons have gone to extremes in the avoidance of antiseptic solutions and speak of the plan they use as "aseptic surgery". This term "aseptic surgery" is in my opinion not a good one. It is looked on by some as implying a different principle to the Listerian one, but, of course, that is not the case. It is only carrying to an extreme the principle of avoiding irritation of wounds and giving Lister's second postulate a position of undue prominence. It is fortunately only a few surgeons who misread the facts to such an extent as to give up any attempt at excluding bacteria and depend upon what is popularly known as cleanliness. These use water boiled or unboiled, sometimes not even adding chloride of sodium to it, and are thus under the happy delusion that they are using materials which will not interfere with the normal resisting mechanism of the body. But so far as that mechanism depends on the integrity of leucocytes and other cells in the wound they might as well, or even better, use antiseptics; for one has only to watch the behaviour of these cells under the microscope on the addition of plain water, to see how rapidly they swell up and become completely disintegrated. I used the term "aseptic surgery" many years ago to indicate Listerism, with the meaning that the wound was kept aseptic, as opposed to "antiseptic surgery", where attempts were made to eradicate sepsis from wounds already infected. At the present time "aseptic surgery" is used to indicate the character of the materials used rather than the result of the procedure. I confess I do not like this use of the term and prefer my own. By all means speak of "aseptic dressings", but in speaking of "aseptic surgery", we ought, I venture to assert, to refer to the results of the method rather than to the materials employed. Even the term "aseptic treatment" is not quite accurate if it implies treatment without antiseptics, for the disinfection of the skin cannot be carried out without antiseptics. As a matter of fact, however, it is only in certain details that differences exist between those who still adhere to the full Listerian views and those who go to extremes in the avoidance of chemical antiseptics. For my own part, I still adhere to the moderate

party – if I may so term it – and consider that antiseptics should not be discarded altogether, but that their judicious use is advisable and important.

Three things have to be borne in mind in connection with an operation. In the first place we have to see that the skin of the operator and the patient is as thoroughly disinfected as possible, and that no instrument or other article which comes in contact with a wound is soiled with living bacteria; in the second place, we have to avoid accidental infection of the wound during the operation; and in the third place, we have to avoid infection of the wound subsequent to the operation.

As regards the *first point*, we have to consider the disinfection of the chief things which must of necessity come in contact with the wound; and more especially the disinfection of the skin of the patient in the region of the operation and of the surgeon's hands and arms; for the chief source of contamination of wounds with pyogenic organisms is no doubt the skin of the patient and of the operator. I do not think that there is any real divergence of views as to the necessity for this procedure, and there is general agreement that this can only be satisfactorily carried out by the use of antiseptics. No doubt there are considerable differences in the methods of disinfecting the skin, but I need not go into them. It is true, also, that a few surgeons are content with rinsing the skin of the patient and of their own hands in boiled water, but I fancy that most will agree that this does not meet the requirements of the case.

In addition to the disinfection of the skin, a good many surgeons take the precaution of wearing gloves in case the disinfection of the hands has been imperfect; indeed, some apparently wear gloves without disinfecting the hands, looking on the sterilized gloves as a complete safeguard. Rubber gloves no doubt may be depended on so long as they are free from holes, but as they are very liable to be punctured or torn, it is somewhat rash to trust to them entirely, and therefore I think that whether gloves are to be worn or not, the hands should be as thoroughly disinfected as possible. In fact, in putting on rubber gloves I always fill them with 1 in 2,000 sublimate solution, and in this way a little of the solution remains in contact with the skin of the hands and continues to disinfect them – a point of some importance should the gloves give way during the course of the operation. As regards this question of wearing gloves I have previously said that the results at the present time are no better than they were by the Listerian method before these extreme precautions were introduced, in fact, could not be better, and therefore gloves are not at all a necessity for those who do not discard the use of antiseptics. But, nevertheless, considering all the possibilities, both of imperfect disinfection of the skin and of possible contamination of the hands during operation, I regard the use of indiarubber gloves as a valuable addition to the precautions, and in the so-called aseptic method they are a necessity. They add security against carelessness in the disinfection of the hands. Besides, apart from carelessness, some surgeons' hands are more susceptible than others to the action of antiseptics, and those who are so afflicted are consequently apt to be perfunctory in their antiseptic ablutions, and even where the surgeon does take pains to disinfect his hands the skin under these circumstances becomes rough and is difficult to cleanse thoroughly. Further, if there is any suspicion of having contaminated his gloves during the operation, the surgeon need have no hesitation in thoroughly washing in an antiseptic solution, as he might if he were not wearing gloves and his hands were sensitive. Cotton gloves are, I think, a mistake; used alone they do not protect the wound from the hands, and used over rubber gloves they prevent the surgeon washing

the gloves clean in case they have become contaminated. The only advantage is that they give a better grip.

Formerly instruments were disinfected in 1 in 20 carbolic lotion; now they are universally boiled, and although in most cases the former method is quite effectual, boiling is, I think, much more satisfactory, especially in the case of toothed instruments, such as Spencer Wells' forceps, &c. At the same time, boiling in ordinary water tends to blunt sharp instruments, such as knives, scissors, and needles, and in the case of those three I prefer to immerse them for a short time in undiluted carbolic acid, and then in 1 in 20 carbolic solution in place of boiling them.

With regard to disinfection by boiling, it must be remembered that boiling water is not instantaneous in its action any more than carbolic acid is. One frequently finds that nurses have the most profound belief in the rapid action of boiling as a disinfectant. An instrument falls on the floor, the nurse picks it up and says that she will sterilize it in a minute, and this is no mere figure of speech; she is actually back in a minute with the instrument, all that she has done being either to dip it into boiling water or throw it into the sterilizer and pick it out almost immediately. This, of course, is much too rapid for disinfection, and, indeed, the length of time required for properly disinfecting an instrument by boiling raises a difficulty in cases where it has not been put out beforehand, and where it was wanted in a hurry during an operation. In that case I believe the quickest and safest plan is to immerse it in undiluted carbolic acid for a minute or two, and then to place it in 1 in 20 carbolic lotion till it is required.

Among other things which come in contact with a wound during an operation, and which may convey infection to it, I may specially mention sponges. I think it will be generally admitted that for the purpose of removing blood from wounds marine sponges are superior to swabs, and yet the great majority of surgeons have given up their use. That is, I believe, in the main due to the conviction, which seems to have become deeply rooted, that heat is the only dependable method of disinfection, and marine sponges are ruined by heat; and also to the terror which some people have of antiseptic solutions. Five per cent. carbolic solution will destroy bacteria and their spores in twenty-four hours, even in an albuminous fluid; if marine sponges are kept in this lotion for a week they may certainly be depended upon to be completely disinfected. This is not a matter of theory but of experiment. For my part I always use marine sponges. They are thoroughly washed and immersed in 1 in 20 carbolic acid for at least a week before use. It is quite easy to wash out the carbolic acid from the sponges subsequently, either in a weak sublimate solution or in sterilized salt solution. I have never seen any reason to reject marine sponges, either from the point of view of asepsis, or from that of irritation by antiseptics, and as a method of drying a wound there is no comparison between them and swabs. Apart from the greater usefulness of marine sponges, I object to swabs in aseptic cases, because, as they do not absorb fluid readily, there is more rubbing and consequent disturbance of the surface of the wound when swabs are employed, especially if they are used dry; and further, except in specially-made swabs, threads are apt to be left behind in the wound, which may form a nidus for the development of bacteria, if any have entered during the operation. The importance of the latter point is by no means inconsiderable. For example, we find in the early experiments on tetanus that infection could not be brought about at all readily unless the bacilli were attached to some inert substance such as silk thread. If injected subcutaneously in small numbers

in suspension in fluid, no effect was produced, while silk threads soaked in a suspension of bacteria and placed beneath the skin led to the desired result. I venture to think that the way in which marine sponges have been thrown aside, and swabs, whether wet or dry, have been substituted, is regrettable and introduces an unnecessary complication into the operation.

We may say, therefore, that as regards the preliminary disinfection, heat, especially in the form of boiling, is the most certain and best method of sterilization, but we cannot do without chemical antiseptics for the disinfection of the skin, and of various articles such as marine sponges, which are of great use during the operation.

The *second point* – and it is one of the greatest importance – is to avoid soiling of instruments, hands, and consequently of the wound itself during the course of the operation. No doubt bacteria are constantly falling into the wound from the air during the operation, but it is well to diminish the number that may get in as much as possible, while it is important not to introduce masses of organisms, especially of pathogenic ones, as may be done if the hands of the operator touch surrounding objects which are not free from bacteria, and are then put into the wound, or in many other ways which an observant surgeon will notice, but which are too numerous to mention. We must, therefore, so arrange matters that in the course of the operation there shall be as little chance as possible of accidental introduction of masses of bacteria into the wound, whether by the surgeon's hands or instruments, or in any other way.

The first thing that is done in order to diminish this risk is to surround the area of operation widely by aseptic cloths. About this point there seems to be no question in any of the plans adopted; the usual method is to cover the blankets, skin, &c., over a wide area in the vicinity with towels which have been sterilized by steam. Personally, I prefer to sterilize the towels by boiling them. I think it is a much more certain way of carrying out the disinfection, especially when we see the small sterilizing machines which are on the market at the present time, and which are so much used, and realize that they cannot sterilize materials placed in them, especially when the latter are packed at all tightly. From the point of view, then, of complete sterilization, I much prefer to boil the towels; the only advantage of the dry towels is the question of keeping the patient dry, but as in any case mackintoshes are first applied over the surrounding area, the moisture of the towels need not penetrate to the patient.

Another objection which I have to *dry* sterilized towels is that dust is constantly falling on them during the course of an operation, and if the operation is a prolonged one a comparatively thick layer of dust may, in course of time collect on the surface, and may be transported into the wound by instruments which have been laid on the towels or by the finger of the operator. For this reason, after boiling the towels, I have them immersed in an antiseptic solution, usually 1 in 2,000 corrosive sublimate, and the sublimate is not wrung out to any extent before spreading out the towels. The result is that any dust which falls on these towels comes in contact with an antiseptic solution, and as regards non-spore-bearing organisms such as the cocci, which are the chief enemies to be guarded against, disinfection will probably occur very rapidly; while even in the case of spore-bearing organisms, it is quite possible that the spores may have their growth, at the very least inhibited by the action of the antiseptic, so that the tissues may be able to dispose of them before they begin to grow. In the same

way instruments laid down on the towels remain in contact with an antiseptic, and are not so likely to become contaminated as if laid on dry cloths. For the same reason I prefer, instead of using dry sterilized linen overalls, to use a mackintosh apron, and to have fastened in front of it a piece of towelling which has been boiled and wrung out of 1 in 2,000 sublimate solution. The insignificant amount of antiseptic which might get into the wound from these sources during the course of an operation could not possibly have the slightest effect; it would at once mingle with the blood and be precipitated, and thereby rendered inert.

As regards the instruments, after being boiled they are very often placed in salt solution and left there during the course of the operation; in other cases they are kept in alcohol. As regards salt solution, the same thing applies, as I have already pointed out, with regard to dry towels. In the course of time, and not a very long time either, the surface of the salt solution becomes covered with floating dust, and an instrument taken out of it will carry with it a considerable amount of dust, which dust retains its vitality. At the same time as the operator picks out instruments he gets dust on his fingers, and while – as I have repeatedly pointed out – this dust is in the great majority of cases innocuous, it may not be so, and it introduces a possible loophole for infection. Hence, just as I have the towels moistened with an antiseptic solution, so I prefer to keep the instruments in an antiseptic solution till they are required for use, that which I use being 1 in 20 or 1 in 40 carbolic solution, which does not injure the metal. In that case the dust falling into the lotion becomes speedily acted upon, and all dangerous organisms are rendered inert. I much prefer the carbolic solution to alcohol, which is not an active antiseptic, and it is just as easy to rinse the antiseptic off the instruments after their removal from the lotion as it is to rinse the alcohol from them.

In a third point I would differ from the extremists, in that instead of having only salt solution at hand during an operation, I have an antiseptic solution as well, such as 1 in 2,000 sublimate solution, so that the fingers and instruments can be rinsed in it from time to time, and thus any accidental contamination got rid of. It always strikes me as if a surgeon voluntarily deprived himself of a very valuable aid to asepsis, when he deliberately avoids having antiseptic solutions at hand during the course of an operation. I do not want the antiseptic solutions for the purpose of deluging the wound with them, but I do want them at hand to rinse my fingers in from time to time, to rinse away the blood from the instruments, and so forth; and for this purpose I always keep at my side a basin containing 1 in 2,000 sublimate solution. As I have already said, the minute amount of antiseptic which will gain entrance to the wound as the result of these precautions is of no practical importance whatever, nor has it any injurious effect. In the case of operations on the peritoneum, joints, &c., I employ only saline solutions as soon as the peritoneum is opened, and I have it frequently changed so as to avoid the accumulation of dust on it; and when I wish to cleanse my hands I wash them first in the sublimate and then in the saline solution. I have repeatedly seen, in watching operations under so-called aseptic conditions, accidental infection of the hands and instruments of the surgeon occur without there being any possibility of removing that contamination owing to the absence of antiseptic solutions. I would point this out strongly as a loophole in the work of the extremists which is an unnecessary one and may lead to trouble.

Another point which has been the source of very considerable trouble to those who avoid the use of antiseptics has been the question of disinfecting ligatures, sutures,

&c. As silk and material of that kind are easily enough disinfected by boiling, the troubles which have arisen in connection with deep sutures must, in my opinion, be explained by infection of the material during the course of the operation. This, as I have tried to point out, may quite readily occur where the use of antiseptic solutions is barred. Apparently, the greatest difficulty has arisen in connection with catgut, and to some the difficulty has seemed so great that they have practically abandoned the use of this material. This, I think, is a great pity. Personally, I do not have any trouble with catgut, and I always use Lister's sulphochromic gut. As it comes from the instrument maker it is, of course, covered with bacteria. I do not think, however, that bacteria are present, at any rate in any numbers, in the substance of the catgut, because in the process of preparation, the bacteria there must have been pretty thoroughly killed, but there is no doubt that on the surface there are a great many organisms. To those who believe only in boiling, or who are afraid of any antiseptic getting into the wound, the disinfection of the catgut presents the greatest difficulty, because boiling in water spoils catgut, however it is prepared. Hence, methods of sterilization by boiling the catgut in various solutions have been introduced. It must be remembered, however, that Lister had in view other points besides the aseptic character of the material in his methods of preparing catgut, such as the strength of the knot, the length of time required for absorption, and so forth. Of late, these points in the preparation of catgut seem to have been lost sight of, and the main question which has been considered has been how to sterilize it. As a matter of fact, I have never found any difficulty in sterilizing catgut, nor have I seen any disadvantage from its use. I always keep the chromicised gut as obtained from the manufacturer in 1 in 20 carbolic solution for at least a week before using it; indeed, in order to make certain of its disinfection, I place it in the first instance for a few hours in undiluted carbolic acid, and then for at least a week in 1-20 carbolic solution. Before use, I place it in a weak sublimate solution so as to soak out the carbolic acid, and I have never seen any reason to attribute any irritation of the wound to the minute amount of antiseptic which may be carried in with the catgut. As a matter of fact, my belief is that with catgut, as with silk, the real trouble is due to reinfection of the material during the operation, and I think this is only another example of how the extremists handicap themselves by their fear of antiseptics.

Before going into the third question, there is one other point to which I wish to make reference – namely, the question of the drainage of wounds. Here, again, I think a retrograde step has been taken by many surgeons. There is no question that if one wishes to carry off fluid, especially if that fluid is thick, as in the case of pus, an open tube is much better than capillary attraction. The drainage of wounds by capillary means was worked at a good deal in the early Listerian days, and with the view of avoiding changing of dressings for the purpose of removing tubes, absorbable drainage-tubes were employed, and also bundles of catgut, and so on. The results were not particularly satisfactory, and these methods did not take root. At the present time, judging from what is written and what one sees, the use of tubes has been given up to a great extent in favour of drainage by strips of gauze, for what reason I cannot imagine. I think it is a matter of practically no importance in the case of aseptic wounds, for the serum will escape quite readily by capillary drainage, the chief trouble being that if much blood is poured out, the gauze drain is apt to be imperfect as compared with the tube. But where I think the use of capillary drainage is a disadvantage as compared with tubes, is in the treatment of abscesses. Apparently, the popular method of dealing with abscesses at the present time is either to pack them

with gauze, or at any rate to insert strips of gauze to act as drains, and certainly in the case of sinuses one constantly sees strips of gauze used instead of drainage tubes. Now there are two objections to this; in the first place, gauze will not drain pus properly, and the result is that accumulation is apt to take place behind the gauze plug, and it is quite a common thing to see, on pulling out a plug of gauze, that some pus runs out which has really been prevented from escaping by the gauze, which had acted as a plug instead of as a drain. The result is that one very often fails to obtain the beautiful result noted by Lister – namely, that if an acute abscess is opened and properly drained, and if fresh bacteria are prevented from entering from outside, there is no further pus formation. At the present time continued suppuration from an abscess seems to be looked on as a normal state of affairs till the abscess cavity closes. In sinuses I think gauze drains are especially bad, because not only do they cork the wound and prevent the escape of the discharge, but, becoming soaked with infective material, they act as irritants and are really nothing more or less than the old setons. I would, therefore, strongly beg for a reconsideration of this question of drainage, and for the resumption of drainage by tubes instead of gauze, certainly in all cases where sepsis is present. I have repeatedly seen cases of intractable sinuses where all that was required to obtain healing was to leave out the gauze plug and keep the orifice of the sinus open for a few days by means of a small drainage-tube.

Coming now to the *third point*, viz., the question of preventing infection of the wound after the operation is completed, I think that we have here the most important difference between the extremists and the Listerian school. Lister from the first pointed out that an essential part of the treatment was to prevent the possibility of infection of the wound after the completion of the operation. Now infection of the wound after the operation takes place by the growth of bacteria in the blood and serum after they escape from the wound, and in the dead epithelium on the surface of the skin, and their subsequent penetration into the wound along stitch tracks, drainage openings, &c. With the view of avoiding this growth, Lister arranged that the discharges from the wound should be received into dressings which contain an antiseptic in such amount that when dissolved by the discharge, it will render the latter an unsuitable soil for the growth of bacteria. As was pointed out in a paper read by Lister at the Medical Society of London some years ago, it is not necessary that the amount of antiseptic thus communicated to the discharge should be very great. All that is wanted is to add enough antiseptic to the discharge to inhibit the growth of bacteria, not to produce a solution strong enough to kill them; and by following that principle, it is not necessary to put on dressings containing antiseptics of a character, or in sufficient amount, to irritate the skin. It is true that some skins are more irritable than others, and that a rash may occur in some cases under a very mild antiseptic dressing, but with the antiseptics which are now used, this is of comparatively rare occurrence, and where necessary can be avoided by placing a layer of plain sterilized gauze next the skin beneath the antiseptic dressing. It may be noted that in any case the antiseptic in the dressing does not get into the wound; it is merely placed there with the object of preventing bacteria growing in the discharge and reaching the wound.

Nowadays, surgeons are using to a large extent dressings which have been heated, and which no doubt in many cases are really sterile, but which do not contain any antiseptic. In passing, I may remark that the sterility of these dressings is by no means certain in all cases, for one has only to look at the small machines which are often

used in private work, and the way in which dressings are tightly packed into them, to realize that no proper sterilization can have taken place. The action of such a dressing is merely that of a filter against the dust of the air, just like the plug of wool in a cultivation tube. The discharge soaks into the dressing, and till it comes near the surface of the dressing it may remain sterile. That, however, will only be the case if the skin has been really thoroughly sterilized and if no bacteria have fallen on the skin or the dressings before they are applied. But, in any case, as soon as the discharge reaches the surface of the dressing, bacteria will grow in it and rapidly spread through it and reach the wound, unless, indeed, the blood has in the meantime become so concentrated by drying that it is no longer a suitable cultivating medium.

When we reflect that an organism dividing three times an hour, which is a fair average, will give rise to something like 33,000,000 bacteria in twelve hours, one can have some idea how quickly the organisms may reach a wound once the discharge has come to the surface of a plain sterilized dressing. Although no doubt after twenty-four or forty-eight hours these bacteria can no longer penetrate into the wound and cause deep-seated trouble, they may quite well spread along the stitches and give rise to the stitch abscesses, which seem to be not at all uncommon in the practice of surgeons who use these dressings. These stitch abscesses have, in my opinion, been erroneously attributed to imperfect sterilization of the stitch material or to imperfect disinfection of the skin. I say erroneously, because, using antiseptic dressings, I have practically no experience of them, and the conclusion which follows from the fact is that it is from the want of antiseptic in the dressings and the consequent growth of bacteria rather than from the other causes mentioned that these stitch troubles arise. To carry out the purpose of this dressing a large mass must be put on, and not the small pieces that one so often sees used. If it fails in its object it does harm instead of good, for it interferes with the drying up of the discharge and, keeping it warm and moist, favours the development of bacteria in it. This plan was tested long ago by Lister, and was given up as being unsatisfactory.

If I were to go over to the extreme party and abandon the use of antiseptics – which I have no intention of doing – I should not apply any dressing to the wound at all. If the wound is left open and protected from direct contact with septic materials, the blood and serum which ooze out in the first instance will very soon dry up and form a scab which will prevent infection of the interior, and if I were dressing wounds in that way I should build up a mass of aseptic dressings on each side of the wound and then fix a thin layer of wool or gauze over the surface, but not touching the wound, so as to protect it from dust. Where wounds can be completely closed from end to end I think the great majority would do perfectly well if treated in this way, and probably better than if covered with plain sterilized dressings; but where drainage has to be provided, as is, of course the case in some operations, such as in some extensive breast operations in fat people, in drainage joints, &c., the problem is different, and there, I think that it is essential that the dressing should not only be sterilized by heat but should also contain some antiseptic if one wishes to be certain of the result.

To sum up the criticism which I have to make on the most recent ideas on the treatment of wounds, it is that the pendulum has swung too far in the direction of the avoidance of antiseptics, and that the reasonable use of all the means at our disposal for securing asepticity of wounds will furnish more constant results. The chief point to which I take exception is the employment of dressings which do not contain an

antiseptic in sufficient amount to render the discharges which flow through them unsuitable for the growth of bacteria; and a second point which I also think is very important is the absence of antiseptic solutions during the operation in which hands, instruments, &c., may be washed from time to time to insure a continued asepsis. A third point which, I think, is a retrograde step is the substitution of gauze plugs for drainage-tubes, more especially for the drainage of abscesses and sinuses. Minor points are the use of swabs instead of marine sponges, and the avoidance of catgut. This extreme view has, however, done good, especially in the way of directing attention to the value of heat as a disinfectant for various purposes in connection with operations. There is no doubt that the sterilization of instruments, towels, &c., by boiling, and of dressings by steam, adds very distinctly to the certainty of the results. It has also done good by calling attention to the importance of diminishing the amount of dust which may get into wounds at the time of the operation, although some of these precautions have been given an importance which they do not deserve.

It always seems to me – and I say this from a large experience in bacteriological work – that the attempt to treat wounds without any antiseptics is a very unnecessary complication. In the first place, it is a great deal more difficult to secure asepticity of a wound under such circumstances than if one takes advantage of antiseptics, and in the second place, it requires a man who is especially skilled and experienced in bacteriological work to bear in mind the various loopholes which have to be guarded against in order to obtain a constant aseptic result. I say that bacteriological experience is necessary because the surgeon has to concentrate his attention on the object of the operation rather than on the aseptic technique, and in order to carry out the object of the operation satisfactorily and at the same time without the risk of sepsis, the aseptic technique must be practically automatic. Therefore, if he has to be thinking all the time not only of the object of his operation, but of the various loopholes which may arise, and which he must most carefully avoid, seeing that he has no antiseptic materials at hand with which to rectify mistakes, one or other point must suffer – either his operation may not be carried out as he would desire it, or his aseptic technique is apt to be faulty. I confess that I can see no reason for this great dread of a drop of antiseptic material getting into the wound. I can only say that my own results, and those of surgeons who use antiseptics judiciously, are in every way as good as those obtained with the more elaborate aseptic precautions; in fact, seeing that we are not troubled with sepsis or stitch abscess at all, I venture to assert that they are better, because they are more constant and dependable.