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ASEPTIC THEORY AND ITS PRACTICE.

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By J. WILLIAM WHITE, M. D.,

*Demonstrator of Surgery; Assistant Surgeon in the University Hospital.*

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*presented by the author.*

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## THE ASEPTIC THEORY AND ITS PRACTICE.

A Lecture delivered to the Graduating Class of the University of Pennsylvania.

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BY J. WILLIAM WHITE, M. D.,  
*Demonstrator of Surgery ; Assistant Surgeon in the University Hospital.*

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THERE is perhaps no subject in the entire field of surgery with which it is of equal importance that you should be familiar in both principles and practice as the one about which I propose to speak to you to-day. The details of the various methods in vogue I shall teach you later ; but I consider it far more important that you should understand the elementary principles upon which these methods are based than that you should memorize special formulæ for

antiseptic solutions or dressings. I shall therefore limit myself to the very groundwork of the subject, using freely the admirable teachings of Lister, Cheyne, Volkmann, Esmarch, and others.

Aseptic surgery is directed against the causes of putrefaction in wounds and their discharges. Putrefaction is a form of fermentation accompanied by the development of offensive odors. Instances of fermentation are seen in the action on amygdalin of emulsin, the former being broken up into various products, chiefly hydrocyanic acid and oil of bitter almonds, the emulsin remaining unchanged, though its presence is necessary for the chemical action. Pepsin, ptyalin, and pancreatin act in the same way. They undergo little or no change and are known as the chemical ferments. It is not with this class of ferments that we have to deal to-day. There is another series which does not act suddenly in this manner but slowly and steadily, and which possesses the power of self-multiplication. This is seen in the alcoholic fermentation. A minute piece of yeast plant introduced into a sugary solution is multiplied and goes on acting until the sugar is decomposed with the formation of alcohol and carbonic acid. This form of putrefaction is a property of living things, and hence these ferments are called the vital ferments. In the putrefaction of discharges in wounds we have to deal with ferments of this class as we do likewise in the fermentation or "spoiling" of all animal fluids and tissues. The cause of this fermentation has been variously explained. It was thought for some time to be an inherent property of such fluids and tissues and later it was said to be due to the action of oxygen upon them. The first theory was exploded

when it was demonstrated experimentally that animal substances protected from atmospheric contamination could be preserved indefinitely; and the second was shown to be fallacious when it was proved that air could be admitted freely without harmful results provided it were first acted upon in certain ways. If we take, for example, a flask of beef tea or of urine, two of the most decomposable and putrescent animal fluids, and boil them so as to expel all air from the flask, and then allow that which re-enters as the flask cools to pass first through a layer of nitric, or sulphuric, or carbolic acid, or through a strong solution of corrosive sublimate, or even to filter through a plug of cotton wool introduced into the neck of the flask, we find that the oxygen of the air can come freely in contact with the fluids without interfering with their complete preservation. If the air which re-enters is simply made to pass slowly through a long curved tube, so that the dust which the atmosphere contains, and the larger particles of which may be seen dancing in every ray of sunlight, can have an opportunity to settle we also insure the thorough protection of the fluids from decomposition. These experiments not only disprove the theories which attributed putrefaction to the essential qualities of organic substances, or to the contact with oxygen, but at the same time demonstrate that the cause of putrefaction is not a gas of any sort but something particulate, heavier than air, and probably organic, as it is completely destroyed by heat and by substances, such as carbolic acid, which exert but little influence on inorganic bodies. With this idea firmly fixed in your minds regarding the behavior of animal fluids and tissues outside the body when protected from

contamination, let us see if we can find any examples taken from pathology which will illustrate the same process within the body. You all know the course of a simple fracture—that is, one in which there is no wound of the soft parts admitting the air to the seat of fracture—and you know that whatever may be the degree of local injury, such fractures as a rule when properly treated run a course which is unattended by fever, suppuration, or serious symptoms of any sort. You also know how much the gravity of such a case is increased when, although in every other respect precisely similar, there is in addition a wound of the soft parts leading to the broken bone. Fortunately at the present day you do not see such cases at their worst, as means are immediately taken to approximate their condition to that of simple fractures, but I shall presently give you a few facts to show you the enormous difference which in comparatively recent times was caused by that little break in the skin. You know the usual conduct of a portion of the general surface of the body, the blood supply of which has been cut off; the change of color, the softening, crepitation, development of offensive odors, sloughing and suppuration, which attend the process known as gangrene or mortification. Now if from embolism or thrombosis a similar cutting off of blood supply occurs in the case of an internal organ, while the affected region of necessity loses its vitality, it does not slough or putrefy in the majority of cases but atrophies, withers, and either undergoes absorption after retrograde metamorphosis or becomes encysted and remains innocuous.

You have seen cases of large collections of pus, in psoas or iliac abscesses

for example, sometimes containing many quarts, having taken months or years in their formation, which, when evacuated, were perfectly sweet and free from all unpleasant odor. Unless, however, the most absolute antiseptic precautions are observed during and after the operation, within forty-eight hours such an abscess which has remained odorless for months, will become stinking and offensive. You have seen extensive collections of blood—the so-called “depots” of blood—exuded as a result of contusion, or sometimes after an operation, remain without producing the slightest general symptom and disappear by absorption if they were absolutely subcutaneous, and you have seen similar collections associated with ulcerated or open wounds admitted to the hospital in a decomposing, putrefying condition. You have observed extensive operations, division of tendons, of muscles, and even of large bones done through minute incisions in the skin barely sufficient to admit the necessary instrument, and protected subsequently from exposure to atmospheric contamination and have seen them heal without the slightest symptom of local or constitutional disturbance. I might multiply such examples almost indefinitely; but I have, I think, sufficiently illustrated the principle that putrefaction, suppuration, and sloughing depend upon the entrance of the tissues of certain germs from without, and that the entire object of aseptic surgery is to prevent the access of these germs to wounds, or to destroy their activity and vitality in some way before they reach the wound. The problem as stated by Mr. Cheyne is as follows: On all objects in the external world septic dust is present—on the skin of the patient, on the hands of the surgeon, on instruments, in the

atmosphere. When a wound is made any introduction of this dust must be carefully avoided. Then after the wound is made great care must be taken to prevent its entrance during the subsequent treatment. Some sort of dressing must be provided which shall prevent its passage in an active state, and at every change of this dressing the problem is the same as at the time of the infliction of the wound.

Before considering the details of the plan by which this is to be accomplished, we must first investigate the relation which putrefaction has to the various diseases associated with wounds and which have caused such terrible mortality, chiefly pyæmia, septicæmia, and erysipelas. These are the great causes of death after operation, and are the maladies against which the whole armamentarium of aseptic surgery is directed. Fortunately, but only incidentally, suppuration, inflammation, and fever are also prevented by asepticism, but the most engrossing labors of modern surgery are directed to the prevention of these wound diseases. We have seen beyond a doubt, both experimentally and clinically, that putrefaction is a form of fermentation, and that fermentation is due to the growth of micro-organisms in organic fluids or tissues whether they are confined in a living body or are external to it; and we know that the particles which cause such putrefaction or other fermentation only rarely enter the tissues through the circulation but almost invariably reach them directly from the air or from surrounding objects. Now it is of no importance for our present purpose whether we do or do not believe in the germ theory of infective disease; whether, in other words, we do or do not believe in the theory that



pyæmia and septicæmia are due to the entrance into the blood of the same germs which produce putrefaction in the fluids and tissues, or to some products which arise during the process of putrefaction or to something else which is entirely distinct. The evidence in favor of the germ theory of putrefaction itself is simply overwhelming ; and to demonstrate its value to surgery it only remains for us to show distinct relations between putrefaction in wounds and the occurrence of pyæmia, septicæmia, erysipelas, and the lesser wound diseases which have been mentioned. Microscopical evidence has of late years rapidly accumulated in this direction, and the existence of certain forms of bacteria or micrococci can be demonstrated with almost absolute certainty in the discharges from all forms of infected or unhealthy wounds. The details of this evidence you will hear more especially from your teachers in pathology, but equally conclusive and much more striking proofs may be presented to you in the shape of the clinical results of some of the most renowned surgeons of the world.

A fair comparison of such results obtained in large numbers of cases is the most logical way of demonstrating the relation between pyæmia and septicæmia and the admission of micro-organisms to wounds. Certain factors are necessary for the production of blood poisoning in addition to the admission of bacteria, but the latter is the essential agent in causing the infection of the system and the above-mentioned diseases. By looking back a few years to the very beginning of the employment of antiseptic methods we can obtain striking evidence of the effect of treatment directed almost exclusively, though then very imperfectly, against the introduction of bacteria. The record of the work of

Professor Lister may well begin our series of examples: In Glasgow, in 1864, '65, '66, Mr. Lister's mortality in a series of operations of all sorts was 45.7 per cent., largely from septic diseases. About this time he began to employ, gradually, some antiseptic methods in his treatment of wounds and during operations. In 1867, '68, '69, his mortality fell to 15 per cent. At Edinburgh, having greatly improved, indeed almost perfected, the details of his system, we find that from 1871 to 1887 he treated 553 grave surgical cases with a mortality from septic disease of only .36 per cent., a diminution in the death-rate which, when we remember that these different results were obtained by the same man operating upon the same class of patients and for the same injuries or diseases, is so striking as to be in itself conclusive. In London, still later, an opportunity was afforded to compare Mr. Lister's results with those of a colleague, Mr. Spence, working in the same hospital, but declining to employ aseptic methods. The total results of their major operations showed that Mr. Spence lost just about three patients where Mr. Lister lost one, while the deaths from infective diseases were 2.4 per cent. among Spence's cases and  $\frac{1}{3}$  of 1 per cent., or 8 times less among those of Mr. Lister. When we turn to the work of other surgeons we find evidence, if possible, still more conclusive of the value of these methods. Nussbaum has shown that for forty years in his clinic under his own direction as well as that of his predecessors, among whom was Stromeyer, the deaths from wound diseases were so common that patients with even the slightest injuries often succumbed to them; that erysipelas and abscesses were matters of daily occurrence; that 80 per cent. of

all wounds and sores were attacked with hospital gangrene, and that nearly all patients with compound fractures died ; and he states that immediately upon the introduction of the antiseptic system all these diseases vanished, and healing by first intention, previously almost unheard of in his service, became the rule instead of the exception. Professor Volkmann, in an address before the International Medical Congress which met in London in 1881, testified so strongly and so clearly to the results obtained in his own practice that, although the subject has now passed beyond the controversial stage, I cannot refrain from quoting, as an interesting and important part of the record, certain statements of his which, in years past, when antiseptic surgery was still strongly opposed by even eminent surgeons in this country and elsewhere, I employed in an argumentative way. Professor Volkmann selected two examples especially : compound fractures and major amputations, as evidence of the value in his hands of the antiseptic method. He said that the mortality after compound fracture had, during the long labors of the surgeons who preceded him as well as during his own, reached the sad height of 40 per cent. When he adopted the antiseptic method of treating wounds his last twelve patients with compound fracture of the leg had all died of pyæmia or septicæmia. From that time up to the period at which he delivered this address he had treated one after another 135 compound fractures without losing a single patient from either of these wound diseases ; 133 were cured ; 2 died, one of fatty embolism of the lungs during the first few hours, and one, a drunkard, of delirium tremens. As to the amputations he asserted that he now cured each year with the antiseptic

method more cases of amputation of the thigh, for example, than during all the rest of his labors before the introduction of that method. In an article on the treatment of compound fractures, Professor Dennis, of New York, has compiled further evidence in this same direction. In the Pennsylvania Hospital between the years 1839 and 1851, there were treated 116 cases of compound fracture of the leg and thigh; excluding those cases requiring amputation there were 51 deaths, a mortality of 45 per cent. In the New York Hospital, during the same period, there were treated 126 cases of compound fracture of the leg and thigh; excluding amputations there were 61 deaths, a mortality of 48 per cent. From 1860 to 1876 there were reported from the surgical clinics of Vienna and Zurich by Billroth 180 cases of compound fractures; excluding amputations there was a mortality of 41 per cent. from septic disease. In the Obuchow Hospital Reports of St. Petersburg 106 cases of compound fracture gave a mortality of 68 per cent. In Guy's Hospital, from 1841 to 1861, there were reported 208 cases of compound fractures with 56 deaths, a mortality of 26 per cent. After the introduction of antiseptics this death-rate immediately fell to 4 per cent. from an average of from 40 to 50 per cent., and in this article of Dr. Dennis's in which he reports 516 cases of compound fractures there was no record of death from septic trouble in any fracture of the extremities, which was the class of injuries included in the above statements. I might easily multiply such evidence as this, but, as I have said, the subject has passed beyond the controversial stage, and I may therefore in this lecture omit much statistical matter which I have for years been in the habit of laying before the class. We

may consider it as proven that there is a definite and distinct relation between the entrance into wounds of bacteria whose vitality has not been destroyed by antiseptic measures and the occurrence of certain septic diseases. There are, however, other factors which enter into the problem and which, though of much less significance, should not be ignored in any presentation of the subject.

The general vitality of the patient is of considerable importance, as healthy living tissues have in themselves a great power of resistance to the growth and multiplication of micro-organisms. This preventive influence is well seen in wounds about the face, where, on account of the great vascularity of the region, healing occurs with exceptional rapidity, even if no aseptic precautions have been taken, provided that there has been accurate co-aptation of the cut surfaces. As this resistant influence of the body does not extend through thick layers of tissue, or of blood or lymph, it follows that in aiming to secure accurate and exact approximation of the surfaces of wounds we are simply observing a minor antiseptic precaution. So, too, in regard to drainage. A certain amount of moisture is necessary for the occurrence of putrefaction, the micro-organisms upon which it depends failing to live and multiply in wound discharges which are very scanty or very concentrated. We meet this indication by a careful arrangement of cat-gut or rubber, bone or glass drainage tubes, to withdraw all superfluous matter from wounds. Elevation of the affected part by diminishing the blood supply and lessening the blood pressure, together with firm uniform compression by bandages, are means to the same end. Bearing in

mind the importance of these auxiliary measures, attention to the general vitality, careful arrest of hemorrhage, removal of wound secretion by drainage, and accurate approximation of cut surfaces, etc., we may now consider the means by which we avoid the introduction of micro-organisms or render them harmless after they are introduced. Miquel has found that in the ordinary atmosphere of a large city there are two thousand bacteria to the cubic yard, the air of a room or an old house in winter showing forty-five thousand to the cubic yard, while the wards of a long-used hospital show ninety thousand germs in the same space; he has also called attention to the interesting fact that sea-air and that of mountain heights are nearly free from them, which would explain in itself the excellent results obtained in surgical cases operated upon in such localities. Of course, all these micro-organisms are not infectious, and Mr. Cheyne has shown that there are probably a few species which are chiefly active in producing septic diseases and suppuration; notably, staphylo-coccus pyogenes aureus and albus, the strepto-coccus of erysipelas, and various others with which we are at present less familiar. It is possible that there is a distinct germ for each form of infective disease, or that on the other hand the variations observed in these diseases are due to varying local and general conditions. They obtain entrance to wounds either by falling into them from the air or much more frequently through the medium of the hands and instruments of the surgeon and his assistants. They exist upon the skin, and upon the hypodermic scales of all persons, and are found in large numbers in dust and dirt of all kinds.

WHEN we consider the details of any antiseptic method we must begin with purification of the hands of all persons who will have to approach the wound as well as of the skin of the patient in the region of operation. Küm-mel, Koch, and others have repeatedly shown that ordinary methods of cleansing and disinfecting are imperfect and unreliable, especially washing with soap and water, which should be employed as a preparatory measure, but cannot be depended upon to produce either in hands or instruments a truly aseptic condition. Nor can the ordinary employment of carbolic or sublimate solutions be relied upon absolutely. Experimental microscopic researches made by the above named German investigators, have demonstrated that after washing the hands thoroughly in soap and water and then dipping them into one to one thousand sublimate solution, or one to twenty carbolic solutions, they still carried into sterilized gelatine nests of bacteria which would set up putrefactive changes. This was thought to be due to the presence of oily matters upon the surface of the skin, which prevented the antiseptic solutions from penetrating into the minute irregularities, particularly in the peri-ungual and sub-ungual spaces. It was therefore thought probable that the use of alcohol, or ether, subsequently to the scrubbing with soap and water, might remove this difficulty, and the experiment being tried, such was found to be the case.

I will, therefore, in describing the details of an antiseptic operation begin by instructing you to scrub the hands thoroughly with soap and warm water to remove the bulk of foreign matters. Then clean the spaces beneath and around the nails ; soak the hands in 95 per cent. alcohol for not less than one minute ;

on removing them place them without drying in a solution of one to one thousand corrosive sublimate, and allow them to remain there for at least one minute. They should be wet at the time of beginning the operation, and should be kept wet during the operation, either by means of the fluid used in irrigating, or by frequently dipping them into the antiseptic solution preferred. The skin of the region to be operated upon should be treated in the same manner—first with soap and water, then with alcohol or ether (preferably the former on account of its greater antiseptic power), and finally with corrosive sublimate or carbolic solution, or the solution now used by Lister of 1 : 20 carbolic in 1 : 500 bichloride. If this procedure can be employed some hours before the operation, and the part in the mean time kept covered with towels wet with bichloride, a more thorough penetration of the skin is secured and a diminished liability of carrying bacteria from it into the depths of the wound during the operation. As it is impossible without the use of the spray, or perhaps even with it, to prevent the occasional falling into the wound of micro-organisms, it is well to have it more or less continuously irrigated with warm antiseptic solutions. Exceptions to this statement are to be found in cases of abdominal surgery, it being undesirable to bring large quantities of more or less irritating fluids into contact with the peritoneum. Even here, however, the greatest success is obtained by modifications of these methods. In addition to perfect cleanliness special attention should be directed to keeping the wound in the abdominal wall (which is made as small as possible), well covered by wet towels or sponges during the necessary manipulations.



In arresting hemorrhage it will be necessary to employ a material which, while thoroughly aseptic, can be left in the wound with the certainty of its being absorbed, and to meet these indications, you may employ catgut prepared in the following manner: Take ordinary commercial gut, which may be procured of various sizes. Place it in oil of juniper for two days to remove the oil of the gut, then wash it in 95 per cent. alcohol, and place it in the same fluid for preservation. Put it to soak in the bichloride solution of 1 to 1000 for ten to fifteen minutes before it is used in operations. Such gut will be absorbed in from five to ten days according to its size. If it is necessary that it should remain longer before absorption takes place it may be chromicized according to the method of Lister, which is as follows: Take one part by weight of gut and place it in a solution containing one two-hundredths part of chromic acid, and one part of carbolic acid to twenty parts of water. In forty-eight hours the color of the solution changes from orange to a faint olive color. The gut should then be withdrawn, washed, and preserved in alcohol. It is treated with bichloride just before it is used and will be absorbed according to size in from ten days to three weeks. The sponges which are used should be prepared in the following manner:—

1st. Soak in—

R            Acid: hydrochlor:  $f\frac{3}{4}$  iv.  
              Aquæ destillat: Oiv.

for twenty-four hours.

2d. Wash thoroughly, and place in the following solution :—

R Potass : permang :  $\bar{3}$  iij.  
 Aquæ destillat : Ovi.

squeezing them frequently.

3d. Remove, squeeze, and drop into—

R Sodii hyposulph :  $\bar{3}$  x.  
 Acid : hydrochlör :  $f\bar{3}$  v.  
 Aquæ destillat : q. s. ad. Ov.  
 M. et filtra—Use while fresh.

Put your sponges in and let them remain a few minutes until bleached. Remove immediately, wash thoroughly in distilled water, store them in dry jars, with glass stoppers. If the hyposulphite solution does not bleach well, add more hydrochloric acid.

The dressings which are applied to the wound are, in the order of their application, as follows : Iodoform is dusted thoroughly over the wound and surrounding surfaces and sometimes into the wound itself. While there is some difference of opinion in the profession as to the exact value of this agent as a germicide, and while it has apparently been shown that in the dry condition it exerts but a slight influence upon micro-organisms, yet it is unquestionable in the light of clinical experience that, moistened by the excess of liquid in the dressings, or by the discharges from the wound, it is extremely valuable,

having a special influence upon certain forms of inflammatory processes, notably, the tuberculous. Certainly the microscopical evidence will have to be much stronger than any yet adduced, before practical surgeons will be content to dispense with an article which has seemed to be of such value in the treatment of wounds. To protect the edges of the wound from irritation by the antiseptic employed, a piece of "protective" is then applied along its entire length, leaving uncovered the extreme angles from which the catgut or drainage tube issues. The protective consists of oiled silk coated with copal varnish and then dusted with one part powdered dextrine to two parts powdered starch and sixteen parts one to twenty solution of carbolic acid. This is the formula for the old Listerian protective. The dextrine and powdered starch are used to give a surface which will permit a film of water to spread itself over it in a uniform manner. If the protective were simply varnished and then dipped in an antiseptic solution, the latter would gather in drops upon its surface and would not diffuse itself evenly. This is the most elegant material for the purpose with which I am familiar, but many surgeons employ ordinary waxed paper or oiled silk in its stead.

The gauze, which constitutes the next portion of the dressing consists of ordinary cheese-cloth impregnated with one or the other of our three great anti-septics—corrosive sublimate, carbolic acid, or iodoform, the first and last being preferable on account of the volatile character of the carbolic acid. The following formulæ, which are in part those employed at the New York Hospital by Dr. Weir, can be used in making these forms of antiseptic gauze: The

cheese-cloth is rendered absorbent by boiling in water, to which a small amount of soda has been added to remove its greasiness, and is then hung up to dry. After this it is soaked in a solution of one part of sublimate and two parts of common salt and five hundred parts of water, and is then wrung out and dried in a clean room, after which it is kept in a moist condition in jars; the salt prevents the conversion of the sublimate into calomel. In making iodoform gauze take three drachms of iodoform and mix with six ounces of ordinary castile soap-suds; pour this emulsion over three parts by weight of absorbent gauze and evenly distribute it through its meshes by rubbing. This makes a 10 per cent. gauze, the soap holding the iodoform in the meshes; for 25 per cent. gauze the iodoform should be increased to seven drachms. The direction which Weir gives to make the soap-suds with a one to five thousand sublimate solution instead of ordinary water seems to me useless on account of the inevitable decomposition which would occur between the alkali of the soap and the bichloride, rendering the latter inert. In the great majority of cases the sublimate gauze should be applied directly over the wound in a thickness of from eight to ten layers wrung out just before applying from a one to one thousand sublimate solution. This wet dressing, which is undoubtedly absolutely antiseptic while in the moist condition, has two disadvantages; first it interferes with evaporation of the wound secretions; and, second, it has a tendency to produce eczema.

I desire particularly, while giving you these details, to impress upon you the fact that there may be many other modes of dressing wounds antiseptically

which will bring about equally good results. I have seen during the past summer a series of cases in the wards of Sir Joseph Lister, in King's College Hospital, London, treated by the method which he is now experimentally employing in his search for an antiseptic dressing which shall be at once cheap, soft and pliable, non-irritating, yet permanently active. The skin is cleansed with a 1 : 20 solution of carbolic acid in a 1 : 500 solution of bichloride, the carbolic acid, by its affinity for oily matters, carrying the more active mercurial solution into the recesses of the skin, the mixture being much more potent than either the carbolic or bichloride solutions separately. Next to the wound, in place of the old silk protective, is laid a piece of gauze which originally contained Sal Alembroth, the latter ingredient being, however, first washed out of it in a 1 : 20 carbolic solution ; this is done with the idea of protecting the edges of the wound from permanent contact with the mercurial salt, which is more or less irritating. The carbolic in the piece of gauze, soon disappearing, leaves an aseptic covering directly in contact with the edges of the wound. Over this is applied a much larger dressing, consisting of from eight to sixteen layers of gauze wrung out of a solution of bichloride (1 : 4000), and over this numerous layers (eight to twenty) of gauze containing three or four per cent., by weight, of the biniodide of mercury. This salt, which is the latest antiseptic used by Lister and with which he is now experimenting, is comparatively insoluble, requiring 6000 parts of water, by weight, to dissolve it, although it is freely soluble in 200 parts of blood serum. The latter solution retains the most active antiseptic qualities. Its permanency and insolubility render it particularly

valuable by lessening the probability of its being washed out of the dressings by the discharges. It is, however, extremely irritating, and not only the wound, but also the skin and surrounding parts must be carefully protected from contact with it by the interposition of the damp bichloride gauze already spoken of. It was interesting to see that, even in dressings which had remained *in situ* for a week or more, and had been thoroughly soaked for that time in the wound discharges, the portion of gauze from which the red color of the biniodide had been thus washed out would still promptly give the characteristic reaction with sulphide of ammonium, indicating the presence of the salt in sufficient quantity to preserve the antiseptic property of the dressing. Over this, without the interposition of any layer of mackintosh, is placed the antiseptic bandage or cloth, made of the same gauze, soaked and dried in a 1:4000 bichloride solution, which serves to retain the dressings in place. Sir Joseph is not yet prepared to publish the further details of this method, but, with characteristic caution, is waiting until he has employed it in a sufficient number of cases to discover all its possible defects, and to test thoroughly and completely its full antiseptic value.

The ideal dressing would be a dry, sterile, absorbent material, absolutely germ free, and at the same time unirritating. This material may be obtained by sterilizing ordinary gauze with steam, and such gauze is now employed in the great clinic of Von Bergmann in Berlin, and in that of Luecke at Strassburg. From the raw material the gauze is cut of proper size and lengths, put in a wire basket, exposed to super-heated steam in the oven for an hour and,

after drying for a moment or two, the basket with its untouched contents is put in an iron cylinder from which the gauze is withdrawn as required. This secures, it is said, with a minimum of handling, an absolutely aseptic dressing under which wounds do admirably. I have not had an opportunity of using it for lack of the needful apparatus, but hope before long to make arrangements by which such dressings can be supplied in one or the other of the hospitals with which I am connected. Dr. Jones, of the Woman's Hospital, Brooklyn, has recommended the employment of an apparatus known as the Arnold automatic steam cooker for the purpose of sterilizing instruments and dressings. I have not yet had an opportunity of employing it, but hope to show you the working of it, or of something still more convenient, in some subsequent lecture. Koch's sterilizer is more complicated and more expensive.

The great objection to ordinary sublimate gauze as it is employed in most hospital wards is that, as kept in the usual way, it is not free from germs and can only be depended upon in the recent moist state. Besides, as Schlangé has shown, much of the antiseptic action of sublimate dressings is lost when they become soaked with blood or albuminous fluids. The first difficulty is overcome by keeping the dressings moist or using them in that condition; the second may likewise be removed by the addition of tartaric acid to the sublimate solutions; using for irrigation, for example, a solution of one part sublimate to five parts tartaric acid and one thousand parts distilled water; and for impregnating the gauze five parts sublimate, twenty parts tartaric acid, and one thousand parts distilled water. Laplace has shown that in this manner the precipi-

tate of albuminate of mercury which otherwise takes place, leaving the solution inert, may be prevented, and I have directed that in the future solutions employed in my own wards and practice shall be made in this manner. Outside of the gauze should next be applied some antiseptic absorbent cotton or cotton from which all grease has been removed by treatment with alkalis and which has afterward been impregnated with corrosive sublimate. This can be bought from reliable manufacturers at low cost, and I need not detain you with the formula for making it. These dressings are maintained in place by bandages made from strips of antiseptic gauze.

All instruments used should have been cleaned, first with soap and water, then boiled and finally soaked in the one to twenty carbolic solution for not less than fifteen to twenty minutes before the operation. I desire to caution you against the too common custom of simply dipping an instrument in an antiseptic solution and believing that its purification has been complete. This is by no means the case, and although it occurs more rapidly when sublimate solutions are used, the effect of this upon the surface and edge of the instruments is so undesirable that it is far better, whenever possible, to have the instrument soaked in the carbolic solution for the time I have mentioned.

You should remember that if you have been entirely successful up to this point in excluding from the closed and covered wound all living organisms your patient still has certain dangers to run. In many cases during the first twenty-four hours one of two occurrences will take place. Either the dressings will loosen so that air can pass in freely under their edges, which often results from



the subsidence of inflammatory swelling ; or oozing of blood or serum will take place to such an extent as to penetrate the various layers of the dressing and show upon its surface. In either case a direct road to the wound is offered to such organisms as may find their way to the edge or the wet surface of the dressings. In the first case it will only be necessary to apply around the edge of the dressing a thin layer of sublimate cotton held in place by another and firmer antiseptic bandage. In the case of oozing, however, steps should be taken to protect the blood or serum soaked dressings from contact with the surrounding atmosphere, or with substances not previously rendered aseptic. With the latter object in view I have all stumps after amputation placed upon pillows made of sublimate cotton so that the first discharge which appears will be received by and will soak into the pillow, and I make similar arrangements for receiving the discharges from all operative wounds. When the dressing does become soaked, if it is but to a moderate extent, it should be reinforced with sublimate cotton in the hope that it will then dry out and remain aseptic. You will understand, from what I have told you in the early part of this lecture, that if that drying-out process is not interfered with and the dressings and wound have been aseptic throughout, you will soon attain by evaporation of the wound secretions a degree of concentration which is incompatible with the development of micro-organisms, and if then no opportunity be given the latter to effect an entrance beneath the dressings they may be left in place for an indefinite length of time. Schlange has shown this experimentally, and believes that even when there is great soaking of the dressings and

the superficial layers have to be changed, the deep layers, if they have begun to dry out, should be left undisturbed.

Whether pyogenic organisms effect their entrance through the dressings or beneath them during the interval between the change of dressings they most commonly, as Cheyne has shown, spread inwards by growing in the discharge which is lying between the dressings and the skin and in the superficial layers of the epidermis, more especially in the latter if, as the result of the irritation of the antiseptic employed, there is hypertrophy of the epithelium. A large number of dead epithelial cells are then present, which being soaked with the discharge form a good nidus for the development of bacteria, unless indeed enough of the antiseptic has been communicated to the discharge and to the epithelium from the dressing to render it an unsuitable soil for the growth of organisms. If this is not the case the organisms will go on growing in the substance of this dead epithelium protected by the superficial layers from the action of the dressing and thus may, if the latter is left on for a long time, ultimately reach the wound. Mr. Cheyne, whose statements I have followed in regard to this question, has been able to demonstrate the progressive development of organisms beneath the dressings from their margin toward the wound, the extent to which they had spread varying with the length of time that the dressing had been applied. He adds very properly that, if these views as to the mode of entrance of bacteria into wounds are correct, it follows that it is very important, when the dressing is changed, to wash and thoroughly disinfect the skin around the wound as far as the dressing extends, and beyond it, with

an antiseptic lotion, care being of course taken by covering up the wound not to infect it while so doing. If this is done, then at each change of dressing the field of battle is transferred from the neighborhood of the wound to the margin of the dressing, and in accordance with the size of the dressing this battlefield will be at a greater or less distance from the wound. I need hardly tell you that at each change of dressing the same precautions are to be observed in regard to the hands and instruments as during operation.

The time has gone by when it is necessary to speak at length upon the precious and inestimable advantages of these and similar methods in the practice of surgery. I need only detain you now to make one further remark, which is that you cannot be too familiar with antiseptic methods and cannot expect to be successful in their employment without you bring to the subject first, a firm belief in the truth and importance of the antiseptic theory, next the intelligent comprehension of that theory—a clear and distinct knowledge of the rationale of each of the details of the method—and lastly, a thorough practical familiarity, only acquired through study and experience, with the various measures which I have described to you. With these conditions you may safely apply to your practice the test which measures your skill by your results, and may accuse yourselves whenever in the treatment of ordinary wounds or after the performance of ordinary operations you meet with the complications which were once so serious and so fatal. The occurrence of pyæmia, septicæmia, erysipelas, or even of suppuration or inflammation, the failure, indeed, to obtain primary union, should always be regarded by you as an indication that

there is something defective in your antiseptic methods ; and you should learn to seek first in your own sins of omission or commission for the explanation of the surgical accidents and complications which formerly were put down to various idiosyncrasies on the part of the patient, or to the dispensation of Providence.

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