An Address

ON

THE TREATMENT OF GUNSHOT WOUNDS.*

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THE problem of the treatment of gunshot wounds has been profoundly modified, if indeed it has not been radically altered, by the knowledge gained during the present war. Neither the civil experience of the last forty years, nor any recent military experience, had prepared us for the kind of work which from the very outbreak of the campaign it was our duty, as surgeons, to perform. The new and unexpected things which occurred were due to a set of circumstances each one of which was in some degree different from anything we had observed before. The character of the missiles in respect of the mode of flight and velocity was not that with which former wars had made us familiar. The damage inflicted upon the tissues was far greater than and different in quality from that commonly seen in South Africa; the organisms carried into the wound from the surface of the body, from the earth around, or by fragments of clothing, judged by their clinical results, transcended in virulence or in fecundity anything known by the present generation of surgeons; and, finally, the soldier, in the earlier months of the war at least, had undergone so serious and prolonged a strain, before being wounded, that he often fell an easy victim to a bacterial onslaught of great ferocity. The efforts of the surgeons to deal with the wounds so grievously infected were at first lamentably inefficient. Suppuration surpassing in profusion or in malignancy anything we had seen before occurred in the majority of cases, and the efforts which our civil experience suggested as the most helpful did very little to check the activity of the process. Failures were spoken of, the failure of the antiseptic system, the futility of aseptic methods, and Lord Lister's immortal work was belittled or held of no account. One of the first tasks I set myself on returning from France early in 1915 was to read again Lord Lister's papers with the new knowledge I had gained on foreign service to help me to a better understanding of the problems with which he had to deal fifty years ago. All that Lister wrote can be read with great advantage to-day. The essential problem he confronted and conquered is that which we have still to meet, and the principles he laid down are as strictly applicable now as they ever were. Lister clearly distinguished the difference between the prophylactic and the therapeutic value of antiseptics; he emphasized the all-importance of the former, and pointed out the inadequacy of the latter. The work of surgeons, since Lister taught, has depended for its almost incredible success upon the prevention of infection in wounds deliberately inflicted; not upon the control of an infection already established. This by comparison is a trivial matter. Lister, however, needs no defence, and if he did, none more eloquent and unanswerable could be written than that which is found in his own papers.

What, then, were the several new factors that had to be considered in this war?

In the early days a very large number of the wounds were inflicted by rifle fire. The German bullet has a muzzle velocity of approximately 1,000 yards per second. In the first 800 yards, or thereabouts, the flight of the bullet is not steady but "wobbling." There are three movements—a movement forward along the line of flight; a rotatory movement, in which the bullet spins round on its longitudinal axis as a result of the "rifling" of the barrel; and a third movement, a "mouvement de bascule" of such a character that while the point of the bullet keeps steady the base of the bullet is moving round a circle, or an ellipse, of a gradually diminishing size. The result of this last form of motion is this, that when the bullet impinges upon any substance, even the soft clothing or the flesh,

the infinitely brief arrest in the point which strikes first allows the base, which is, of course, much heavier, to overtake the apex, and the bullet then lies sideways, or begins to turn over and over as it ploughs its way through the soft parts. In this early part of its trajectory the missile has, of course, a great momentum; it is a heavy bullet, travelling with great velocity. The consequence is that the damage inflicted is not confined to the track it rudely makes through the limb; the parts around the track are damaged also, often to a great extent. Every wound, therefore, caused by a bullet at short range, consists not only in a visible tearing and destruction along the path the bullet has followed, but in a dead zone everywhere surrounding that track—a zone in which death and destruction or disintegration of the parts has occurred by reason of the tremendous concussion produced by the bullet as it tore its way clumsily through the tissues. Sir Anthony Bowlby has proved this by a series of exemplary instances. In one of these the kidney was wounded in its lower pole; the upper pole appeared normal to the naked eye, yet on microscopic examination the tubules were seen to be disorganized. Other examples of the widespread damage inflicted are quoted in his Bradshaw lecture. And even that is not all. The momentum of the bullet is such that to everything it encounters it imparts some of its own velocity. As we all know, shreds of the clothing or belt, or the contents of the pocket, may be carried deeply into a wound. So also are pieces of skin or muscle. And if the bullet should chance to strike a bone, the bone is not only broken into many fragments, the "splinter" fracture, but to all fragments there is conveyed enough of the momentum of the bullet to convert them into projectiles also, capable of tearing a way into the softer tissues. Many of the wounds, therefore, were deep, irregular in shape, with large or small cavities; of the variety the French term "anfractuous." Into these recesses blood escapes, and owing to the tearing and unequal retraction of cut muscles, pools of fluid may be shut off from the main track of the wound.

If a rifle bullet is not checked in the first 500 yards of its flight it begins to steady down, and probably when it has travelled 1,000 yards it is moving evenly. An injury inflicted then is of a quite different character. The bullet cleaves its way through the soft parts, bores a neat hole through a bone, and little destruction is done. We see many cases where the chest or abdomen are traversed from side to side, or where the neck has been pierced, and, miraculously, no real damage has been done. Examples of this form of injury were of course common enough in the South African war. They have been less frequent in this war because the range has often been shorter, and the bullet in respect of velocity and weight is different.

The campaign in Flanders and in Northern France has been conducted on fields many of which have been as highly cultivated, and were therefore as heavily manured, as any in Europe. Generations of husbandmen have earned their livelihood from this earth, and it has therefore been necessary to enrich the soil by applications of manure—the faecal material of horses, cows, and pigs. The contact between the soldier and the soil upon which he fought has never been more intimate. The hands and faces, bodies and limbs, were grimy with the mud and dust that penetrated and clung to the clothing of these soldiers. And opportunities for the change of clothing were not frequent. In the earlier days of the war men were commonly a couple of months or more without the chance of taking off their trousers. They were literally covered from head to foot with clay and earth and mud. And this mud, largely manurial in origin, contained micro-organisms which, given the chance of growth in a fertile medium, proved luxuriant. They were the organisms of tetanus, the gas-gangrene bacillus (*Bacillus perfringens*, *Bacillus aerogenes capsulatus* of Welch), the *Bacillus coli*, putrefactive organisms of several forms, and a streptococcus which has since been recognized as the enterococcus of the French writers. All were of faecal origin. It was very interesting to find that while I was in France we rarely found the *Staphylococcus pyogenes aureus*, the common cause of suppuration in the wounds of civil practice at home. It was only at a late stage in the history of the cases that this organism invaded the parts.

In the early months of the war the soldier who was wounded was often wearied almost beyond endurance by

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excessive exertion, loss of sleep, and unceasing anxiety and strain. When I had the opportunity of visiting field ambulances and some clearing stations I was struck with the condition of the patients on admission. As soon as a man reached shelter and quiet he fell asleep. Even during the dressing of his wounds he often slept heavily, and the temptation of hot soup or the inevitable cigarette could hardly persuade him to rouse himself for more than a few moments. Left to himself he fell asleep at once. Even at the base hospitals I have known men sleep for forty-eight hours with barely a movement, other than that grudgingly made to take a drink. When the wounds were serious, as in compound fractures of the thigh, the men were often collapsed, cold, and white, with feeble pulse and flickering breath. A part, no doubt, of this reduction of the patient's vitality to so low an ebb was due to the delay in bringing him to an aid post or a field ambulance after he had been wounded. But no organization in the world can alter this, for it does not depend upon us, but on the enemy. Little or no respect is paid to the Red Cross near the firing line, probably because it is not easily visible. A stretcher party bearing a wounded man is exposed to the fire of rifle or of shrapnel, if at any moment it allows itself to be seen. This is equally the rule at night also. It is only by stealth, and at opportune moments, that a wounded man can be taken away, and the delay in tending him, which is deeply regrettable, cannot be prevented.

Such, very briefly, are the conditions present when a man is wounded. The missile inflicts great damage along the track it follows; hollows and recesses, caused by the unequal retraction of torn muscles, are formed everywhere, and within them effused blood may be pent up. In all the parts round this bullet track the parts are dead, offer no resistance to the bacterial invasion, but rather form the most nutritive medium that could be desired for the propagation of bacterial life. Into every tiniest cavity micro-organisms may be carried with some degree of violence, and sown everywhere on a fertile soil. The micro-organisms themselves, if not always of the greatest malignity, proceed to develop with the most intense activity, finding all conditions most suitable. They are given time to make headway, because of the interval that needs must elapse before a careful dressing of the wound can be undertaken. And the victim of this injury is himself very often in a condition of such fatigue or general collapse as will reduce his power of resistance much below the normal. Nothing, of course, in any degree comparable to this condition of affairs is ever seen in civil practice, and when the methods of civil practices were brought to bear on such cases they very naturally failed to give the results which had been expected of them.

The treatment of gunshot wounds may, I think, concern itself with (1) the prevention or control of the infection in wounds at the earliest possible moment after their infliction; (2) the reduction or the abolition of the infection after this has once been fully established in the wound. Before these matters are discussed, however, there are certain first principles, applicable to all wounds, which may be stated once for all.

A.

Excision of the wound, if it can be practised, is, of course, an ideal method. Unhappily the great majority of the injuries inflicted are of such a kind that the wound surfaces are most irregular. This is partly due to the actual damage done by the bullet; partly, indeed chiefly, to the very unequal retraction of torn muscles. An accurate excision of the surfaces of an anfractuous wound is, therefore, hardly possible in the majority of cases. When, however, it can be done, it is certainly the most desirable, for the zone of the infection once cut away there remains only a clean wound, which may be closed completely by suture, and healing by first intention may be secured. Wounds of the scalp, penetrating wounds of the knee-joint, and wounds of the abdominal wall all lend themselves at times to this method of treatment. The technique must be scrupulous and exact, or the good results are jeopardized. Colonel Gray has advocated this method in suitable cases and speaks well of it.

B.

In all cases of large or penetrating wounds a thorough examination and preparation of the wound for its sub-

sequent dressings must be made. The administration of an anaesthetic is frequently necessary at the earliest opportune moment. A preliminary disinfection of the skin with some efficient antiseptic is clearly necessary. I regret to notice that iodine in some form or other is the favourite application. It is, of course, easy to use, and because of its colour it is easy to see whether, and to what extent, it has been applied. But its very simplicity is often a drawback, for we can never afford to forget that the ritual of surgery must on all occasions and at every moment be as scrupulous and exact as it is possible to make it. Perfunctory work at one period breeds laxity at others. It is not easy to sterilize the skin or to keep it sterile for half an hour by any method of preparation. I have more than once seen the tincture of iodine painted over a limb to which dry dung or earth was adhering. To believe in the efficacy of such methods is mere fetish worship. All the methods of iodine preparation of the skin are short of the best, and many of them are utterly inefficient. Abundant experimental evidence, which need not now be quoted, supports this contention, and a thorough trial by myself and others shows clearly that the quality of healing in operation wounds, when the skin has been prepared by any of the iodine methods, leaves something to desire. The cleansing of the skin is very important, because from organisms in the skin the wound may often be reinfected. This is more especially the case when the old form of civil dressing is used. This consists in applying a large amount of gauze, a mass, large or small, of wool, and finally bandages. When the discharges from a wound are free it is probably not many minutes before the gauze, with a layer of this wool, is soaked with them; until the next change of dressing the wound is then fomented with its own secretions, and the discharge infects the parts surrounding the wound. Unless, therefore, the skin is thoroughly cleansed afresh a new dressing is infected by it at the moment of application. The skin must be thoroughly cleansed, then, by ether soap, ether, benzine, petrol, or other efficient material, and an antiseptic liquid applied. Binioidide of mercury in spirit, Harrington's solution, Macdonald's solution, or Dakin's solution are the most effective. The latter, for the purposes of war, is to be preferred, for the subsequent irrigation and dressing of the wound may be carried out with the same preparation. After cleansing the skin adequate drainage must be secured. This may need the enlargement of wounds already existing, or the making of new openings into the large and irregular wound cavity. Whatever is necessary to secure full and free drainage must be ruthlessly done, since the necessity for the unimpeded escape of all wound discharges is paramount. If by any chance the *Bacillus perforans* has obtained access to the wound the patient's limb or life will depend upon the sufficiency of the drainage. The wound is then carefully examined; any fragment of clothing or any missile felt at once, is removed; dead or soiled fragments of torn muscle are taken away; the whole wound is irrigated with the antiseptic solution which has been selected for the purpose, say Dakin's solution, and the parts are then immobilized and dressed.

C.

Immobilization of Wounded Parts.—I fear that far less attention than it merits has been given to the consideration of this subject. When a bone is broken splints are applied as a matter of course, and the parts, as far as possible, are immovably fixed. This is recognized as essential, not only because of the obvious diminution in the patient's suffering, but also because it is now well recognized that any form of movement in these war wounds aids appreciably the extension of the infection. It is not yet, I think, sufficiently realized that immobilization of wounds in the soft parts is equally essential. The comfort of the patient is sensibly increased, and the spread of infection is checked. Like every other useful measure, however, the immobilization of limbs can be misapplied. It is important to remember that fixation of legs or arms for an undue length of time may result in stiffened joints and withered muscles, and that months of painful passive movements and of massage may be needed to repair the errors of a few weeks.

1. THE PREVENTION OR CONTROL OF INFECTION IN GUNSHOT WOUNDS AT THE EARLIEST POSSIBLE MOMENT AFTER THEIR INFLECTION.

Shortly after the outbreak of the war the surgeons whose duties kept them at home were amazed at the severity of the infection in the wounds of soldiers returning from France. It was felt that adequate measures were not being taken to deal with these injuries. And discussions, both public and private, were frequent and not devoid of acrimony. Sterner measures were advised, the painting of all wounds with pure carbolic acid, or with tincture of iodine, which in the few years before the war had come again into favour among surgeons for many purposes. These various measures were indeed tried in France very thoroughly for a certain period. A large number of wounds were treated exclusively with pure carbolic acid, a certain number with tincture of iodine, others with simple field dressings. By the time the base hospitals were reached it was not possible to say what early measures had been tried. In all wounds suppuration was rampant, and the early and thorough applications even of pure carbolic acid were found not appreciably to alter the subsequent severity of infection. As we now look back upon that experience we realize, I think, that this failure was due, in part, to the feebleness of the antiseptics used. Pure carbolic acid, since Lister introduced it, has been taken as the standard of germicidal power. We have thought and spoken of pure carbolic acid as something of the greatest potency, all-conquering in its fight with germs. The truth is, of course, that, speaking comparatively, pure phenol is a very feeble antiseptic; and in contending with the organisms which had obtained a firm hold on the nutrient medium of these fresh wound surfaces it was little better than nothing. Its bactericidal power, always feeble, is much reduced when it is called upon to act in the presence of serum or pus; and when used in full strength it is apt to damage healthy tissues. It soon became evident, therefore, that if we were to fight with any chance of success against the particular type and degree of infection seen in the war, a few more powerful antiseptics must be discovered. It was here that Dr. Dakin came to our help. Dr. Dakin, an old student of the University of Leeds, had gone out to France early in 1915, with Dr. Alexis Carrel from the Rockefeller Institute in New York, for the purpose of carrying on medical research in a hospital attached to the French army. He had in mind various ideas as to the kind of antiseptic that might perhaps be used with success. One after another of these proved of little value, until finally a preparation was made from chloride of lime—bleaching powder. The details of the making of "hypochlorite" solution have been given by Dr. Dakin.¹ It has on examination proved to have a bactericidal value which is far higher than that of any antiseptic we have been accustomed to use. Pure carbolic acid, for example, will kill the *Staphylococcus aureus* in the presence of serum after acting for two hours when at a dilution of between 1 in 50 and 1 in 100. Dakin's solution acts in like circumstances at a dilution of 1 in 1,500 to 1 in 2,000. It possesses other qualities necessary in any germicide for use in conditions such as I have described. It is diffusible, it does not irritate unduly, it has a remarkable power of clearing away sloughs, it is easily obtainable, and it is very cheap. It has proved, in the hands both of the French and the British surgeons who have tried it, to retard or to prevent the development of sepsis more effectively than any other preparation that has been tried.

The preparation was first made at the University of Leeds by Professor Cohen to Dr. Dakin's formula, and I had therefore the earliest opportunity of acquainting myself with the virtues of the solution. I used it in cases of fresh and of old infection—in cases, for example, of compound fracture into joints where infective material had been introduced. In the cases in which the solution was used from the outset a powerful inhibitory effect was produced. Wounds healed as though no infection was present, and a thoroughly aseptic course was seen. In wounds where suppuration was already in full course very marked benefit was also seen, but of this I will speak later. It was quite evident, therefore, that in this "new antiseptic" a most powerful agent for good had been found. In several

cases, however, a moderate degree of irritation, especially of the skin, was seen. The degree of irritation seems to vary in different cases and in different districts. It may be that the bleaching powder from which the preparation is made is not always of the same quality. It may be, as Dr. Dakin suggests to me, that the solution, which has a strong decomposing effect upon other antiseptics, forms with them, if they have previously been used in the wound, some compound of an especially irritating character. If irritation is seen, a reduction of the strength of the antiseptic is necessary, and still good results will be obtained; for, even in considerable dilution, it is far more effective than pure carbolic acid. The method of the application of the solution varies with the position and extent of the wound. If possible, the wound should be lightly packed with gauze wrung out of the fluid. Underneath the limb a photographer's "developing dish" should be placed, and at intervals of an hour or two a little of the solution should be poured on to the gauze lying in the wound from a Florence flask. The gauze which packs the wound should always be kept damp. It must never be forgotten that there is no such thing as a "gauze drain." Gauze does not drain any wound for more than a very short time; its meshes soon become clogged with lymph, and it is then a plug and not a drain. If the position and extent of the wound do not allow of this method, strips of bandage or of lint may be kept lying out of the wound and their free ends immersed in a dish of the solution, which is then slowly sucked into the wound, whose surfaces it keeps constantly moistened. Or small tubes, with many perforations, wrapped round with one layer of Turkish towelling, may be pushed into the recesses of the wound and left to pass out through a loose dressing of gauze and wool. At frequent intervals small quantities of the hypochlorite solution are injected slowly into the tubes and are diffused through the wounds. This is Carrel's method, and in many cases is the best of all. The skin around the wound may be protected by vaseline. The fluid must always be fresh—not more than five days old. As the solution is so cheap it is not a matter of importance if some quantity of it has to be thrown away. It is very important to ensure that no impermeable material lies outside the gauze, jaconet, or oiled paper, or rubber sheeting. Free escape must always be provided for the Dakin's solution, and for the wound discharges.

I have had the opportunity of trying another preparation of Dr. Dakin's, "chloramine," which in some respects is better than the hypochlorite solution. Chloramine is toluene-sodium-sulphochloramide. The molecular concentration required to kill staphylococci in presence of serum is one-fifth that of the hypochlorite solution. It is very soluble and very easily diffused. After many trials, Dr. Dakin succeeded in preparing chloramine gauze—a gauze in whose meshes powdered chloramine is held. This gauze, thoroughly impregnated with this strongly antiseptic powder, was made in the hope that when introduced into the wound the discharges would dissolve the powder little by little and carry it to all parts of the surface with which they come in contact. In our work in Leeds and elsewhere in the Northern Command we have used a certain amount of this new gauze, with results that justify us in believing that it is the best method so far introduced for checking and controlling the development of infective processes. I have used it in wounds very heavily infected, and its power of cleaning a wound, abolishing the offensiveness of discharges, and bringing about a growth of new healthy granulation tissue is very remarkable. The opportunities for testing its inhibitory properties are very few in civil practice, but such little experience as I possess suggest that it may prove to be one of the most powerful of all known methods for aborting a grave infection in any of the wounds of war.

The researches of Alexis Carrel appear to show that in wounds quite recently inflicted by bullet or by shell the infection at first is slight. When smear preparations are taken at once from the wound surfaces several fields may have to be searched before any micro-organisms are found. Such organisms as are present, even if of no great virulence, finding everything to their liking, grow apace. Every hour that elapses increases the extent, the penetration, and the virulence of the infection. I think, therefore, that the first attack made by a surgeon on a wound

received in battle should be by an antiseptic, and the most powerful which it is proper to use. I do not think that Wright's method is applicable, in the worst cases at least. For, as I have said, the condition of the soldiers who have received severe wounds is one of exhaustion, with lowered blood pressure, cold extremities, feeble pulse, and marked pallor. A few of these patients need infusion before any remedial measures can be attempted, and very many suffer from shock in greater or less degree. The introduction of saline tabloids into the wounds would probably not cause any outflow of serum, and if it did it would be a most undesirable result, for fluid cannot then be spared.*

2. THE REDUCTION OR THE ABOLITION OF INFECTION AFTER THIS HAS ONCE BEEN FULLY ESTABLISHED.

When once the processes of suppuration are ablaze in a wound the problem of their treatment, as was recognized by Lister, is a far more difficult matter. To prevent putrefaction in a wound quite recently inflicted, or in a wound about to be made, is by comparison very simple. It is dependence on the certainty of this that has led to all the surgical developments of recent years. To control or check these processes when once they have become rampant is always difficult, and may indeed be impossible. Nothing could be more futile than the methods commonly practised in civil life. A freely suppurating wound may be irrigated for long periods with carbolic or mercuric lotions, and an antiseptic dressing applied; yet when the dressing is removed pus will still be found to pour freely from all parts of the wound, and to lie stagnant on the surfaces of the gauze and wool. In such wounds the old form of dressing is really a pus poultice. We did not realize its hopeless futility before the war, because serious infections in wounds in civil practice are nowadays very rare. A very brief experience of the bountifully purulent wounds of this campaign soon taught us that other methods than these must be found. The methods I have myself practised and seen practised in such cases are briefly the following:

The use of hypertonic salt solution—of a solution consisting of 5 per cent. salt and $\frac{1}{2}$ per cent. sodium citrate. This is the method introduced many years ago by Sir Almroth Wright and revived by him during the present war. Probably every one interested in the surgical treatment of wounds has read all that Sir Almroth Wright has written; if he has not, he should do so forthwith. For his papers state the problems with perfect accuracy and with much insight. The principle of the hypertonic method is to make use of the bactericidal power of fresh serum, which is encouraged to flow from the wound surfaces by the application of a more concentrated saline solution than blood serum. A process of osmosis is at work. It is argued, or rather asserted, which is not the same thing, that serum is a fluid which will not osmose, but the fact is indisputable that when these strongly saline dressings are applied the discharge from all the wound surfaces is increased enormously in quantity. The patient is often compelled to drink freely, so considerable may the drain of fluid be. The discharge from the wound after the first few hours becomes clear, and within two or three days may be found sterile or of low bacterial content. The streptococcus seems the most resistant of all micro-organisms; after two or three days it is often the only germ remaining. As I go round from one hospital to another, or from one ward to another, I think I am generally able to pick out the cases which are being dressed by Wright's solution. The granulation tissues have a fuller, deeper colour, and the surface looks cleaner than when any other form of dressing is being used.

The best method of applying the dressing is that already mentioned as applicable to Dakin's solution. A loose packing of gauze, in a wound well drained, is kept constantly moistened with the salt solution. The copious discharges are collected in a dish. It is important to allow no wrapping up of the limb in wool or swathing in bandages, which restrict the free outward flow of the wound discharges.

There are, however, certain disadvantages in the long continuance of applications of hypertonic saline solution. After the wound has once become thoroughly clean, when the granulations are glowing vividly with health and the discharge is sterile, further treatment with Wright's

solution is apt to cause hæmorrhage, and the granulations become sodden and oedematous. It is therefore desirable before these changes take place to discontinue the treatment. One of two courses may then be followed—either the wound, when of suitable size and proportion, may be closed completely by suture, or its sides may be drawn together by strapping, or some bland dressing may be tried; a dressing of normal saline solution, or of red lotion if moisture is needed; or, otherwise, one with zinc or boracic ointment or sterile vaseline.

As a rule, the treatment by hypertonic salt is painless, but now and again one hears complaints of stinging and burning. To overcome this I had some tabloids made containing chloretone as well as the two salts. Chloretone is a local analgesic of slight power. I think there is some advantage in its use.

A variant of Wright's method, practised by Colonel Lawson and many others, consists in the application to deep anfractuous wounds of a gauze wick into the centre of which tabloids of salt and sodium citrate are placed. There are wounds so placed and of such depth that it is impossible to dress them by the methods applicable in surface wounds. Into the remote recesses of these one or more saline tabloids may be placed, either wrapped in gauze or placed in the extremity of the lumen of a rubber tube, round which a catgut ligature is tied so tightly as to prevent the tabloids from escaping. The tabloids excite a profuse discharge of serum, and the gauze or tube need not be changed oftener than once in every twenty-four hours.

A. E. Morison and Tulloch have advocated the use of a solution of magnesium sulphate in place of sodium chloride. In a preliminary communication² they point out the greater efficacy of their solution in ridding the wound of the streptococcus, which is the hardiest and tardiest inhabitant of all war wounds, and the equal efficacy of the solution in cleaning the wound, changing the quality of the discharge, destroying its offensive character, and causing that crimson glow of health which we like to see. In a very few days that blue edge appears on the wound which Solomon had doubtless in mind when he said "the blueness of a wound cleanseth away evil." I have seen some of the wounds treated by Mr. Morison, and can testify that, clinically, his claim is just.

I have had a large experience with Dakin's solution in the treatment of heavily infected wounds, in which the discharge was copious, and very offensive. Its virtues are remarkable. On the first day of trial it was used on three very septic cases in the Isolation Block at the Leeds Infirmary, under the care of Captain A. Richardson. The first case was one of severe infection of the arm arising in an enlarged olecranon bursa. The tissues were sloughing, greenish-black, bitterly offensive. The organisms were cocci, a diphtheroid bacillus, and a coliform bacillus. On the third day the sloughs had all cleared away, the wound was healthy, and no growth could be obtained from the discharge. In two other cases there was a pure culture of the *Staphylococcus aureus*. On the fifth day no organisms were found in the discharge in one case, on the fourth day a very attenuated growth in the other. This experience has been confirmed by many later cases. The most remarkable effect of the application of Dakin's solution is seen in the disappearance of all sloughing, dead and decomposed material. The wound casts them off with great rapidity, and a clean and glowing healthy surface remains. The discharge soon becomes clean, rather "sticky" and inoffensive, and the infection, however virulent, is brought under control or rapidly disappears. It is most essential to dress the wound as I have described. The old methods will not do. A mass of gauze, with tubes securing drainage must be in or on the wound and must be kept constantly saturated with fresh solution. The solution must be newly made every five days; it must not be heated before use, but applied cold or tepid; no other antiseptic may be used at the same time, and the skin must be protected from the occasionally irritant action of this powerful antiseptic. I have found it a little difficult to convince those responsible for the actual dressing of wounds that the old method of applying a layer or two of gauze, a pad of wool, and a firm bandage are utterly unsuitable for the septic wounds of war. Free

access of the antiseptic, constantly renewed, and free escape of the discharges are essential to clean and quick healing.

One of the old fashioned and one of the most successful methods of cleansing the dirty sloughing wound is by constant immersion and irrigation in a bath. For wounds of the hand and forearm, of the foot and leg, this procedure is very simple; but in wounds of the thigh, body, or chest it is difficult or impossible. It is not a matter of any importance as to the antiseptic used in the water; salt solution, a weak solution of carbolic acid, potassium permanganate, or tincture of iodine, all give the same results.

In the treatment of all gunshot wounds where the septic processes are raging, and the temperature varies through several degrees, an immense advantage will accrue from placing the patient out of doors. While in France I developed a great affection for the tented hospitals. There is great movement of air, warmth, and comfort; when a sunny day comes the side of the tent may be lifted and the patient enjoys the advantage of open-air treatment. Major Adye-Curran was the first to convince me of the striking effects caused by exposing uncovered septic wounds to the air and the sun. Wounds which were sullen in healing quickly brightened and became clean. Even in the winter and in Leeds and Sheffield we have some patients out of doors day and night. On Monday last I saw at the 3rd Northern General Hospital with Lieutenant-Colonel Connal a row of beds in the open occupied by ruddy, happy men with quickly healing wounds. I asked many of the patients how they liked the exposure, and all at once replied that they were quite happy and "wouldn't go inside to sleep if they could help it." I am confident we do not sufficiently take advantage of the immense help which open-air treatment can give to patients suffering from the serious wounds of war. I find that wounds clean more rapidly, patients sleep better, eat better, and feel better when they are kept out of doors night and day. The vagaries of the temperature chart need not influence our decision as to the wisdom of this treatment. Many years ago I learnt at Johns Hopkins Hospital that a high septic temperature was an indication for moving the patient on to a balcony rather than a reason for dreading the effects of exposure.

I cannot properly omit mention of the vaccine treatment of patients suffering from septic wounds. It is remarkable to find such widely divergent opinions among physicians and surgeons as to the virtue of a vaccine in any disease. When opinions are so wide apart, so confidently expressed, and so utterly irreconcilable, it is probable that opportunities for judgement are not identical. The changes in wounds are often so swift when any one of the recognized modes of treatment is tried, or indeed when little of value is done; a vaccine when tried is so often only one of several agents brought to bear almost at the same moment upon the patient and his wound; degrees of change in a wound are so difficult to express in terms of accuracy, and their appreciation depends so much upon the desires and prejudices of the observer, that argument and experience are alike fallacious. But no one can deny, I think, that a case has been made out for the trial of vaccines in appropriate cases, and in suitable conditions. The principle of the vaccine method is, of course, to fortify the blood serum in respect of those bodies which are inimical to the development or to the life of an invading micro-organism. If, therefore, a wound is imperfectly drained or not properly dressed, the administration of heroic doses of the most potent vaccine is merely futile. When, however, a wound is well drained and there is a free access of serum to the wound, with a free opportunity for its discharge into the wound and of rapid escape from it, then it would seem reasonable to suppose that the more potent the bactericidal power possessed by the serum, the greater will its effect be in causing the wound to clean and to heal. This suggests that the vaccine treatment, in conjunction with the application of Wright's solution, will be likely to give the best results. Of the great value of the streptococcus vaccine in the serious wounds of this war I am thoroughly convinced, and I have no doubt whatever that advantage would be gained by a freer use of it in cases of infection with this most obdurate organism. So much has reference to the therapeutic use of these agents.

Their prophylactic virtues, if they possess any, have not yet been given a full trial in this war. It would be interesting to watch the effects of vaccines given before a man goes into action, or to a man immediately after his wound is inflicted. But the factors at work are so many, so variable from time to time, from place to place, and from man to man, that the scrutiny of inoculated cases would require powers of analysis denied to most of us. Sir Watson Cheyne, the redoubtable champion of the antiseptic methods—and, indeed, one of the earliest and most successful pioneers of modern surgery—has suggested that bacteriologists have a very great opportunity at the present time, and that they may profitably be employed in raising the immunity of new recruits against all the ordinary bacteria which occur in wounds received in war time.

One of the most sensational experiences in connexion with all wounds, even the most trivial, is the inordinate length of time that micro-organisms may remain dormant in the tissues long after healing is complete. I have seen tetanus and gas gangrene develop in wounds many weeks after their infliction when relatively trivial operations were performed upon them for the purpose of extracting bullets, shell-casing, or fragments of khaki cloth. Even the passive movement of a stiff joint, in whose neighbourhood there is a healed wound, may light up a raging septic process which threatens or takes the patient's life. It appears to be more especially in cases where compound fractures of bones have occurred at the primary injury that these grave troubles are apt to arise. A knowledge of the danger must warn us always to be on guard against premature surgical interference in wounds recently healed, or in sinuses which fail to close.

REFERENCES.

¹ BRITISH MEDICAL JOURNAL, 1915, ii, p. 318. ² *British Journal of Surgery*, 1915, iii, p. 276.

REMARKS ON DELAYED TETANUS.

THREE CASES, IN ONE OF WHICH GAS GANGRENE
DEVELOPED SEVENTY-THREE DAYS AFTER
A WOUND.

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At the 2nd Birmingham War Hospital we have had the unusual experience of three cases of tetanus occurring respectively fifty-one, fifty-three, and forty days after suffering wounds, the three cases being under treatment simultaneously.

CASE I.—*Tetanus with an Incubation of Fifty-one Days.*

Private M., aged 20, wounded August 20th, 1915, by shrapnel in the left shoulder and lower lumbar region of spine. The injured parts were treated immediately by iodine, and two hours later the patient was given a prophylactic dose of antitetanus serum subcutaneously. A few days later bits of shell were removed from the lumbar wound.

When he was admitted to the 2nd Birmingham War Hospital, on September 20th, the shoulder wound was found to be healed; the lumbar wound was suppurating, and a radiograph showed fracture of the body and transverse process of the fifth lumbar vertebra, but no foreign body. There was threatening of suppurating in the right axilla, and four days later a considerable amount of pus was evacuated from this region.

On October 10th he experienced difficulty in opening his mouth; some days later rigidity was noticed in the muscles of the back and in the sterno-mastoids.

I first saw the patient on October 30th; he was then sweating rather profusely, risus sardonicus was well marked, the masseters and sterno-mastoids were only slightly rigid, the belly muscles were very rigid; there was no distinct opisthotonos, though the muscles of the back were rigid. Antitetanic serum was at once given subcutaneously and continued until November 11th, when the tetanic symptoms had practically disappeared; altogether 37,500 units of the serum were given.

The symptoms in this case were much less severe than in the two about to be recorded.

CASE II.—*Tetanus with an Incubation of Fifty-three Days.*

Lance-Corporal M., aged 22, was wounded on September 25th, 1915, by a bullet which passed through the left forearm, fracturing the radius and ulna, and by another bullet in the upper part of the right arm. A dose of antitetanus serum was given subcutaneously two days later.

On admission to the 2nd Birmingham War Hospital on October 1st, 1915, the forearm wound was healing well; the