The Bradshaw Lecture

ON

WOUNDS IN WAR.

[WITH SPECIAL PLATE.]

BY

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It is a striking testimony to the advances made in our knowledge of the healing of wounds that one of the most important points for present consideration in connexion with the wounds of war is the geographical situation of the battlefield. In all old treatises on gunshot wounds we find that the authors devoted their attention mainly to the nature of the projectile and its direct effects on the tissues of the body; but, important as are still these considerations at the present day, they must now be studied in conjunction with the terrain of the war.

It is for this reason that I would preface what I have to say to you to-day with the statement that my own experiences are limited to two wars, the one in South Africa in 1899-1900, and the other the present war in Northern France and Belgium. So widely different have I found the conditions of the wounds in these two campaigns that I realize it would be unwise to speak too dogmatically of wounds in those many other fields of the war now being waged in different parts of the world. I propose, therefore, to speak only of the wounds I have seen during the past fifteen months, for it was in September, 1914, that I went to France, at a time when the battle of the Aisne was in progress. From that time until the second week in October I was chiefly occupied at the hospitals at Rouen, although I also visited Paris and its neighbourhood.

Early in October, however, I was directed to join the General Head Quarters in the North of France, and ever since that time I have visited daily the various casualty clearing stations at the front, and have also seen from time to time the work done in the field ambulances. My experiences, therefore, are on the whole concerned with recently wounded men, but many of these latter have been kept under observation for several weeks, either in the clearing station or in the large stationary hospital where Mr. W. Dickie is in chief surgical charge.

COLLECTION OF WOUNDED: GENERAL CONDITIONS.

In the first place I wish to point out how radically different are the fields of war in South Africa and in France. In the former we had to fight in a very thinly inhabited country which supported very few domestic animals, and which for the most part was quite uncultivated.

The soil was dry and sandy, and in many places the rocks projected in the form of the well remembered "kopjes." The ground was uncontaminated by manure and was to a great extent "virgin soil." Rainfall was slight, cloudy days were few, and a hot sun with fresh breezes or strong winds desiccated the soil and prevented the growth of any luxuriant vegetation. The consequence of all these conditions was that, in the absence of decaying vegetable and animal matter, the soil was almost entirely free from all pyogenic organisms, and bacteriological examination proved that all forms of pathogenic bacteria were absent from the soil of the veld except in the neighbourhood of the dwellings of man.

At the present seat of war we find all these conditions reversed. The country is thickly populated with human beings and supports many cattle and pigs; the soil is a rich loam, and rocks nowhere project through it; it is more heavily manured with the excrements of men and animals than almost any other land, and is covered by luxuriant crops. Rainfall is copious, cloudy days are numerous, and in many months sunshine is almost absent for long periods. One result of these conditions is that every form of micro-organism flourishes, and even in soil

taken from a considerable depth below the surface the spore-bearing pathogenic organisms abound.

The behaviour of the wounds in the two wars presents an unfortunately grave difference, which corresponds to some extent with the conditions I have just enumerated. But, in addition to the differences in the soil and surroundings, the wounds of the South African war also differed in almost every way from the injuries of the present campaign. The "ogival" bullet of that day produced much less smashing and rending than does the pointed bullet now in use; and, while in this war the majority of the wounds are inflicted at close range by a missile travelling at the height of its velocity, in South Africa they were more often due to bullets fired at a distance of half a mile or more, and which, travelling at a much lower speed, had infinitely less power for harm.

In addition to this, shell wounds amongst the British troops were extremely rare in the African campaign, while in this war they are, perhaps, quite as numerous as those caused by bullets. In general terms it may be said that the injuries seen in the Boer war were infinitely less severe, and the complications due to them far fewer and less serious than those of the past year in France, so that it very soon was evident that we had to unlearn most of our South African experiences. I will give but one example to illustrate this. In January, 1900, two Australian troopers were sent into the Portland Hospital in South Africa, in each of whom the femur was fractured and comminuted in its upper third by a bullet wound. The injuries were three days old, and the only treatment had been the application of a small first field dressing and the bandaging of the limb to a rifle with puttees thick with dust. The blood-stained breeches had not been removed and the first dressing and the puttees had not been changed. Yet the men were in excellent condition, and their wounds never gave the slightest trouble. But similar injuries with similar treatment in the present war would almost certainly have resulted in the death of the patients from gangrene, or at least in prolonged suppuration and probable loss of the limb, and many surgeons who are familiar only with South African conditions seem unable to realize the completely altered picture of the present war.

I am very well aware of the difficulty of explaining with sufficient clearness the conditions under which our men in France are wounded and treated; nevertheless, before I attempt to describe the general nature and treatment of their wounds, I will endeavour to put before you the circumstances in which these wounds are received.

All are well aware that ever since the battle of the Marne the opposing armies have lived and fought in trenches, but it must be remembered also that in both of the battles of Ypres, as well as at Neuve Chapelle and Loos, and on many other occasions, there has been a great deal of fighting in the open as well. Still, the fact remains that, owing to their partially subterranean life, men are usually covered thickly with either mud or dust at the time when they are wounded, and their comrades who help them are in a similar condition. When a man in one of the advanced trenches is hit and falls he lies in mud or dust, or else in muddy water a foot or more in depth. Close at hand, or else perhaps some hundred yards distant, the regimental medical officer has prepared a larger and deeper excavation commonly known as a "dug-out," and to this the wounded man will walk if he is able. If unable to walk, he must be carried, but he cannot be carried on the usual stretcher, because it is too long to pass along the narrow trench, which is rendered tortuous by the many "traverses." In these circumstances he may be carried sitting on a sack slung from a pole, if he is well enough to help himself, or else he may be taken on a "trench stretcher," which is much shorter than the usual stretcher and is a very simple and ingenious invention which has been of great service. His wound is not infrequently dressed by his muddy and dusty comrades if it is accessible to them, and in any case it is dressed in the dug-out, if not before. From here the patient has now to be transferred to the first-aid post, which is established by a section of a field ambulance at some place which is as much sheltered from fire as may be, half a mile or more in the rear. Access to this is generally obtained by passing along a "communication trench," which may be 6 ft.

or 8 ft. deep and more or less muddy or wet. The first-aid post is usually above ground, but may be in a "dug-out" or in a cellar. The patient is not detained here longer than absolutely necessary, but is transferred by a horse drawn vehicle or on a wheeled stretcher to the main field ambulance a mile or two further back. Here are either tents or buildings which have been adapted for use, and here fresh dressings and food and much-needed rest on stretchers are all provided. The wounded man is now in comparative safety, and if his injury is slight and there is no crowd of wounded he may remain here for some hours. If, however, his wound is serious or dangerous, or if a battle is in progress, he is taken in a motor ambulance to the "casualty clearing station," a very few miles further back, and usually placed so as to be just out of the range of ordinary shell fire.

These clearing stations were the invention of a date subsequent to the Boer war, and were for the first time put to a practical trial in the present war. Their personnel and equipment were provided for the treatment of 200 wounded, and they were originally intended merely to enable the field ambulances to "clear" themselves and then to pass the wounded on to the stationary hospitals or to the base. The circumstances of this war, however, soon showed that they could be made infinitely more useful than this, and before the end of the year 1914 they had been transformed into well-equipped hospitals capable of dealing with all urgent operations and of retaining and nursing those patients whom it was not advisable to send on by rail. It is into such hospitals as these that the wounded come from the field ambulances, and at which they often arrive within a very few hours of being injured.

It must next be realized that in the early days of trench warfare the long "communication trenches" of the present day did not exist, for they may take months to complete, and, as a consequence, men had usually to be retained in the advanced or support trenches till night afforded some protection from the enemy's fire, and in this way much delay necessarily ensued in getting the patient out of his muddy surroundings and to a place where he could be adequately treated. There are some trenches in which similar conditions still prevail and from which the wounded can only be evacuated after dark.

On many other occasions, after a fight in the open, badly wounded men have been left lying between the opposing trenches, because any attempt to rescue them at once drew the fire of the enemy, and might easily have resulted in the death of the patient as well as of his would-be rescuers. In such circumstances, after night-fall men will crawl in even with badly smashed limbs, and in other cases they are brought in by stretcher-bearers at very great risk. Others of them, however, cannot be brought in, and, especially after an unsuccessful attempt to capture an enemy position, they sometimes lie out for even days and nights. No doubt many such have died, and in others who have been ultimately rescued the condition of the wounds has been very bad. It was, of course, the men who were the worst wounded who had the most difficulty in getting into our lines, for those who had badly fractured legs or thighs or were shot through the head, the lungs, or the abdomen were quite unable to save themselves, and had to wait till the enemy was driven back or till darkness allowed their comrades to try and help them, in spite of the light given by the frequent "star shells" and the subsequent fire from the German lines.

One man lay out in a coppice last January for ten days with only a little pond water to drink, and lost both his feet from gangrene but escaped with his life. Another man lay for eight days in a German "dug-out" with a completely smashed leg and in constant expectation of being discovered and killed, yet he also survived after amputation of the leg.

THE MISSILES.

It is now time to turn attention to the nature of the missiles which cause the wounds we are considering, and they are certainly more varied and numerous than in any previous war. It is not yet possible to say with any accuracy what proportion rifle bullet wounds bear to the whole, and it must be remembered that the quick-firing machine gun, which has borne so prominent a part in the German armament, fires the ordinary rifle bullet, as does

also our own quick-firer. The rifle bullet of British, German, and French alike differs from all the bullets of the Boer war period. The point of the older bullet was rounded or ogival, and the whole bullet was of the same diameter in nearly its whole length. The point of the present bullet is like that of a sharpened lead pencil, and the consequence is that the balance of the bullet is altered, so that its posterior half or base is much the heavier, and its centre of gravity further back. The importance of this to the patient and the surgeon is that the bullet is very easily caused to turn completely over on its long axis and so to enter the body sideways or base first. This is all the more likely to occur because in trench warfare bullets often pass through the earth of the parapet or strike a sandbag, but it is also true that when the speed of one of these pointed bullets is much diminished towards the end of the flight it will readily turn over within the body after entering with its point first.

The German and the British bullets are much alike. Each of them consists of a soft core of lead or other metal contained in a sheath or "mantle" of hardened steel, and, though the German bullet has a higher muzzle velocity, I do not think there is much difference in the effects it produces in the human body, and I have seen a considerable number of Germans who have been wounded by our bullets. As is well known, the impact of the mantle-coated bullet on a rock or stone may break the mantle and allow the core to extrude, so that when it strikes a resisting structure, such as a large bone, it spreads and breaks up, and causes much more extensive damage to the tissues as a result. It is seldom in my experience that the bullet is broken up by mere impact on a bone, though no doubt this does occur.

The French bullet is made of a copper compound, and is solid and homogeneous throughout, so that it has neither core nor mantle. It is longer and heavier than either of the other bullets, but, as I have not seen very many patients wounded by it, I do not propose to allude to it further beyond saying that I think there is very little difference in the effects it produces on the human body.

In addition to bullets, an immense number of other forms of missiles have been employed, so that wounds have presented the utmost variety. It is not possible or necessary to describe in detail all the forms of shell, but in order to understand the nature of wounds it must be realized that shells differ immensely in their structure and in the way in which they produce injury.

1. Shrapnel.

Shrapnel shells of all kinds and sizes are characterized by the fact that they contain some 250 to 400 round bullets of lead which is in some shells soft but in others is hardened by various agents. These bullets vary in size—in proportion to the size of the shell, but are never more than about $\frac{1}{4}$ in. in diameter. The shell is usually timed by a fuse to burst in the air over the object aimed at, and the shell case being blown open by the explosion, the bullets are propelled in a cone-shaped stream whose velocity is dependent on the velocity of the shell, and is not due to the force of the explosion which bursts the shell. The violence of their impact is great in proportion as the shell is still travelling at high speed and is not too far from the ground where it bursts, and the direction of the blow is generally downwards. Wounds may also be caused by the metal case, which is a foot or more long and weighs several pounds at least, but such wounds do not differ from those caused by the solid variety of shell. The velocity of the bullets is never as great as the muzzle velocity of a rifle bullet, and, as they very quickly lose force and power of penetration, their effective range is not a long one.

2. High Explosive Shells.

These shells vary in weight from a few pounds to about a ton, and they consist of a thick iron case containing in a central cavity a violent explosive charge. The latter is, in the case of German shells, trinitrotoluene, and as much as 200 pounds weight of the latter may be present. Such shells are usually burst on percussion by a detonator which acts by the impact of the shell on the ground or on some other object. These shells do not contain bullets, and the injury they do is caused in chief part by the jagged fragments into which they are split by the explosion, and also to some extent by the impact of portions of buildings,

such as stones or bricks, which are scattered with immense force by the violence of the explosion. The fragments of the shell are always very rough and ragged, and of every variety of size and shape. For example, the base of a 17-in. shell may weigh 150 pounds, and if it struck the body of a man would completely destroy it. Other fragments may weigh a few pounds and may tear off a limb or crush it to pulp, while in the smaller shells there may be scores of fragments about the size of the end of a finger, or much smaller.

It must also be kept in mind that the mere explosive force of the gases of a large shell exercises great powers of destruction. The expansion of the gases is alone sufficient to kill, and in the only case in my experience in which an autopsy has been made, the brain was the seat of very numerous petechial haemorrhages.

3. Bombs, Hand Grenades, Rifle Grenades, Shells from Trench Mortars, etc.

All these are characterized by a shell case of iron or other metal containing a relatively large charge of a high explosive. In the German projectiles this is always trinitrotoluene. The bomb case varies immensely. In some it is composed of iron about half an inch thick, often partially cut up into segments about half an inch square. In others, chiefly German, it is composed of quite thin steel

Wounds caused by shrapnel bullets are not so extensive as the worst of those caused by the pointed rifle bullet, for although the former may make a large hole of entry they do not exercise the same divulsive or explosive force as the latter; they are, however, often multiple, and on account of the fact that this form of shell bursts in the air, the bullets very often wound the skull and brain.

The wounds caused by shell high-explosive fragments and by bombs and grenades are so infinitely various that it is not possible to describe a characteristic shell wound as a type. It may be noted, however, that, all shell fragments being rough and jagged, tear away parts of the clothing and carry the latter into the extreme depths of the wound. The large fragments tear away from the limbs or trunk huge masses of skin and muscle, so that the whole of the calf or the front of the thigh, or the gluteal or deltoid regions may be destroyed and the tissues from which these have been avulsed are themselves so crushed and lacerated that all the vessels are pulped and extensive areas die. In the neighbouring tissues there is, of course, widespread contusion and extravasation of blood, and, as a result of these injuries, the exposed muscle often loses all its natural characteristic appearance and looks exactly like a mass of mud, for it becomes a homogeneous mass of dark brown or slate-coloured matter without any appearance of striation or vitality, and, as it is quite dead, it may

Fig. 4.—Pole and sacking for sitting cases.

Fig. 5.—Major Rogers's trench stretcher in use.

Fig. 6.—Orderly carrying Major Rogers's trench stretcher.

or other metal. When a bomb or grenade bursts, the case is commonly broken up into very numerous fragments of every size, from a pin's head to a lump of metal weighing as much as an ounce. Some of these may be quite pointed, and with an edge like a knife; others are often quadrilateral. Some of the German bombs contain also irregular jagged pieces of loose metal, and others are loaded with rough iron boot nails about half an inch long and pyramidal in shape.

All forms of shell and bombs also scatter stones, earth, or sand from the parapets, and these all become projectiles, and are specially liable to injure the face, neck, and shoulders of men standing in the trenches.

THE WOUNDS.

Such, then, are the various projectiles by which the wounds of the present war are caused, and it will be readily appreciated that the wounds are as various as the projectiles themselves.

The so-called "normal" bullet wound, such as was common in the South African war, and was characterized by a tiny aperture which might have been made by a gimlet or a trocar, is in this war quite rare, and even if the entry is of this nature the exit is almost always ragged and large. In many of the cases bullets tear the soft tissues to rags and blow out the muscles and fascia through great rents in the skin, and when no bone is struck such injuries as these are always due to the discharge of the rifle at close quarters, and generally within fifty yards. When a large bone is struck the damage is yet greater, and the part looks as if it must have been struck by a large fragment of shell. This is due to the fact that the bullet, travelling at the height of its velocity, not only smashes the bone, but also imparts its momentum to the shattered fragments and drives them in every direction, so that the injury to the soft tissues is inflicted in great part by the fragments of bone themselves.

be cut away without causing either bleeding or pain. The condition is one which I have never seen in even the worst machinery accidents in civil life. In other cases fragments of big shells may tear away the abdominal wall and expose the viscera, or may carry away portions of the face or neck, while the bones of the limbs may be fractured or the limb itself may be completely shot away.

Nothing is more striking than the immense amount of destruction wrought by even quite small pieces of a shell burst by a large charge of a high explosive, for the wound in the tissues may be ten times as large as the missile. Thus I have seen a man in whom a piece of shell not so big as the end of the little finger tore a large wound in the liver and then rent completely away the whole of the hepatic flexure of the colon, while in the limbs I have seen wounds as large as a clenched fist caused by quite small fragments which evidently mainly owed their power of destruction to the extraordinary velocity with which they travelled as well as to their jagged edges.

The various forms of bombs and grenades are specially liable to cause multiple wounds, for they generally wound by bursting close to the patient; they break up into very numerous fragments, some of which are large and heavy and some of which are quite minute. At very close quarters quite small, sharp-edged strips of metal may penetrate very deeply, and even be driven into the intestine or lungs through tiny apertures, while many other men who are hit at some little distance by similarly small pieces of these bombs suffer little violence, for, as the fragments quickly lose their great initial velocity, such wounds as these are often slight. It has thus happened during the last months of the war that a very large number of men have had small wounds from which they quickly recovered, although, on the other hand, it is often noticeable that many of these grenade and bomb wounds are on the face, and that one or both eyes are often blinded by small pointed fragments or by gravel or

stones. These wounds are also specially liable to be badly infected, and for the reason that, as the bomb usually falls to the ground before bursting, it scatters showers of mud in every direction and plasters it into the wounds.

It will thus be seen that the wounds in this war are often quite unlike those of previous wars because they have been caused by new and different missiles, and it is further to be noted that the proportion of wounds by rifle bullets compared to wounds caused by shells or bombs is certainly much less than in previous wars. It is well known that never before has such extensive use been made of artillery and bombs, nor have armies ever previously faced each other over fronts of hundreds of miles at a distance of a few yards. It is this proximity and shortness of range which has caused bullet wounds to be so severe, and it is by the same proximity that the injuries by bombs have been made possible and frequent.

GENERAL CHARACTERS OF GUNSHOT WOUNDS.

The very various wounds I have thus briefly described are for the most part quite different from injuries met with in civil life, and all surgeons in past years who have had war experience have recognized that gunshot injuries form a class apart. It is of course true that a very large number of slight and superficial wounds and some cases of fracture present no striking features, but where missiles have penetrated the body at high velocity the differences between such injuries and those of civilian life are radical.

The essential nature of all accidents such as are caused by machinery in motion, by vehicles of all kinds, or by kicks or blows is a crushing and mangling of the limbs or trunk by force applied from without inwards, so that the parts involved are crushed by a comparatively slowly moving object. On the other hand, in all penetrating wounds by bullets of all kinds, and by shell fragments moving at immense speed, the main injury is done by a force of a divulsive or expanding nature, so that the tissues are torn asunder from within instead of being crushed slowly from without. It is this rending asunder which is the special characteristic of all typical "gunshot" wounds, and it has been shown that the injury caused by a bullet is largely due to the wave of compressed air which the bullet drives in front of it, and which expands within the tissues. In all wounds which completely traverse the tissues this divulsive or explosive force is present to a greater or lesser extent, and the effect produced is heightened by the resistance offered to the explosive power. The result is that the injury, instead of being limited to the tissues on each side of the bullet track—as it would be if the wound were not made by a bullet but by a trocar—is diffused in every direction, and radiates through all the surrounding structures. It is of course well known that in the case of the brain enclosed in the skull, or in the liver enclosed in its capsule, explosive effects are typical, and this is attributed to the enclosure in a strong capsule of tissues which are largely composed of water. But it is not sufficiently appreciated that these same effects are produced in every other part of the body and limbs also, and are directly proportionate both to the speed of the whirling projectile and to the resistance offered it by the structures which it encounters. The truth of this may be demonstrated on any limb shattered by a bullet or a fragment of a high velocity shell perforating it, for it will be found on examination that the missile has not only shattered the tissues in the line of its flight, but that the divulsive force has separated the fascia from the skin and split the muscles from each other along their intermuscular planes. The effect of the injury may, indeed, spread up and down,

a great part of the length of the limb, and vessels may be burst and extravasation of blood may be found far from the obvious track of the missile.

But, although the effects of a bullet or piece of high-velocity shell are so evident and extensive, it will be found by microscopical examination that they are even more extensive than appears to the naked eye, for if muscles whose sheath is yet intact, which appear perfectly normal, and are at some distance from the wound, are so examined there will be found fractures of the muscle bundles, extravasation of blood, and necrotic changes in the surrounding fibres.

This microscopical evidence of widespread injury is found not only in the limbs but also in the viscera, so that the liver and the kidney may show extensive interstitial haemorrhage and a very remarkable disintegration of the cells at a considerable distance from the site of the obvious injury. I am much indebted to Lieutenants Adrian Stokes and McNee for the following reports on various specimens they have examined, and on which, amongst others, the above statements are based.

KIDNEY.

CASE I.—Sergt. C. died about twelve hours after shrapnel wounds of the chest and the abdomen, and the right kidney presented a perforation in its lower pole. A piece of kidney was taken from what was apparently a healthy portion of the upper pole, for microscopical examination. It was hardly recognizable as kidney. There was present only a fibrous stroma of the tissue without any of the specific kidney cells, and only one or two glomeruli were recognizable. The tubules had apparently desquamated all their lining epithelium, and in a few of the collecting tubules there was present some granular material perhaps representing the destroyed cells. The whole section was full of small haemorrhages, and in places there was a slight infiltration with polymorphonuclear cells.

LIVER.

CASE II.—Pte. C. C. S., wound by bullet of anterior margin of liver, 2.30 p.m., October 6th, 1915; died 8.20 p.m., October 7th.

Condition of Liver.—The bullet had penetrated the organ close to the anterior

margin, just internal to the line of the gall bladder. The laceration extended for a depth of 1½ in. into the liver substance. On cutting the liver into two parts so as to include the line of the laceration an irregular area was observed, different in colour from the other parts of the organ, and situated almost 3 in. from the tear. No direct track could be found leading from the site of the injury to this yellowish area.

Microscopic sections from this yellowish zone showed the following appearances:

"The cells of the lobules are in many places very well preserved, the only abnormal feature being the great vascular engorgement of all the capillaries. Scattered throughout the sections, however, are numerous haemorrhages, some of them exceeding in size two liver lobules. Round the margins of the areas of haemorrhage the liver cells are definitely necrotic, nuclear staining being lost, and the protoplasm granular and faintly staining. In most places the ring of necrosis is narrow, but in others a wider area is involved in the process. In some sections areas of necrosis alone seem present, but these are evidently in relation to haemorrhages not included in the same section. No leucocytic infiltration or other evidence of sepsis is present anywhere."

MUSCLE.

CASE III.—Corpl. (S.F.), wounded by shell, 9 a.m., on October 11th, 1915. Superficial injuries to foot, hand, and sculp. Three deep wounds on front of right upper arm, just below insertion of pectoral muscles. The patient collapsed from haemorrhage on admission. Amputation was performed at the shoulder-joint on October 13th, and tissue was taken for examination from the belly of the biceps muscle, 2 in. below the lower margin of the wound, at a place where the muscle appeared to be quite normal.

Condition of Muscle Examined.—"The most interesting finding is the presence of a definite transverse rent, tearing across several bundles of muscle fibres, as seen in longitudinal section. (See Fig. 3.) The ends of the muscle fibres torn across show necrosis, and the rent itself is filled up entirely by a mass of red cells and polymorphs, showing an intense

DESCRIPTION OF SPECIAL PLATE.

[From drawings by Mr. J. R. Ford.]

Fig. 1.—From the upper pole of the kidney of a soldier who died about twelve hours after shrapnel wounds of the chest and abdomen, the kidney having been perforated through its lower pole. The epithelium of the tubuli is desquamated, and most of the tubuli contain red blood cells; on the lower left-hand side there is shown part of a haemorrhagic extravasation, in which there is an excess of polymorphs.

Fig. 2.—From the liver of a soldier who died thirty hours after being wounded. The bullet perforated the anterior margin of the liver: the section is made at a distance of about 3 in. from the laceration. It shows extensive haemorrhage, and areas of necrotic tissue in which the hepatic cells are no longer recognizable. An undamaged area is shown at the lower left-hand corner of the drawing.

Fig. 3.—From the biceps humeri, taken from the belly of the muscle, 2 in. below the lower margin of the wound, at a spot where the muscle appeared to be normal. The section shows one of several microscopic ruptures, the fissures between the retracted fibres of which are filled with blood. (In some fields the injured muscle fibres were necrosed.)

FIG. 1.

FIG. 2.

FIG. 3.

inflammation to be present. Everything points to this small tear having occurred at the time of the original injury higher up the arm.

"In other parts of the sections bundles of muscle fibres are widely separated, the interval between the bundles being filled entirely with polymorphs and red cells. One such bundle, separated from its neighbours on either side by a gap containing inflammatory cells, shows absence of all striation of the fibres, and is evidently approaching a condition of necrosis."

CASE IV.—Pte. F. (D.C.L.I.), gunshot wound of left leg above the ankle, causing compound fracture of both bones. Wounded October 11th. Amputation 24 hours after the wound was received.

Muscle tissue taken for examination from the tibialis anticus several inches above the seat of the wound.

Condition of Muscle Examined.—"The most striking feature in the sections is the wide separation of bundles of muscle cells from one another. A condition of very acute inflammation is present, all the spaces between the bundles being full of polymorphs. A distinct transverse tear is seen going half-way across one bundle. The muscle fibres involved in the tear are quite without striation and obviously necrotic. The gap between the torn ends (see Fig. 3) is filled in by polymorphs and red corpuscles, indicating, along with the necrosis of the muscle fibres, that the rupture occurred *ante mortem*, and not during the preparation of the sections."

It is very easy to demonstrate the far-reaching effect of bullets when the bones are involved, and I will quote the two following cases as striking examples.

In the first case a man was shot across the face and through the nasal cavities, the entrance wound being below the zygoma on one side and the exit through the zygoma on the other side. His symptoms were those of a man shot through the brain, and he died on the fourth day. The autopsy by Mr. Adrian Stokes showed that, although the track of the bullet was an inch or more below the level of the base of the skull, yet the latter was fractured right across, and although the dura mater was unhurt, one frontal lobe and one temporo-sphenoidal lobe were more or less pulped.

In the second case a young officer was shot across the back of the neck and became completely hemiplegic, although the wound was apparently superficial. He died in two days, and an autopsy by Mr. Stokes showed that the bullet had only broken off the tip of the sixth cervical spine. The laminae were not fractured and the dura mater was intact, yet the cord had been contused and its grey matter was broken up by haemorrhage. But it is possible also for the spinal cord to be injured by a bullet which does not even touch the vertebral column, and one patient died with haemorrhage into the spinal cord in whom the bullet had merely passed through the muscles at the side of the neck and had caused no hurt to any of the vertebrae.

Other very striking examples may be cited in which the intestines have been torn open by bullets without the peritoneal cavity being opened. In one case a bullet passed across the pelvis at the level of the trochanters, causing immediate collapse, from which the patient never rallied. He died in about ten hours, and at the autopsy it was found that the bullet had passed in front of the sacrum and had not entered the peritoneum. Yet, when the peritoneum was opened anteriorly it was found that a coil of the ileum 6 in. from the caecum had been completely torn across. In a second case of the same kind a bullet entered the upper gluteal region and emerged in the inguinal region, cutting the spermatic cord, but not opening the peritoneum. Nevertheless, the patient died from rupture of the intestines.

It will thus be seen that, whatever tissue is examined, or whatever part of the body is involved, all the evidence goes to show that in gunshot wounds the passage of the missile results in injuries to tissues which appear to be quite remote from its track, and it must be concluded that the vibrations set up by the projectile in the fluids of the body result in very widespread disintegration of both the small blood vessels and of the cells of the parenchyma themselves.

As will be seen on further consideration, these changes are of great interest in considering the resistance of the body to microbic infection.

CONDITION OF THE WOUNDED MAN.

The next matter which demands consideration is the condition of the wounded men themselves. This necessarily depends on other circumstances besides the nature and extent of the wound, for it is influenced by the time

that elapses before assistance arrives, by the amount of blood lost, by exposure to cold and wet, by want of food and drink, and by exhaustion due to want of sleep; and it is seldom that, even in the case of slight wounds, none of these factors complicate the injury.

I think that the thing that would strike most forcibly any observant person who was brought into a room filled by large numbers of recently wounded men from a big fight would be the fact that nearly all of them were asleep, in spite of wounds which one might well suppose would effectually banish sleep. There they lie on their stretchers with muddy or wet clothes, with bandaged limbs or head, quite content with the transition from the turmoil of battle to the comparative peace of a crowded room which in itself offers little comfort. Some of them ask for food, but with many this is a secondary consideration, for when a man is worn out by long periods of watchfulness and laborious work in the trenches, and when the intense excitement of fighting for life and killing other men in the midst of the crash of shells and the clatter of rifles and machine guns has passed, then there comes the reaction and exhaustion of a tired-out man and an overwrought nervous system. It is only a few of these men who are excited and talkative, and still fewer who wish to talk of their recent experiences, and those who only see wounded men in the base hospitals have little idea of the silence of a crowded room in a clearing station when heavy fighting has been in progress for a day or more.

But as the surgeons work their way from man to man it soon becomes evident that some of those who are asleep are also suffering from profound collapse, so that there are many in whom the hands and feet are cold, the lips pallid, and the pulse either very small and rapid or quite imperceptible at the wrist. The wound of such a patient may, for its own sake, demand prompt treatment, but all who have had experience know that there are hundreds of men whose best chance of life is to be kept warm and left absolutely quiet, and persuaded to take hot soup, or cocoa, or perhaps alcohol, before again going to sleep. It is at first surprising to find how many quite pulseless men will slowly pull round if they are only given time and kept thoroughly warm, and there are no more striking cases of this than men with bad compound fractures of the lower extremity, or with multiple injuries. They are indeed often so nearly dead that it may be several hours before any attempt can be made to dress their wounds, and, even with every care, there are not a few who die. The common causes of this collapse I have enumerated above, but it is often true that various causes all combine to bring about the condition. It thus happens that when a man has had a bad smash of a limb by a bullet or shell, the shock caused by such an injury is alone sufficient to cause much collapse. Yet in many cases this is followed by the anxiety of prolonged exposure to further wounds and often by hours of wet and cold spent in the open, with no food, and with an undressed wound which hourly becomes more painful. And after all this there is the unavoidable pain of moving him from the battlefield to the hospital.

It is also a very noticeable fact that in many of these cases the patients are quite unable at first to retain any food, and that, even if no food is taken, retching and vomiting are very common for many hours. This is a complication of shock of which I have had no similar experience in civil practice, but it is, unfortunately, not only common, but often serious in gunshot wounds, as men who are much in need of food are unable to retain it.

In many of these cases of vomiting, and also in all cases of severe collapse, numerous lives have been saved by the subcutaneous or intravenous injection of normal saline solution to the extent of several pints, and enemata of hot water and brandy have been similarly useful. As far as drugs are concerned, nothing has been more helpful than pituitary extract. There are also very many men who have sustained multiple injuries from bombs or shells and some of whom have had two or even three compound fractures, and no class of case suffers more from shock than this. In others of these cases of multiple injuries the whole chest or back, or the surface of both thighs or legs, is covered with numerous wounds which are caused either by fragments of the bomb or else by gravel and mud from the parapets, and, although the wounds may be quite superficial, the patients are very frequently severely collapsed. I have been in the habit of comparing

these cases of multiple surface wounds with those of extensive superficial burns where there is also much shock, and I think the two classes have much in common, for not only do they suffer from shock, but the sepsis following a burn is more than paralleled by the severe infection with anaërobic due to the multiple infection carried in by the mud and bomb fragments. As in the case of burns, also, picric acid is at once an excellent analgesic and antiseptic.

SECONDARY COMPLICATIONS OF WOUNDS.

The primary complications of haemorrhage and collapse are accompanied or followed by the secondary complications of bacterial infection, and it is practically true that every gunshot wound of this war in France and Belgium is more or less infected at the moment of its infliction. I have already described the condition of the men and their clothing, and how mud and dirt pervades everything, and bacteriological investigations of the soil, of the clothing, and of the skin, demonstrate the presence of the most dangerous pathogenic organisms in all three.

No more interesting work on this matter has been recorded than that done by Mr. Alexander Fleming,¹ in Colonel Sir Almroth Wright's laboratory, and his whole paper is well worth study. I will here only quote some of his conclusions, and, in the first place, the results of his examination of the clothing of wounded men. He says: "From this it will be seen that of the twelve samples of clothing examined *B. aerogenes capsulatus* was found in 10, *B. tetani* in 4, *Streptococcus* in 5, and *Staphylococcus* in 2, besides other organisms." It is therefore evident that the patient and all his surroundings when he is wounded are grossly infected, and all missiles which pass through the contaminated skin as well as through the clothing are liable to carry bacteria into the depths of the wound. And it must also be kept in mind that, even when no large piece of clothing is found in the wound, in practically all cases of injuries by shells or shrapnel bullets minute shreds of coat, shirt, or jersey, will be found by a careful search.

Mr. Fleming gives the following table, showing the microbic infection of 127 patients at different stages.

Time after Infection.	Total No. of Cases.	<i>B. aerogenes capsulatus</i>	<i>B. tetani</i>	Putrefactive Bacilli.		Streptococci.	Coliform Bacilli.	Staphylococci.	Wisp Bacilli.	Diphtheroid Bacilli.	Large Bacilli.
				B. X.	B. Y.						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
STAGE I: 1 to 7 days ...	127	103	22	14	5	102	37	40	9	0	2
STAGE II: 8 to 20 days ...	56	19	5	4	1	51	18	16	17	4	4
STAGE III: Over 20 days ...	27	5	0	0	0	24	19	19	16	0	6

He adds: "The spore-bearing anaërobic . . . progressively diminish in relative frequency as the age of the wound increases. . . . In the early stages these spore-bearers are present in much greater numbers than anything else, whereas later . . . their numbers are relatively few." He considers also that all the first eight of the group of organisms tabulated above are of faecal origin, including the streptococcus which is so common an infection.

The work of pathologists at the front (Major Rowland and Lieutenants Stokes and McNee) has also demonstrated the presence of anaërobic and other organisms in quite recent wounds, and the conclusions arrived at in the British army are all supported by the surgeons in the armies of our allies.

Such, then, are the main facts as to the nature of the infection of the wounded parts, and it is the result of this infection that is the all-important question which has so deeply interested not only the medical profession, but also the public in general.

TREATMENT OF SEPTIC INFECTION.

I think it may truly be said that nothing has more impressed the public mind than the septic nature of many wounds and the prolonged sufferings caused thereby. It may also be said that this sepsis came as a surprise to

most surgeons, and as a disappointment to those who had believed that in antiseptic surgery we had forged a weapon to combat all such conditions. Many, indeed, have not hesitated to blame the surgeons in France for the conditions of the wounds, while others have devised and advocated many new remedies to deal with the unexpected condition.

It becomes, therefore, a matter of much interest to try and analyse the different bearings of this septic infection and to suggest how it may best be combated.

Gas Gangrene.

In the first place we must realize that, in the gas-forming anaërobic at least, we have to deal with an infective agent which is to all intents a new experience, and not only are these bacteria found in almost every wound, but they also attack the tissues more rapidly and violently than any other organism. They are practically unknown in civil practice in Great Britain as a regular wound infection, for they are so rarely encountered that prior to this war most of the younger British surgeons had never seen a case of gas gangrene.

I will not here interpose a long description of this condition, but will merely state that these anaërobic cause an inflammation characterized by great swelling and a copious sanious discharge full of bubbles of gas. This may only result in a cellulitis, or may involve the whole of the tissues of a limb, and has a special tendency to extend in muscles. It may cause discoloration and death of the skin alone, or else the whole limb may swell enormously and be rapidly converted into a gangrenous mass of putrefying material emitting the odour of a newly manured field. The patient in the worst cases presents all the appearances associated with severe shock or collapse, is often very sick, rapidly becomes pulseless, his hands and feet become damp and cold, the tongue dry and furred, and death follows the onset of the disease within about forty-eight hours. There is often very severe pain in the early stages, and most of this is due to the extreme swelling and tension, but, as the tissues die, all sensation is lost, and the end is usually quite painless. In the vast majority of wounds, however, although the same anaërobic are present, they are comparatively powerless to do much harm, their action is localized to the wounded area, and they produce merely a local sepsis and inflammation. The question naturally arises why such very various results should ensue from the same infection, and it is a noteworthy pathological fact that the action of the gas-producing organisms is greatly assisted by the presence of staphylococci or other bacteria.

In considering the explanation of these phenomena we are at once struck by the fact that these anaërobic attack a recent wound with the most alarming rapidity, and they produce their characteristic local and constitutional effects more rapidly after being inoculated than do any other organisms. I have, indeed, seen well-marked infection with the formation of gas within five hours of the receipt of a wound, and I have seen a whole limb gangrenous in ten hours, and the patient dead from haemic infection sixteen hours from the time he was injured. It was evident, therefore, that in such cases the organisms meet with no resistance from the tissues, and the question to decide is why do not the tissues resist in some cases when in very many other wounds the anaërobic have evidently but little power for harm?

A good deal of light is thrown upon this matter by the behaviour of the anaërobic in question when a limb dies from injury to its main vessels. I have seen many cases of gangrene due to injury to the iliac, femoral, or popliteal vessels, and some due to injury of the axillary artery, and in every case but one as soon as ever the limb has died from loss of its circulation it has at once been invaded by the gas-forming anaërobic, and, if it has not been removed, typical gas gangrene has extended and killed the patient. In other patients where wounds have been infected to only a slight degree before death, as soon as death has occurred typical gas gangrene has so rapidly spread that within three or four hours the limb has become a putrefying mass.

The important facts to keep in mind, then, are, first, the extreme rapidity with which recent wounds become infected, and, secondly, the fact that these anaërobic develop most characteristically on dead or dying tissues. Keeping these in mind, we can appreciate why certain

wounds are affected more than others, for, other things being equal, it may be briefly said that "the more severe and extensive the injury, and the more the tissues are lacerated and devitalized, the more is the wound likely to be badly infected."

I have already described how the tissues are pulped by bad shell smashes and by bullet wounds with explosive effects, and I have mentioned that the muscles which have been crushed out of all resemblance to muscle may be cut away without causing pain or bleeding because they are dead. The fact is that the tissues left behind when a piece of shell has torn away a great mass of skin, cellular tissue, and muscle are either dead or partly devitalized over a very large area, and I have described how microscopical examination shows that the injury is really very much more extensive even than it appears to be. It is in the widely extravasated blood and in these dead and dying tissues that the anaërobic bacilli in particular find an unresisting prey, and it is a matter of daily experience that in the very large shell wounds of the shoulders and pelvic region, where amputation cannot be performed, gangrene almost inevitably supervenes. In simple flesh wounds it is quite rare, and the peritoneum is practically immune even when the abdominal wall is fatally infected.

Streptococcal Infection.

Much of what I have said of the anaërobic bacilli is true also of the streptococcus, which is found in such large numbers by Mr. Fleming, for Sir Almroth Wright has specially pointed out that this organism, like the anaërobic bacilli, also grows with extreme rapidity. It is therefore evident that in the wounds in France there are at least two organisms with which in civil practice in England we are not familiar, and the whole group of faecal bacilli has been hitherto comparatively unknown in modern surgery. It must, of course, be evident that the common pyogenic streptococci and staphylococci are also liable to infect wounds in France as well as in England.

Effect of Exposure on Wound Infection.

But, important as are the nature of the wounds and of the microbic infection, if we are to realize to the full the conditions that favour the growth of organisms we must turn from the conditions of the wounds to the conditions of the patients, for the wounds that undoubtedly do the worst, apart from the severity of the injury, are those in which the patient could not be rescued for some time, and has been left lying out and got thoroughly chilled, or has had severe bleeding, and these two conditions are often combined.

As I see it, the whole picture is much as follows: The man is wounded, and simultaneously inoculated with organisms which immediately fasten upon any dead tissue. The safety of the patient depends for the time on his own inherent ability to resist, and if he is collapsed from loss of much blood, and is wet, cold, and starving, his leucocyte defence is enfeebled or absent; the bacteria grow unopposed, and either destroy the unresisting dead or partially devitalized tissues locally, or else, in addition, poison him by their toxins. The condition of the man himself to a great extent determines the reaction of the injured part, and must be taken into consideration, together with all the local complications, if the infections of wounds are to be really understood.

It is very natural, therefore, that suggestions should have been made for the application of an antiseptic agent by the wounded man himself or his comrades as soon as he is wounded. But, although such treatment sounds plausible, it is really perfectly useless, for not only would very large quantities of any agent be required for the numerous large wounds, but it would be obviously useless to employ antiseptics unless they could penetrate to all injured tissues and unless the wound could at once be protected from further contamination. If the man lies in the open he cannot generally get at his own wound at all, either because of its situation or because he cannot remove his clothes, while he is also tolerably certain to be shot if his movements show that he is yet alive. Or if one pictures to oneself the wounded man lying in a deep and narrow trench, still covered by his muddy clothes, possibly in the dark, and perhaps with a broken limb, his own hands and those of his comrades grimed with mud, and no one know-

ing till clothing is removed where the wounds are situated or how numerous they are, it becomes evident that to apply antiseptics under these conditions is worse than useless, and no one familiar with these conditions would ever think of advising such treatment. It is indeed clear that the very best thing is to get the patient away as soon as is possible to some place where he can be thoroughly treated and kept in safety for a sufficient time, and in the British army that place is in some cases the field ambulance, and in all the worst cases the casualty clearing station.

Antiseptics.

It is at this stage that we find there are two different schools of thought amongst those who are not at the front as to what is best to be done in the treatment of the wound. One school, which draws its experience mainly from the surgery of civil life, would persuade us that all our wounds, if properly treated, should be completely sterilized—at a single dressing if seen early enough—by the application of this or that antiseptic agent, and can only see in any subsequently septic wound evidence that the surgeon's work has not been done as well as it ought. The other school, which draws its limited experience from this present war, asserts that antiseptics are useless as such, and considers that they should not be used at all.

I am myself very decidedly of the opinion that neither school is right, and that, on the one hand, the badly infected wounds in badly injured men can seldom be completely sterilized at a single dressing, and, on the other hand, I am quite certain that antiseptics are useful and necessary for the proper treatment of all the wounds of war, and that they have been of the utmost service.

For many years I have been on the staff of St. Bartholomew's Hospital, and I have seen both the end of the pre-antiseptic days of surgery, and the whole of the antiseptic period since Lister's views became generally accepted. I have seen many changes in methods and practices, and I know full well that in each succeeding decade the results obtained by surgery have been better and better. Consider for a few minutes what is the practice which is commonly accepted as correct for a bad compound fracture of the leg caused by the wheel of a heavy vehicle. My own house-surgeon would proceed much as follows: The patient would be deprived of his dirty clothes and washed, and would then be taken into an operating theatre where every one would wear sterilized gloves and gowns. His skin would be shaved and washed with acetone or ether, and then painted with a 2 per cent. solution of iodine in spirit. The wound would be enlarged if necessary; the dirty ragged skin edges and bits of torn muscle would be cut away; sufficient drainage would be provided; loose bone fragments would be removed; the whole wound would be thoroughly washed again and again with a solution of mercury binioidide (which I prefer to perchloride because it does not coagulate albumin), sterilized or cyanide gauze would be applied, and splints would be fitted to the limb.

And what would be the result? In my experience, in nine cases out of ten the fracture would heal as well as if there had been no wound, and the wound itself would heal either by first intention, if not too lacerated, or else by granulation with the minimum of suppuration if it was extensive and if some of the skin had been destroyed. What has the treatment effected? I should reply that it has at least mechanically cleansed the wound without adding to its previous contamination any microbes on the hands of the surgeon or on his instruments, and that further, it has rendered harmless any bacteria in the skin of the patient, and has both mechanically removed organisms already in the wound and has temporarily inhibited the growth of those remaining, so that the healthy tissues could quickly destroy them.

And if I am told that the antiseptics I have employed to the skin and to the wound itself have played no part, and that sterilized water would have done as well, I should reply that I know by experience that until we did use antiseptics very thoroughly we did not get these results, and that the wounds which have been treated in the manner described have done consistently better than those of previous years. I should add that practical experience has shown that suitable dilute antiseptics have never done harm, and that consequently there can be no possible objection to their use.

But if, on the other hand, I am taken to task as to why we cannot get as consistently good results in war as in peace, my answer is to be found in what I have said—namely, that, in the first place, neither the conditions of the patients themselves nor the character of their wounds are at all comparable; and, in the second, that the microbic infection is also quite different from that in civil life.

And if the question be asked, Are, then, antiseptics to be used in the case of the recently wounded men, and, if so, what good can be expected from them? I should unhesitatingly answer that, whenever possible all these soiled wounds should be treated just as carefully and thoroughly by antiseptics as any dirty wounds would be in any great British hospital, and that exactly the same amount of good is to be expected in recent gunshot injuries from the cleansing of the skin and of the wounds. The ordinary pyogenic organisms, at least, can be eliminated in sufficiently early and favourable cases, and the patient has in consequence a much better chance in his fight against his new enemies. If we cannot kill all the bacteria there is no reason why we should not kill as many as we can, and as we have in civilian practice already succeeded in sterilizing for all practical purposes by a single dressing very many of the septic wounds which we habitually treat, we naturally do not credit those who assure us, as a result of experimental evidence, that this cannot be done, and we not unreasonably hope that we are already succeeding in finding better methods than we have hitherto possessed for the wounds of war and the anaërobic and faecal infections. I altogether object to the attitude that antiseptics never have and never will overcome early sepsis.

The line of treatment I have indicated above, with minor variations such as more extensive excision of injured tissue, has been carried out in thousands of patients in this war, and I claim that practically all those who have had slight wounds, as well as many who have had serious wounds, have done exceedingly well. We have, indeed, had abundant evidence of this both in the way our patients have recovered, and also in the numbers of wounded men who have returned to the colours, and it should be a satisfaction to every one to know that except when overcrowded by the rush of battle the conditions for the treatment of the wounded in well-equipped operating theatres are not one whit behind the best that can be found in civil life. No better work has been done during this war in the saving of lives and limbs than the thorough cleansing and dressing of severe wounds, whether complicated by fractures or not, and except for the very great difficulties inherent in warfare which I have already described, there is no more delay in conveying the patient to field ambulances and clearing stations than in getting a patient from an accident into a civilian hospital. I am also quite certain that it is most inadvisable to teach that no wound can ever be sterilized by the proper use of antiseptics, for in the first place the statement is contrary to the experience of surgeons for many years past, and in the second it is liable to discourage well intentioned efforts.

Bad Fractures and Shell Wounds.

But if it be asked whether the treatment I have advised can be relied upon to sterilize completely the large lacerated shell wounds and the bad compound fractures, the answer must be that up to the present time neither this nor any other treatment yet adopted and described in the armies of the enemy or of the Allies can claim to have accomplished this end in this class of injury by any single dressing or cleansing, even when the wound is treated at once. It is, indeed, a notable fact that no surgeon who is familiar with the wounds and conditions at the front has ever made such a claim, and it is only those who know these wounds subsequently who are prepared with antiseptics which have each failed when put to trial. And it is for this reason and with this knowledge that we, who see these men soon after injury, say that such wounds should never be treated as if they had been rendered aseptic, and as if they could be safely closed by suture. There is, of course, no doubt that slight and simple wounds may be so completely excised that all infected tissue is removed, and all the surrounding skin cleansed so thoroughly that primary aseptic union may ensue in a large percentage, but no such result as this has been obtained in the very large lacerated wounds where com-

plete excision is an impossibility as a routine consequence of any method of disinfection at a single dressing. The best we can reckon on is that only after several or many days may the wounds become free from dead tissue and virulent bacteria.

DRAINAGE.

It is especially in these cases of bad compound fractures and in the lacerations by shells that free drainage is so absolutely essential, and my colleague, Surgeon-General Sir George Makins, directed special attention to the need for this very early in the war. Colonel Burghard and Lieutenant-Colonel Sargent were each subsequently insistent, yet in spite of this it was some time before we could get free drainage universally adopted at the front, and for the following reason: It became evident that some of the most recently qualified medical officers had been so much accustomed to deal with clean wounds which could be safely sutured, and had got so accustomed to obtaining union by first intention, that they could not believe that the gunshot wounds they treated had not also been satisfactorily sterilized. The fact is that owing to the very success attending the practice of surgery in recent years there was a certain amount of ignorance of septic wounds—an ignorance which is easily accounted for when one considers how very little suppuration is to be found in the wounds in all civil hospitals of the present day. But when sutures were finally given up and large drainage tubes were used freely all the wounds did better, and the stimulus supplied by the work of Colonel Sir Almroth Wright was of inestimable value in promoting sound practice on these lines. Let us clearly recognize, however, that the provision of efficient drainage is no new thing, and that it is, of course, quite easy to appreciate its benefits in the infections by anaërobes when we remind ourselves of the fact, on which I have already laid stress, that the anaërobes live mainly in dead tissue and are quickly killed by healthy cells. It is not material whether they find dead muscle or dead fluid, and the surgical principle that septic wounds should be drained is an established practice of surgery and was thoroughly understood in all its bearings long before the present war supplied so large a field for its use.

MEANS OF COMBATING ADVANCED SEPSIS.

But while we should strive to cleanse all recent wounds, it must constantly be borne in mind by all military surgeons that the longer the time that elapses between the infliction of the wound and the first thorough dressing the more impossible does it become to obtain a good result. I have already pointed out the many reasons why and how this delay is so fatal, but all of them lead finally to one paramount reason—namely, that the longer the wound is left in its primitive state of blood-stained and crushed tissues, contaminated by a bacteria-laden soil and muddy clothes, the more extensive and far-reaching is the growth of the micro-organisms, and the more impossible does it ultimately become to attack them with any hope of immediate success. The more likely, also, is the patient to be already infected beyond hope of recovery, and I have known men who, before they could be rescued, were already dying of the results of the infection by gas-forming organisms. How, then, are we to treat cases where advanced sepsis is definitely established beyond hope of early sterilization?

Hypertonic Salt Solution.

We have the choice between the hypertonic salt solution of Sir Almroth Wright and the use of antiseptics, and each of these has many supporters. The object of each is the same in reality, for it is recognized by the advocates of both that it is necessary for dead tissue to be disintegrated or cut off as sloughs, and for granulation tissue to grow before healing can take place; and as one watches the blood-stained unhealthy discharge from the dead and dying tissues give place to the formation of pus by healthy granulations, one appreciates more clearly than ever before why the older surgeons spoke of "pus laudabile et bonum." They understood that when the velvety granulations and the creamy fluid appeared destruction had ceased and repair had begun, and we recognize to-day, as they did, that there is such a thing as a relatively "healthy suppuration."

I think that those who prefer antiseptic to saline treatment have found, as in all sloughing wounds and cellulitis of civil practice, that nothing is so good as prolonged immersion in an antiseptic fluid; but unfortunately most of the wounds are not so situated that this is possible. When this is the case then the next best thing is to employ constant irrigation, and very many wounds have done exceedingly well under this method, whether saline or antiseptic fluids have been used. But, whatever fluid is employed, every surgeon knows by an experience which is far more valuable than any other source of information that good results in complicated wounds can only be obtained if the treatment of the wound is varied according to its conditions. It could only be inexperience of wounds that would limit a surgeon to a single form of lotion, and it is the merest truism to say that in complicated and septic wounds a change of lotion or other application is as necessary as is a variation in the diet of the patient.

It has seemed to me that the period during which the saline hypertonic treatment is useful is strictly limited to the separation of sloughing and unhealthy tissue, and that once a granulating surface is obtained throughout it had better be abandoned, for it is generally painful, and if it is continued the skin becomes irritated, the granulations often become exuberant and flabby, and the healing process is correspondingly slow. The use of such well-tried applications as silver nitrate and zinc sulphate may then well prove more beneficial than that of the most potent solution of antiseptics or salines, for to treat wounds according to the daily report on their microbic infection to the neglect of all else is as foolish as it would be to treat every symptom of an illness rather than to treat the patient who is ill.

Hypochlorous Acid.

Within the past few months the treatment by solutions of hypochlorous acid has been most extensively tried, and the methods of producing it, advocated by Dakin and Carrel and Lorrain Smith respectively, seem to most observers to be equally good. Personally I may add that, as far as I have seen, there is nothing to choose between the two solutions, and I think I may safely say that almost all surgeons are pleased with the results obtained in the early treatment of recent wounds, and many have given up other methods in its favour. Where wounds of the hands and feet have been immersed in the solution, they have cleared up with great rapidity, and where extensive lacerated wounds and bad compound fractures have been treated by irrigation many patients have done extremely well. I think that wounds of this class have done better under treatment by hypochlorous acid than under any other, but I cannot say that they have become sterilized as rapidly as the cases recently described by Carrel, and I do not think that the good results he obtained were in wounds of the class I specially refer to—namely, extensive lacerations by shells and bad compound fractures. It is, however, my very decided opinion that the hypochlorous acid treatment is an important advance, more especially when used in recent wounds and before suppuration has occurred, and I find that it has to a great extent displaced all other forms of treatment in many of the casualty clearing stations. It is generally believed to have prevented the occurrence of gangrene in many bad lacerated wounds and to have arrested its progress in others; and, although I am well aware that it has not always been successful, I consider that it has already been productive of very much good and to be more useful in this class of wound than any other application we have yet tried. It is also a very remarkable fact that, unlike most antiseptics, it can be used in solutions sufficiently powerful to destroy virulent microbes very quickly without at the same time injuring the tissue cells. It should, however, be only used in solution, for if used as a powder, it, like many other powders, is liable to form hard lumps, which obstruct free drainage and so counteract its good effects.

CONCLUSION.

I have now, Mr. President, completed the task I set myself at the beginning of this lecture, and I have placed before you as well as I am able to do in so brief a space of time the circumstances and conditions of our wounded

soldiers in France and Belgium and the nature and treatment of their wounds.

But there remains yet a duty which I feel I owe both to the army itself and to the medical profession at large, and that duty is to express to you how deeply I feel the whole country is indebted to the medical officers in whose hands are ultimately placed the duties of caring for our sorely tried soldiers.

I do not propose to say one word about the general efficiency of the corps to which I have the honour to belong, for it needs no words of mine. What I do wish to say is that nothing has impressed me so forcibly or so favourably as the qualities of many of the younger surgeons on whom has rested the chief stress of the actual treatment of the wounded. There is not a medical school in Great Britain or Ireland that has not reason to be proud of its pupils, and the work of the surgeons has been equalled and supported by that of their pathological colleagues.

I do not know whether to admire most the energy and keenness which has enabled the staffs to work days and nights without adequate rest, or the technical surgical skill in the complicated and difficult operations on the abdomen and limbs alike, which has been so conspicuous a quality in so many officers. The care, the zeal, and patience displayed in efforts to save limbs and life have been no less praiseworthy than operative dexterity.

The Royal College of Surgeons of England has influenced and guided the teaching of surgery during many years, and all who have shared in this responsibility may feel a legitimate pride in the splendid work now being done by its pupils. "The tree is known by its fruit," and the future of British surgery is in safe keeping, for many of the best brains and hands which guide its course are yet young.

REFERENCE.

¹ *Lancet*, September 18th, 1915.

IODINE AND SODIUM HYPOCHLORITE AS WOUND DISINFECTANTS.

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WHILE the use of iodine and the recently revived hypochlorites as surgical disinfectants is of old standing, very little in the way of laboratory records of their efficacy, particularly with regard to the special difficulties occasioned by the sterilization of wounds, is to be found in the literature, and although the actual lethal effect of a disinfectant on the bacterial flora of a wound to which it is being applied is only one of a number of qualities desired from an antiseptic, it has been thought of interest to carry out a number of comparative tests with phenol, iodine, and Dakin's hypochlorite solution. Noguchi,¹ Turner and Catto,² Kutscher,³ Brünning,⁴ Réclus,⁵ Firth and Macfadyen,⁶ among others, have investigated the sterilizing power of iodine, but in most cases from the point of view of its application to the skin before operation, in the manner advocated by Grossich.⁷ Based for the most part on the older thread and garnet methods, the results are in marked conflict. Firth and Macfadyen employed both the thread and Rideal and Walker's drop method, and used as test bacteria *B. prodigiosus* and *B. typhosus*; with the latter they determined as well the efficiency of iodine in the presence of a certain amount of urine.

In the experiments which are described below the drop method was followed; the organisms used were *Staphylococcus aureus* and *B. oedematis maligni*, as examples of the sporing and non-sporing groups; and, as a test of the efficiency of the disinfectant in the presence of organic matter, in one series disinfection was carried out on bacteria suspended in distilled water; in another series on bacteria suspended in sheep serum.

In the case of the staphylococcus, an emulsion was prepared in distilled water and in serum from a twenty-four hours agar shape culture. These suspensions were then counted in Thoma-Zeiss slides; the predetermined density was effected, and to 4 c.cm. placed in a sterile test tube were added 4 c.cm. of disinfectant. In this way both emulsion and disinfectant were diluted one half, and it is in this ultimate working strength that the disinfectants