OUNDS OF THE HORAX IN WAR

J. KEOGH MURPHY

OXFORD
WAR PRIMERS

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PREFACE

I WAS asked by the Editor of this series to write a short practical account of wounds of the thorax received in war for those who have begun the art of repairing wounds inflicted by their 'brethren'.

At the present time, it is obviously useless and undesirable to attempt to introduce statistical results or other statements marking out special cases. I have therefore endeavoured to make the account the result of my own personal experience as well as of those with whom I have been brought into personal contact; and I must leave the statistics of these inquiries to be dealt with in full by others when the time has come to collate from many different sources the general results of injuries in the Great War, and these will no doubt show wide differences in various theatres.

I desire to express my thanks to the Director-General of the Naval Medical Service for his permission to publish this short account. Also to Colonel Sir G. H. Makins for much help received from his writings and for his kind permission to make use of some of his illustrations, and to Professor Robinson for the same friendly courtesy.

17 DEVONSHIRE PLACE,
July, 1915.

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WOUNDS OF THE THORAX IN WAR

CHAPTER I

THE CAUSES AND GENERAL CLINICAL FEATURES OF WOUNDS OF THE THORAX IN WAR

Even from the earliest days when prehistoric man warred with his fellows, the greater apes, a multiplicity of weapons to produce the desired consummation—to wit, the death of his foe—were introduced.

In the present year of grace, though the number of scientific weapons used and the methods of their use have widely expanded, there seems to be some reversion of type, and the effects of the cruder weapons which produce mere wounds may be regarded under two categories: (1) those produced by cutting and stabbing implements, by ragged edges such as shell fragments, fragments of bombs, grenades, and the like; and (2) the more highly specialized wounds produced by bullets, whether small-bore rifle, or shrapnel, or revolver.

1. These all produce lacerated wounds which, if they penetrate the thorax, are liable often to be exceedingly grave, and in some cases immediately fatal.

Bayonet Wounds.—Not so common in our hospitals owing to an admixture of science and prudence in our adversaries. The long sword-bayonets of our own troops closely resemble alike those of our allies and enemies. Nearly all produce a penetrating wound of the thorax, which may go through a rib or ribs, and if it is close to the middle line the probability is that such a wound will prove immediately fatal. It is to be remembered that many bayonet wounds of the thorax slip off along the ribs and tear the muscles, emerging in the back. As a rule, a bayonet wound is septic from the beginning, and hæmorrhage is severe.

Sword Wounds.—These are either of a cutting character or the result of a stab, which produces much the same effect as a bayonet wound. In both cases hæmorrhage is severe and the outlook is of the worst. Very different are these from the old rapier wounds, which would appear to have usually run much the same course as a modern bullet wound.

Shell Wounds.—These are of endless variety. They are caused by the explosive energy of a bursting shell. The solid wall of the shell is split into all kinds of fragments which, it would appear, vary very widely. The outer part of the shell, in many cases, is covered by a certain amount of paint or carboniferous material. This is generally burst into many minute fragments. Next follows the main body of the shell, and here the character of the fragment appears to depend on the composition of the shell itself as well as the amount of bursting charge. The cast-iron shell recently known as 'Turkish Delight' would appear

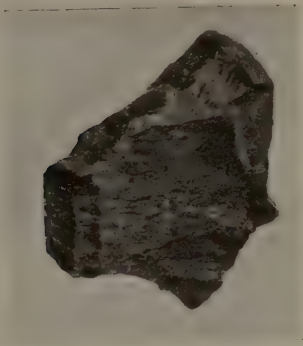


FIG. 1. Cast-iron fragment of shell from H.M.S. ——, Dardanelles. Actual size.

FIG. 2. Fragment of steel shell from H.M.S. ——, Smyrna. Actual size.

to usually burst into more or less rectangular fragments ; whilst the steel shell bursts in sharply-pointed pieces along the main axis of the shell.

A

It is said that in larger shells the nose and cap of the shell are blown off whole, or nearly whole. The main body of the shell is blown outwards in fragments. The fuse of the shell is usually blown off whole and frequently lodges in the body, causing a most serious wound. The inner part of the shell near the explosive

contents is again covered with some black material resembling paint, and this is usually blown away in showers. To show how widely different are the

B

FIG. 3. Part of nose of shell fired from *Scharnhorst* just before she sank. Actual size. A, external aspect; B, internal aspect.

wounds caused by a shell explosion even in the open, I may quote the case of two officers and five men standing together on the quarter-deck when a

shell of some size exploded just behind them, all being close together. Two were blown to pieces, probably by large fragments; the third had an enormous lacerated wound of the thigh, but no fragment was to be found. The fourth and fifth had lacerated wounds, one of the ankle and two of the shoulder carrying away most of the top of the humerus. Number six, a few small shell fragments, none larger than a threepenny piece, none of which had penetrated below the subcutaneous tissue. Number seven, from the back of his head to the soles of his feet was one mass of minute shell fragments, as in number six, and, in addition, very numerous minute black specks, probably due to the paint of the shell, had entered under his skin, or had produced small burns—which, it was impossible to say.

The results of the bursting of a shell in a confined space where many men are, scarcely bears description.

All shell wounds of the chest are wide and ragged; many of them do not penetrate; those that do, produce large open wounds into the pleural cavity, through which the air whiffs in and out, and many fragments are retained in the chest. Some pass through the chest, but as a rule, in non-fatal cases, they are liable to remain. The shell wounds from the larger fragments are, not unnaturally, most of them immediately fatal. With regard to after-effects, without exception, wounds caused by shell fragments are septic, and a prolonged course of suppuration is the least serious result we have to fear.

Hand-grenade Wounds—Bomb Wounds.—These are

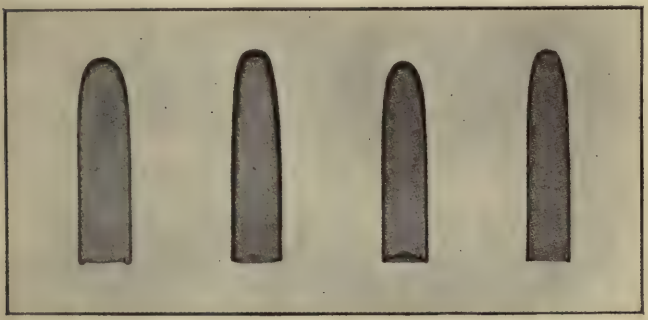
produced, on the whole, by smaller fragments than in the case of high-explosive shell. They give rise to much the same wounds. In the thorax they are usually multiple and do not penetrate with at all the same frequency.

2. **Bullet Wounds.**—The scientific achievements of mankind have, in the last twenty years, introduced many changes in bullets. The main points in a successful bullet are (1) distant range and, more especially, exact trajectory; (2) to produce a clean wound (probably of these No. 1 is by not a little the more important). Before 1889 conical leaden bullets 0·450 of an inch in diameter were used in the old Martini-Henry and Snider rifles. These were moderately exact for comparatively short ranges, and were composed of soft lead hollowed out at the base in order that the main mass of the bullet should be exploded by the explosion in the bore and so 'take' the rifling; they did not, however, easily take the rifling of the rifle and spin accurately on their own axis, 'stripping' along the 'lands' of the bore or intervals between the rifling, thus avoiding turning over the bullet and making the trajectory accurate. They also had the disadvantage (or ? advantage) of splaying out when they struck a hard substance, and thus produced frightfully extensive wounds on emergence from the body or striking a bone. From the very extent of such wounds they were often thought to be due to 'explosive' bullets. Thus they were excellent stopping bullets for all forms of game from man downwards, but, in order to stop their man, they

had to get there first, and this, owing to their weight, softness, and comparative loss of velocity, they did not do with the desired precision. Thus the leaden conical bullet was inaccurate in aim, probably through its not taking the rifling properly owing to its softness and therefore not spinning evenly in its course. Besides, owing to its size and weight, with a given charge, the effect of gravity on the heavier bullet was obviously greater than that of the lighter, and its velocity and range were smaller. After 1889 rapid changes came over the bullets in use. The bore of the rifle was reduced from that of the Martini-Henry 0·450 inch to 0·303 Lee-Metford, and the bullet was gradually reduced in weight from 480 to 215 grains. A method was found to ensure the rifling of the bullet by making the first part of the rifle-barrel into a so-called ' explosion chamber '. Here the diameter was slightly greater than that of the rifled part of the bore, varying between 0·303 and 0·309 of an inch. Thus the bullet was forced into the rifling by the explosion and rapidly turned round on its axis. The next change to be made was that the leaden body of the bullet was capped and covered in by a mantle of some hard metal. The first mantle covered the end only, but it was very soon carried along the length of the bullet so as to take the rifling, and in the more recent mantles its ends were turned in at the base of the bullet. The main body of the bullet was still composed of lead.

A mixture of copper and nickel was the usual composition of the mantle or envelope, but some nations,

notably our present adversaries, used from the first, and still use, a steel envelope lubricated with oil externally. The bore of the earlier mantled rifle bullets was as follows: British, 0·303; French, 0·315; German, 0·311; and these have not at present been altered. The small-bore rifle bullet thus made was



Guedes. Lee-Metford. Mauser. Krag-Jörgensen (steel).

FIG. 4. Section of bullets to show relative shape and thickness of envelope. (Makins.)

able to attain a great range with accuracy; the force of gravity acted less on it, and, owing to its taking the rifling accurately, it spun freely on itself as well as more rapidly, and had less resistance to the air. To give an idea of the alteration of the action of the rifling, the old Snider bullet made one complete turn in 78 inches of flight. The modern Lee-Enfield bullet makes one complete turn in 10 inches, and its initial

velocity is 2,060 to 2,440 feet in one second, known as foot-seconds.

The particulars of the more modern bullets are as follows:

British: 215 grains; diameter, 0·311; muzzle velocity, 2,060. Rifle with Mark VI ammunition, about 2,440 foot-seconds. Mark VII ammunition, 2,040 foot-seconds.

Austria, Mauser: weight, 244 grains; initial or muzzle velocity, 2,094 foot-seconds, with steel lubricated mantles; present, 2,882; muzzle velocity, 2,034 foot-seconds.

Germany: pointed steel mantle coated with nickel, weight, 154·5; diameter, 0·323 and 2·882; muzzle velocity, 2,882 foot-seconds.

Turkey, Mauser: steel mantle, diameter 0·327; bullet of copper zinc coated with cupro-nickel; m.v. 2,066; no envelope (rounded bullet has still cupro-nickel mantle); 211·3 grains.

French, Lebel: 198 grains; diameter, 2·380; 2,380 foot-seconds velocity; no envelope (bullet, copper zinc). *Textbook of Small Arms*, 1909.

At the present time we have alterations in the rifle, such as the magazine and automatic mechanisms, which introduce a greater rapidity of fire, but for the present purpose these may be neglected. Still more recently a change was made in the shape of the head of the bullet. The rounded end became more and more pointed until, at the present day, most, if not all, of the bullets in use have sharp-

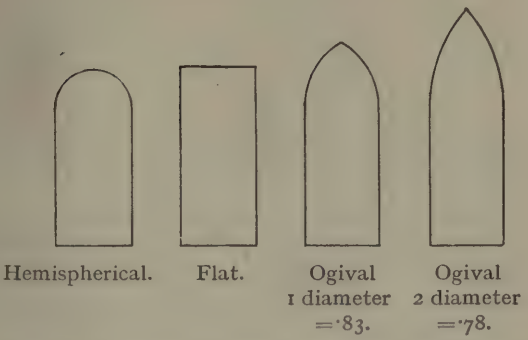


FIG. 5. Shapes of heads of bullets. (Spencer.)

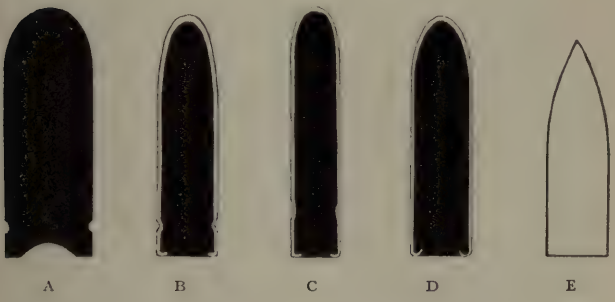


FIG. 6. Sections of bullets. A, section of Martini-Henry bullet (·450). B, section of Lee-Enfield bullet (·311). C, section of Japanese bullet (·260). D, section of German Mauser bullet (·322). E, outline of new German bullet for comparison with D. (Spencer.)

pointed extremities, inside the point of which the mantle is much thickened; the French pointed bullet has no mantle, but is homogeneous, being made of copper zinc. It will be interesting to have accounts of wounds produced by it.

Clinical Effects of Modern Bullets.—At the outstart it must be recognized that wounds from modern bullets differ widely from the old large bore. Speaking generally, the modern bullet, if it passes through soft parts and soft parts only, makes a small wound of entrance which rapidly contracts, does not bleed, and very soon resembles little more than a bite of what my friend Dr. A. E. Shipley describes as 'one of the minor horrors of warfare'. The bullet travels straight in the line of its original course through the tissues, inflicting but little damage. It would appear that it can even penetrate great vessels with a certain amount of sealing up of the holes it makes. (See case to be mentioned.) It certainly can and does penetrate coils of intestine with a like result, as I have seen in the case even of the Service revolver at point-blank range. The solid viscera can often be perforated without much damage, and the bullet finally emerges. In such cases, the point of emergence is usually oblique or round according to the direction of the bullet and slightly larger than the wound of entrance. There is also some small amount of superficial laceration of the tissues and rather more bleeding from the wound of exit. If the bullet, in such a case, is found at all, it will be but little altered in shape. In my own experience the result

is much the same unless the bullet is actually a spent one, whether the range is near or distant, and it is to be observed that wounds by spent bullets are of some rarity. The clothing is not usually carried in by such a bullet. Makins pointed out, in the South African War, that even the older types of rifle

FIG. 7. Normal Lee-Metford bullet after firing. Notice rifling on bullet. (Makins.)

bullet rarely carried clothing in with them unless loose flannel or portions of a Highlander's kilt, and, as he observes, this, at any rate, is a medical reason why the kilt should be discarded in fighting. The results of a shell wound are very different. I have seen the contents of a jacket pocket carried down inside the thigh by a shell fragment and lying under the skin below the knee. The clinical course of such

a wound is that there is usually slight suppuration at the entrance and exit wounds, probably produced by organisms in the skin acting on damaged tissues, but the main track of the wound heals without any septic symptoms and may, indeed, be regarded as sterile. Thus, the modern bullet wound in the soft tissue is eminently a merciful wound. Far different, however, is the result when the bullet either strikes the ground before entering the patient or strikes a bone during its course through the patient or even some hard substance contained in the patient's pockets or garments. The hard superficial envelope at once splits and breaks into one of a thousand different shapes, the lead following it splays out into a flattened horror of sharp angles and edges or perhaps into an infinite number of small sharp fragments. The lead core either follows it or perhaps takes a different course. One or other shatter the bone and splinter it in a variety of ways, and the course of the bullet is usually deflected until the fragments of bone and bullet alike either remain fixed in some part of the body or are driven through the skin. Here they tear everything they go through, and ultimately, on their emergence, form a lacerated wound often known as an 'explosive' wound, which bleeds very freely and through which project torn masses of muscle, tendons, or even fragments of bone. Such wounds are septic throughout. The tissues are badly damaged and form an excellent nidus for organisms of all kinds. There is very extensive sloughing and suppuration, which continues until the foreign body or bodies are

removed, as well as any loose fragments of bone. Still worse is the result of such a bullet wound if, after hitting a compact bone, it strikes a substance of even slightly lesser density than the rest of the tissue, such, for example, as the liver, kidney, or heart. Here the fragments tear, and disintegrate the organ and produce most extensive shock and hæmorrhage. Such, then, are the characteristics of a small-bore bullet wound when it has struck either a bone or the ground before entering the patient's body, or a bone after entering it. It is to be remembered that, in far the greater number of small-bore bullet wounds, the bullet leaves the body. In the Russo-Japanese War, where more or less rounded envelopes were used, only three or four per cent of the bullets were estimated to have entered the body and there remained.

Special Characteristics of Bullet Wounds of the Thorax.—Such wounds are naturally common in men advancing under fire without cover. A very large number of the wounds at the landing in the Dardanelles were of the thorax or abdomen. In such cases, a bullet wound of the thorax is usually transverse, and its results are much better than similar wounds in the abdomen. When the men are lying down and firing, longitudinal wounds of the head, neck, and thorax are usually more frequent, and it is to be remembered that such wounds are much more fatal. One fact is of considerable importance, that the results both immediate and remote of the bullet wound depend rather upon the amount of damage

done to the anterior and posterior chest walls than on the perforation of the lungs. The lung being an elastic organ readily contracts after a small-bore bullet has perforated it and thus checks most of the bleeding. Indeed, healing of the pleural surface of the lung itself takes place with great rapidity; so much so that, within three or four days of the injury, it will be difficult to find post-mortem the actual track of the bullet through the lung. If the bullet wound is in the neighbourhood of the middle line, its fatality is greatly increased. Wounds of the great veins or great vessels at the root of the neck or the lung root on either side are probably always immediately fatal.

Wounds of the Heart.—In earlier writings, it has been stated that no perforating wound of the heart is recovered from, and that all wounds of the heart are immediately fatal. Makins, writing in 1901, admitted that some wounds of the heart might be sealed up, and it was suggested that, owing to the movements of the heart in contraction, the heart can move away from a bullet or, again, from the loose tissue in which the vessels of the posterior mediastinum as well as the heart lie; a bullet in its course can push them aside. Such an explanation appears to me highly improbable. Before the present war, it is well known that there were cases on record in which revolver bullets had actually been removed from the wall of the heart itself. Cases are on record in the Boer War where, from the line taken by a bullet, it would appear that the heart must have been

perforated in several places by the bullet. I have seen no less than four such cases ; in three of these the bullet entered in the third and fourth spaces just internal to the right nipple, to emerge close to the angle of the left scapula. In none of these was there much disturbance of the heart's functions, when seen. All tended to a slow pulse ; in one only was there any local symptom of pericardial friction near the apex. I have also had under my care a case of very extensive shell wound. Here I opened both sides of the chest for pyothorax and had subsequently to drain the pericardium, removing a large part of the sternum which was smashed by a fragment of shell. I was able to observe a tear ascending upwards along the right ventricle on to the right auricle, but there was no perforation. I believe the patient subsequently recovered.

With regard to the effect of a bullet passing through a rib, it is to be observed that ribs are usually broken by the bullet, but the bullet is by no means less splayed out in so doing. The cancellous tissue of the rib is usually so large in amount that the bullet goes through it, making very often a neat round perforation. On the other hand, splintering may radiate from this perforation. The same holds good for the sternum, and, as a general rule, it may be said that a perforating wound of the thorax, as far as the exit wounds are concerned, presents nearly the same characteristics as does a wound through soft tissues only. It is very different when the bullet strikes part of the vertebral column. I can

well remember a case illustrating this point. A bullet entered through the left front of the chest downwards and backwards. It escaped in some way, and passed inwards, perforating apparently two ribs, part of the spleen, stomach, and probably the upper pole of the left kidney. It then struck the spine, splayed out, and destroyed the whole vertebral column and lower

FIG. 8. Grooved Mauser bullet removed from abdominal wall after crossing the ribs: grooving probably due to impaction on the ribs.

end of the spinal medulla, leaving a hideous wound of exit extending to the depths of the spine nearly the size of a saucer. The unfortunate patient suffered only from paraplegia, and the rest of the course of the bullet caused no symptoms.

Revolver Bullets are at present in a transitional state. The older revolver bullets are still conical leaden bullets, and have a muzzle velocity of 1,150

to 1,400 (Mauser) foot-seconds (Colt's 1,300 foot-seconds). At short range, the results produced by firing them closely resemble those of the old leaden bullets. Naturally, they do not penetrate as far, and they are apt to be diverted in their course by bones rather than extensively fracturing them. If they leave the body, they form a small explosive exit wound. The track of the bullet is uniformly septic. The automatic pistol bullet has a rather high velocity, extending from 1,800 to 2,000 foot-seconds in the larger pistols (Colt's automatic 1,300 foot-seconds). Its calibre varies, a favourite one being rather larger than the rifle: 0·350 (Colt's automatic), the so-called 0·380. The bullet is provided usually with a partial cupro-nickel envelope. This gives rise to very considerable splaying of the leaden core if it strikes any hard substance, even though the envelope itself may not be split. The weight of the bullet varies between 85 and 105 grains. (*Textbook of Small Arms*, 1909.)

Shrapnel Bullets.—Shrapnel is held to be the principal projectile of all modern field artillery, forming, in the U.S.A. artillery, 80 per cent of the ammunition supply. Special leaden bullets of varying size are contained in a shell which was first filled between the interstices of the bullets with a bursting charge; in later forms the bursting charge is contained in the base; the bullets are moderately soft and have no envelopes, and are composed of lead hardened with antimony. On the outer shell envelope bursting they are scattered in various directions by

the explosive, and, by striking each other, often become irregular in shape before they strike any other object. The balls are usually surrounded in the shell with a smoke-producing matrix so as to show the position of bursting. The present-day shrapnel has the bursting charge in its base, the outer case is strong and remains intact, the apex of the shell only is blown off and, like the cap of common shell, often causes a desperate wound. The bullets are usually about 0·5 in diameter, the area of dispersion of the bullets is about 100 yards by 150, with an effective zone of 30 × 20 yards. At 6,500 yards, the shell itself has a velocity of 565 foot-seconds; bullets on bursting have a velocity of 300 foot-seconds, therefore the total velocity of the bullets would be about 865 foot-seconds. Thus they have a very low velocity; they do not penetrate far, and many of them remain in the body, a large number immediately below the skin or in the superficial muscles; they produce jagged painful wounds which *are always septic*; they do not usually produce extensive fractures when they strike bones, but more commonly indent the bone and remain in the indentation they have made; they should be removed when possible; they are especially prone to lodge in the chest wall in a rib or below two ribs.

CHAPTER II

THE IMMEDIATE EFFECTS PRODUCED BY WOUNDS OF THE THORAX

Death.—Most of the observers on the actual battle-field are agreed that immediate death from wounds of the thorax is by no means as common as one might at first imagine, for the proportion of wounds of all kinds which are situated away from the fatal middle line is very large indeed. Again, wounds of the thorax from side to side have a wonderful way of missing the great vessels, whether of the lung roots or posterior mediastinum; instant death probably only takes place when the heart itself is perforated and extensively lacerated. Death is probably inevitable but delayed for a little when the great vessels at the root of the neck, or lung roots are freely perforated, unless in those cases where the wound communicates freely with a large bronchus and the patient is immediately suffocated by aspiration of his own blood through the lungs. It must be remembered that there are grounds to believe that even cases of perforation of the great vessels are not uniformly fatal, and every attempt should be made to save life to the very last. (I refer to such a case under 'pseudo-perforating wounds of the thorax', page 39.)

Shock. — It is remarkable that the amount of shock resulting from a wound of the chest entirely

depends upon the damage done to the thoracic wall. In a case of extensive fracture of the ribs, or of a bullet ploughing up the posterior part of the chest wall, shock is usually profound; but the amount of shock has no reference at all to the injury of the lung. Shock in wounds of the chest is readily overcome; indeed, it may be said that, if there were more shock, it is probable that the results of such wounds would be better. For, above all, in these cases, nature demands absolute and perfect rest. It is indeed strange to see a patient with a grave and serious wound of his chest suffering less shock than his more unfortunate neighbour with a perforated foot or toe.

Pain.—There is little pain in connexion with wounds of the chest. Many assert that they have had no pain at all; that something merely 'came and took the wind out of them', and that, after they got their breath again, they were quite right. They complain about a certain amount of pain and tenderness about the point of entry and exit due to fracture of the ribs. It is also worth remembering that a bullet under the skin of the back sometimes gives rise to the most acute pain from the very first.

Partial Recovery.—It is not surprising, considering the small amount of shock and the absence of pain, that, after a very short interval of time, many cases of punctured wound of the chest jump up and endeavour to resume their place in action. Such cases should be especially looked out for, because nothing is more certain than that early motion and

muscular effort have the gravest possible effect on recovery.

Dyspnœa.—Most patients complain, at the very beginning, of great difficulty in getting breath, and oppression of the chest. This soon passes off. On observing the wound of entrance, some observers believe that, in penetrating wounds of the chest, there is a lack of mobility of the chest wall on the affected side. In later cases, this lack of mobility certainly occurs. In early cases, my own personal experience is not sufficient to make me contradict this assertion, but the accounts I receive from my friends are very contradictory on this point.

Hæmoptysis.—Immediately after a perforating wound of the chest, hæmoptysis is not common. We must except those cases where blood pours forth from the mouth either through the laceration of a great vessel communicating with the bronchus at the lung root or the trachea, or even where blood is continuously vomited up owing to a wound of the œsophagus and aorta. All such cases as we have already suggested are rapidly fatal. In the more usual case, an irritating cough begins soon after the injury, and this is rapidly tinged with blood. This bleeding with a cough is never severe, and rarely enough to give rise to any danger. There is little anxiety on the part of the patient, and one cannot fail to contrast it with the profuse hæmoptysis of phthisis and the accompanying restlessness, shock, and grave apprehension of the patient.

Vomiting and Hiccough.—These are rare symptoms

of perforating wounds of the chest, but are of the greatest importance. They are probably pathognomonic of perforation of the diaphragm, and will be dealt with later. See page 95.

Immediate Treatment.—The ideal treatment is simple, but it is equally impossible to attain under war conditions. The patient and his chest should be kept at absolute rest, turned, if possible, on to the affected lung for that purpose, neither moved, nor shaken, nor spoken to, nor interfered with in any way. All these conditions are obviously Utopian. Rest is impossible, at any rate a permanent rest is much more likely to be added to a temporary. The patient must be brought to a protected area and disposed of. Artificial rest is obtained by giving the patient at once a hypodermic of morphia; atropine grains $\frac{1}{150}$ had best be given with the morphia, and he who thinks that a man struck down in the heat of battle will be well composed by the gentle administration of a quarter of a grain of morphia had best seek some other sphere for his activities. Half, two-thirds, or even a whole grain should be administered. The patient should be given fluids in plenty, but not alcohol. He will probably complain much of thirst, and there is no reason why this should not be soothed. The wound in his chest will probably be found not to bleed, and both wounds can be readily treated by dry aseptic pads obtained from the first field dressings. This will be dealt with later in greater detail. The graduated pad used by the Japanese is probably the best. If time or

circumstances allow, both pads can be kept in place by a strong and tight bandage. No other immediate treatment is necessary, but it must be insisted upon that, if the surroundings allow, every attempt should be made in case of perforating wounds of the lung to move the patient as little as possible. The treatment, as a whole, will be dealt with subsequently.

CHAPTER III

VARIETIES OF WOUNDS OF THE CHEST

Wounds of the Thoracic Wall Itself. Though not common in the case of small-bore bullets, wounds of the thoracic wall are met with frequently and occur in very considerable variety. In the case of bayonet wounds and fragments of shell entering the side of the chest in front and above, it is to be remembered that they will very often plough up the muscles underneath the skin, to disappear below the deeper muscles towards the axilla, leaving, in both cases, only a small superficial wound. The muscles torn away from their origin give to the finger the sense of a hole, and a diagnosis may easily be made of a penetrating wound of the chest itself. Very considerable bleeding occurs in wounds of the thoracic wall, especially in the case of wounds of all kinds opening up the subpectoral space, or the axilla. Another variety of non-penetrating wound is an extensive wound with comminuted fracture of the ribs. This may seem to be merely a skin track of a bullet where the bullet would appear to merely graze the side of the chest wall, producing a gutter in the skin and the superficial muscles. So great may be the radiating effect of the bullet that, in some cases, the muscles are really torn right down to the ribs and two, three, or even more ribs would be found most extensively

fractured and in fragments. I believe that, in such cases, it is rather exceptional for the pleural cavity to be opened. However, it is, of course, immediately below what must inevitably prove to be an intensely septic wound, and I would recommend, in the first instance, that a very careful search be made for fracture of the ribs in all cases of wounds of the thoracic wall, however trivial they may seem to be; secondly that, if the muscle appears deeply torn, a careful and immediate X-ray examination should be undertaken. Contrary to the practice usually observed, I believe that such cases should, at any rate, be opened up under an anæsthetic, the sequestra removed, and the wound drained. It appears to me that the risk of spreading infection deeper is far less if the proper surgical treatment of leaving the wound open and draining be undertaken than facing the danger of an inevitably foul and septic wound with sequestra which will keep up a septic condition close to or in immediate continuity with the pleural cavity. It is quite a different matter when we consider what should be done with a bullet or shell fragment. If the foreign body lies in the midst of the ribs, immediately under the wound, it can be removed at the operation; but, on the other hand, if it has tracked to one side of the chest some distance from the wound, it appears to me to be unwise to attempt to remove it except at a much later stage when there is every reason to believe that the pleural cavity is both closed and free from infection.

Wounds of the Back.—Here very extensive longi-

tudinal ploughing wounds are found in the muscles of the back. These are usually fairly close to the middle line, and, even if they cross the middle line, it is rare that they open up the vertebral canal or damage the spinal medulla. They very often destroy the skin, leaving a raw gaping track of the saddle-of-mutton variety from end to end. If they pass across the middle line, they very often smash one or several vertebral spines, and, if the wound becomes subsequently very septic, it may be necessary to remove loose spinous processes. If the longitudinal wounds are more laterally situated in the region of the angles of the ribs, or still more laterally, there may be most extensive fracture of many ribs, for here the ribs are practically unprotected. Moreover, such lateral wounds, probably from the position of the front when the shot is received, very often turn inwards below, piercing the diaphragm, liver, or spleen, and perhaps end by piercing many abdominal structures.

Shell Wounds of the Back.—The deep muscles of the back afford a convenient resting-place for shrapnel bullets and shell fragments. The smaller and more spent shell fragments may, as I have already said, be studded over the whole back; the larger produce very ghastly wounds, opening up the posterior mediastinum, tearing the lung, and frequently rapidly ending the scene by tearing through the aorta.

Concussion of the Spinal Medulla.—Examples of this have been seen in both transverse wounds of the

lower thorax and longitudinal wounds of the back, more especially in those which have divided one or more spinous processes. Here, there is complete paraplegia with absent reflexes and the usual bladder and rectal symptoms. There is either great pain in the lower limbs or else sensibility to touch is not completely absent, and this should arouse suspicion that the hope may be justified that the case is not one at any rate of permanent complete paralysis. A more careful local examination will probably show that one or more spinous processes have been neatly amputated by the bullet or shell fragment, and there is no sign of compression or fracture of the laminæ. In such a case, if surroundings permit, it is at least justifiable to cut down on to the laminæ and, if a fracture is found or any signs of bleeding underneath the laminæ, that a clot should be looked for and, if found, removed. If no injury is discovered, no further attempt should be made, the wound being drained and left open. But, on the other hand, if a fracture is found and the fragments have been elevated and removed, I believe that we should be slow to attempt any opening of the dura mater, considering the septic character of the surroundings. Concussion paraplegia is usually fairly well recovered from, and, if the case is one of this nature, some alterations in the symptoms are to be looked for by the end of the first week. If the case remains unchanged for from three to four weeks, it is unfortunately only too likely that there is some real and permanent injury of the spinal medulla. In the general nursing of these cases, one

point deserves special mention: that is, that the muscular, active individual without undue accumulation of fat is more liable to bed-sores than the obese.

'Pseudo-Perforated Thorax.'—I have ventured to give this name to those cases where a bullet has entered the upper and lateral part of the chest, pierced some part of the shoulder, and emerged again. The position of such wounds often gives rise to the very greatest difficulty in deciding whether or not they have actually pierced the lung. There may or may not be some slight hæmoptysis; there is usually considerable shock and very considerable external bleeding. The entrance wound, in our cases at any rate, was usually in front, somewhere in the first three spaces and at least an inch and a half from the middle line. According to the direction, the exit may be (1) through the coracoid process; (2) through part of the spine or acromion; or (3) even through the shoulder-joint in its upper part. If the wound is more horizontal in direction, the exit would be through the ala of the scapula, and the wound would obviously not be one which has pierced the lung. From the very thickness of the muscles, it is usually impossible to diagnose whether a rib has been broken or not; while a moment's thought as to the position of the axillary and subclavian vessels will show that there is extreme danger of injury to these; while if the wound has pierced the chest, the apex of the lung is certain to be pierced, and possibly the superior vena cava or innominate vein. The last condition may be ignored, as it is improbable that the patient

will survive any length of time. The following case illustrated some remarkable features of this variety. A.B., a marine, was shot in the left shoulder from certainly not more than fifty yards' range, and probably less; he was at once knocked out, and lay in his own blood till he became unconscious. He was rescued about half an hour afterwards; he was then pulseless, no cough, entrance wound third left space two inches from middle line; exit immediately below left acromion; minute exit wound; obvious comminuted fracture of coracoid process; he was swathed in bandages, which were soaked in blood; the bleeding was continuing. Most judiciously the surgeon who first attended him carefully advised against any interference with the bandages. During first twenty-four hours eight pints of saline were given per rectum; after continued profound collapse he improved, and after two days it was considered possible to dress the wounds. By this time there was no reason to believe that the bullet had entered the chest, and a radiograph showed clearly that the coracoid was the only bone injured. The wounds healed rapidly, the arm was unbandaged on the seventh day, and the whole forearm was now found to be paralysed. Quite wrongly, as it turned out, I came to the conclusion that the brachial plexus had been divided in the first part. A week later I cut down to examine the plexus. Fortunately, I divided both pectorals first. The axillary sheath seemed to contain an old clot, but the track of the bullet through the muscles had entirely disappeared. On opening the axillary sheath, I

attempted to clear the vein, when it became apparent that the bullet had severed the entire anterior half of the vein, and almost at the same time the imperfectly healed track burst open with the most furious bleeding. This was got in check with great difficulty, and a side ligature was put on of chromic catgut by transfixing part of the wall of the vein with it. The cords of the plexus were then examined as well as the patient's condition would admit. All were differentiated, and no trace of any injury to them by the bullet could be found. The muscles and the wound were sutured in the usual manner. Shortly after the operation the patient began to recover some use in the hand, which he very obligingly put down to a successful operation. I could not myself, however, feel entirely disposed to agree with him. The case, therefore, is of interest in that it shows (1) the great difference between the amount of hæmorrhage and shock from an ordinary perforating wound of the lung and one of these 'pseudo-perforating' cases; (2) that a great vessel such as the axillary vein was almost completely divided and was undoubtedly recovered from despite my ill-timed efforts; (3) that the damage and complete loss of function in the brachial plexus at the time was due to the radiating concussion effects of the bullet, not to any actual lesion. I should add that when I last saw the patient he could execute all voluntary movements with the left arm.

Penetrating Wounds of the Thorax.—Most of the symptoms of penetrating wounds of the thorax have

already been discussed. For purposes of comparison, it may be convenient to group them here :

1. Shock, usually slight.

2. External hæmorrhage, usually small in amount.

3. Damage to chest wall varies widely; on it the severity of the symptoms, both immediate and later, would appear to entirely depend.

4. Damage to lung. It must be remembered that the lung is a highly elastic structure ; a perforation through it is almost at once recovered from by the elastic tissues closing up the hole made in the lung and puckering the pleural surface as effectively as a purse-string suture. Probably even large vessels and bronchial tubes penetrated in the interior of the lung are sealed up by the elastic tissues surrounding them. Be this as it may, it is agreed upon by all observers that there is practically no hæmorrhage into the pleural cavity from the pleural surface of the lung. Any hæmorrhage taking place into the pleural cavities will be found to come from the injured walls of the thorax. We must, of course, except those cases in which a very large vessel, either at the lung root or a great vein at the root of the neck, has been perforated. Here, of course, the whole pleural cavity is at once filled with blood.

Hæmoptysis.—As may be expected from the above, hæmoptysis is not a prominent feature. Some slight amount of blood is spat up in the first three or four days. This rarely, if ever, is sufficient to give rise to any anxiety ; indeed, the patient usually thinks as little of it as the surgeon. All hæmoptysis is at an

end by a week from the injury, and it is worth remembering that the hæmoptysis usually ceases suddenly as distinguished from the rather long-continued rusty sputum after a hæmorrhage from a tuberculous lung.

The Mortality of Penetrating Wounds of the Chest is not without interest. In the American Civil War the average mortality of the large-bore bullets was 62·5 per cent. In the South African War, according to Makins, the mortality varied from an extreme one of 16·4 per cent to 13·4 per cent. Another point of interest is that few observers can detect any real differences depending upon the range from which the bullet was fired—that is to say, its velocity. Given a straight hit, a small-bore bullet is quite able to penetrate the soft tissues of the chest at any range.

Condition of the Track of the Bullet.—As a rule this is septic from the first at the entrance right down to the broken rib or pleura. The track through the thorax, whether aseptic or not, usually heals without suppuration ; but the exit wound again is usually septic. Both infections are probably derived from organisms in the patient's clothes or skin. If derived from the skin itself, staphylococci ought to predominate. It will be seen that this is at least not very often the case.

Traumatic Hernia of the Lung.—This may occur immediately through a free opening in the thorax made by a shell fragment. When the wound is attended to, the prolapsed lung may be returned to the chest cavity, provided that the pleural cavity is

well drained in anticipation of the inevitable sepsis that will occur. On the other hand, if there is difficulty in returning the lung, the part protruded may be transfixed, secured by a strong chromic catgut, ligatured, and cut off, the ligatured stump being returned to the chest cavity.

CHAPTER IV

LATER EFFECTS PRODUCED BY PENETRATING WOUNDS OF THE CHEST

THESE are the following: (1) Injury to the chest wall, surgical emphysema of the chest, septic fractured ribs, &c.; (2) injuries to the pleura: hæmothorax, pyothorax, pyo-hæmothorax, pneumothorax, pyo-pneumothorax; (3) injuries to the lung, continued hæmoptysis, abscess of the lung, gangrene of the lung, pneumonia; (4) injuries of the heart, pericarditis with or without effusion, pyo-pericardium, injuries of the heart wall, actual penetrating wounds of the heart (doubtful).

INJURIES TO THE CHEST WALL

Surgical Emphysema.—This is a very uncommon complication, if it can be called a complication at all. A tremendous swelling of the chest wall starts within twelve hours of the injury, beginning usually in the neighbourhood of the wound of entrance. It obviously contains gas, and it crackles under the touch. It spreads rapidly downwards over the abdomen, upwards over the neck, face, and head, converting rapidly the athletic soldier into a beatified German sausage. Its pathology is well understood; there is some communication between a bronchial tube and the wound in the chest wall; the communication

between the bronchus and the wound has probably become valvular, allowing air to be forced into the tissues on inspiration, and to be returned in them on expiration. Fortunately this condition is quite harmless, the air is absorbed, and the patient has regained his normal appearance usually under a week. The only thing that need be done is to relieve his anxiety if he should note an extraordinary change in his appearance. It may be noted that it does not tend to occur when the injury to the chest is at all extensive or serious, nor does it occur when the chest has been wounded by shell fragments. As I have said, the essence of this condition is a minute track, communicating with the lung, which has become valvular.

Septic Fractured Ribs.—It has already been said that the entrance wound is usually septic. It is impossible to have the opportunity of any exhaustive series of bacteriological examinations, but, where possible, I have had film preparations and cultivations taken, and I have been struck with the frequency with which streptococci of various kinds have been reported rather than staphylococci. The same remark holds good for the great majority of the cases of pyo-hæmothorax which have come under my treatment. The septic process would appear to be nearly always localised, and not very virulent. I have not seen a diffuse cellulitis of the chest wall myself. The fractured rib or ribs may be broken into a number of fragments, most of which will probably require removal. I have already, on page 35, suggested that it is well to open the wound freely and

drain, having in view the obviously great danger of sepsis.

Injuries to the Pleura.—These are probably by far the most important of the later results. In some cases there is a localised pleurisy with friction sounds, but this is quite the exception. It may be induced by a splinter of broken rib; it is not accompanied by acute pain, and the friction sound usually disappears rapidly. It is much more common to meet with an effusion into the chest, and there is scarcely room to doubt, even without ocular demonstration, that this effusion is blood.

Hæmothorax.—One or two points of importance come first in considering the question of hæmothorax. All are agreed that hæmothorax is the result of slow bleeding from the chest wall through the parietal pleura, and that it does not come from the perforated lung. When we consider how readily the intercostal vessels may be torn by a bullet or by a fragment of fractured rib projected by the bullet, this is not difficult to believe. Again, the frequency of hæmothorax forms an interesting study. There is no room to doubt that it is a very common and serious complication occurring in at least about 60 to 70 per cent of all cases from a gradual continued oozing from an intercostal vessel. The frequency varies enormously with the early treatment of the cases. As one might anticipate, it is much more frequent in those cases which have not had the benefit of prolonged rest after the injury, and it is especially frequent in those cases where a transit of wounded has

been rapidly effected shortly after the wounds were received. Colonel Sir G. H. Makins first pointed out after the South African War that the case occurrence of hæmothorax in perforating wounds of the chest received on the eastern side, where patients were soon brought to large base hospitals where they could lie in comfort and rest, was 30 per cent, but in those cases who received their wounds at the Modder River, where a long transit had to be made, hæmothorax occurred in no less than 90 per cent of all perforating wounds of the chest. In those cases I have had under my personal care, there can be no question of the truth of Makins's observation being clearly confirmed. The cases were of necessity rapidly shifted, on receipt of their injuries, from the shore to a ship, and had to be brought over a long sea journey before they could be treated by rest in hospital. The case occurrence of hæmothorax was much more than 90 per cent, so far as we can judge, in these patients. Makins divides such cases into (1) gradual or primary, where there has probably been a steady small oozing from the beginning; (2) recurrent, where there have been several bleedings into the pleural cavity; (3) secondary. This he considers to be of precisely the same nature as secondary hæmorrhage elsewhere, and to occur somewhere about the eighth to tenth day.

The Method of Checking Hæmothorax.—The bleeding is checked by (1) pressure of the lung against the injured parietal pleura. (2) If the lung is collapsed owing to the admission of air, blood accumulates in the pleural cavity until it exerts sufficient pressure

to check the parietal bleeding ; the blood then usually clots, and may or may not be gradually absorbed. The blood, as it does elsewhere, produces a local irritation, causing thickness of the pleura, and this forms adhesions which separate the blood-containing space from the rest of the pleural cavity. Moreover, the blood itself, partly through its own pressure and partly to the irritation caused by its presence, causes collapse of the part of the lung in contact with it, with a certain amount of consolidation and perhaps a low pneumonic process. Recurrent hæmorrhage may occur from detachment of the guarding clots allowing a fresh hæmorrhage to take place into the pleural cavity. As I have said, the blood may be absorbed and no doubt is often gradually absorbed ; the process of absorption, however, takes many months, and some physical signs of thickened pleura or collapsed lung are usually left behind. Another factor, however, must be taken into consideration—that is, the possible infection of the hæmothorax. We know that, in the case of a pelvic hæmatocele, the blood is very often infected by organisms passing through the bowel, although the peritoneum may well be believed to be not a little resistant to the entrance of organisms. In the case of the pleural sac, we are led to believe that the pleural membrane has very little bactericidal power and is not very resistant to the entrance of micro-organisms. Yet here we have a septic wound in immediate contact with what was but recently a hole in the pleura, and there is at least the probability, speaking generally, that the pleural cavity

has also been affected by the track of the bullet. Thus it appears to me to be not a little extraordinary that so many cases of hæmothorax are still said to be absorbed without suppuration, and, in the absence of demonstration as to the actual character of the fluid in the pleural cavity, I would venture to assert that many such cases are purulent. I well remember how a great clinician, the late Dr. Samuel Gee, was wont to suggest that, in the days of the great Laennec, despite all his researches and for long after his day, the majority of cases of empyema were coughed up and so cleared. Is it not possible that this may be still the case? Be this as it may, the fact remains that septic infection is at least very common. Makins (*Surgical Experiences in the South African War*) said that he had only seen two cases of 'primary' empyema. In both these cases an attempt had been made to remove a bullet. In one case suppuration occurred a long time after the removal of the bullet; in the other, the bullet was removed very late, and was just underneath the skin. My own experience in the present war has, I must admit, been widely different. Perhaps because of the exigencies of climate or transit, or some other unknown cause, the cases I was called upon to look after were all of them late cases of pyothorax. In over 70 per cent of these cases the clinical course seemed to point most clearly to the presence of pus and, in each one, I am glad to say, my belief was justified by an exploring syringe. I suggest, therefore, that, at any rate in the present time, the presence of suppurating hæmothorax must

be taken into consideration, and I venture to believe that statistics of the war will, at a later date, when ultimately collated, confirm my statement. I will return to this subject when dealing with pyothorax.

Symptoms of Hæmothorax.—These are very doubtful ; there is slight local pain in the chest, of a diffuse character. The pulse is usually not altered much in frequency at first, there is some slight pallor and inspiratory difficulty—in the milder cases the patient has little to complain of except that he resents the tedious process of lying in bed, although he begins to feel that all is not well with him.

Signs of Hæmothorax.—These are, as a rule, definite and convincing as far as the presence of fluid is concerned. They are: (1) on *inspection* a fullness of the affected side is observed more usually at the base of the chest—there is also less expansion of the side on inspiration as compared with the healthy side. (2) On *palpation* there is dullness and resistance on percussion, and it may be remarked that both these signs are even more well marked and distinct than in the case of pleural effusion ; there is marked absence of vocal fremitus—the shape of the area of dullness usually shows a convexity upwards, and in hæmothorax this shape is said not to usually alter on change of position at some points. (3) On *auscultation*, breath sounds are usually absent or very faint over the area of dullness ; at the upper margin of the area of dullness breathing can sometimes be heard, this depending upon the amount of collapse of the

lung owing to the pressure of the blood; the peculiar blowing sound on deep respiration or speaking known as ægophony may sometimes be heard above the area of tubular breathing; distant tubular breathing may be heard over the area of dullness instead of absent breath sounds; and occasionally whispered pectoriloquy; but, as a rule, breath sounds are either absent or greatly diminished; the breath sounds are the feature of auscultation.

The temperature is usually raised and irregular in type, but its elevations usually correspond to some fresh onset of bleeding into the pleural cavity; as a rule there is a primary rise reaching 102°–103° on the third or fourth day; about the seventh day there is usually a secondary rise with some sweating and quickened pulse; other cases again show recurrent attacks of fever with irregular intervals; the temperature chart is almost invariably of the 'hectic' type, and it is most rare to observe a temperature steadily raised for thirty-six hours. *Lastly*, blood may be drawn off by an aspirating needle.

Comparative Value of Signs of Hæmothorax.—Absolute dullness appearing gradually on one side of the chest is by far the most important symptom; next to this should be taken the absence of vocal fremitus. These two signs, when distinct, show the presence of fluid in the chest. The absence of vesicular breathing is more indefinite, and very frequently distant tubular breathing is to be heard all over the area of dullness in a hæmothorax; the tubular breathing probably depends upon the tubular sound

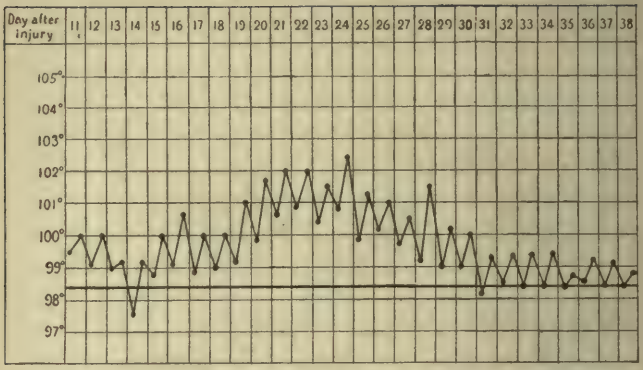


FIG. 9. Primary hæmothorax. Secondary rise of temperature with increase in the effusion. Spontaneous recovery. (Makins.)

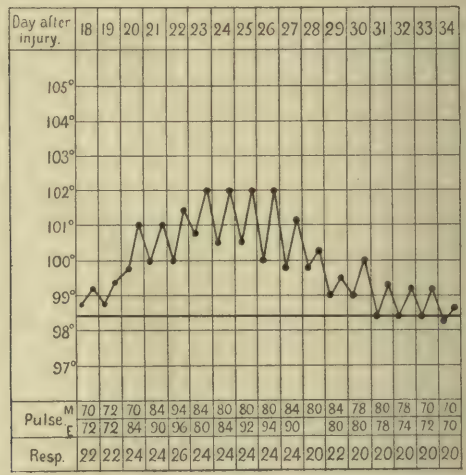


FIG. 10. Wound of lung. Secondary development of hæmothorax with rise of temperature. Spontaneous recovery. (Makins.)

being transmitted through a small part of solidified lung to a semi-solid hæmothorax—thus the character of the breathing is of little real importance, but the faint distant character of the breath sounds, whatever they may be, is of considerable weight. The

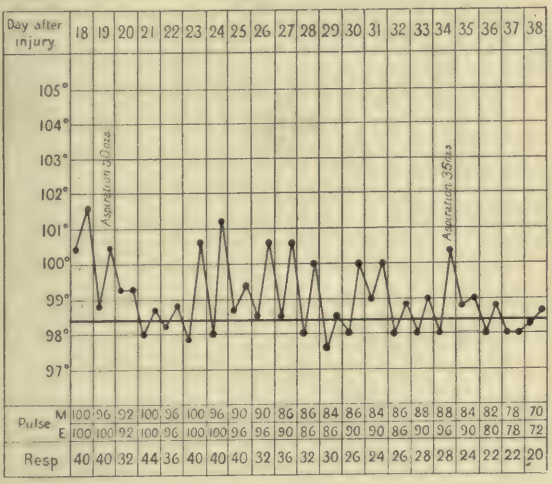


FIG. 11. Hæmothorax, primary and secondary rises of temperature on each occasion falling on the evacuation of the blood. (Makins.)

presence or absence of tubular breathing and ægophony at the upper part of the dull area is of no importance. I cannot say that I consider the absence of any change in the area of dullness on changing the patient's position to be easily made out or to be at all diagnostic of hæmothorax. Such, then, are the signs and symptoms of a moderate-sized hæmothorax. I have

purposely omitted consideration of the use of the aspirating syringe for the moment.

Clinical Course of a Moderate Hæmothorax.—Such patients nearly always recover; provided no infection of the hæmothorax takes place the blood is slowly and gradually absorbed, after first becoming coagulated; this coagulation is rarely complete, the deposit of fibrin being most dense at the periphery of the hæmothorax, and some part of the centre of the mass usually remaining fluid—the rise of temperature was originally attributed to absorption of fibrin or streptococcus débris (Makins). Such cases usually recovered, and there was very little tendency to a fatal result. Provided that the patient is kept in bed, absorption takes place slowly; the temperature first gradually returns to normal, the breath sounds over the affected area gradually gain in strength, little change is to be made out in the dullness; it is by this time not quite so absolute, nor is the resistance to percussion so marked; a few added moist sounds or crepitations may next be heard, and these may be taken as evidence of some expansion of the lung; the patient gradually recovers, and once the temperature has completely subsided for a week, he may be allowed out of bed.

In the South African War Makins considered 'that most of the cases of slight hæmothorax left the hospital in six weeks, there being then still dullness and deficient breath sounds remaining, and most were invalided home'. (*Surgical Experiences in the South African War*, 2nd Edition.)

Treatment of Moderate Hæmothorax.—There can be little doubt that the best treatment of such cases is absolute rest in bed, coupled with careful observation of symptoms; if there is no reason from the patient's symptoms to suspect infection of the hæmothorax, it is beyond question wrong to make any attempt, however skilfully conducted, to explore with an aspirating syringe or to drain the hæmothorax, and if there is reason to believe that the bullet is in the pleural cavity, nothing is gained by an attempt to remove it, provided always that there is no infection. An attempt at absorptive treatment may be made by giving large intermittent doses of iodide of potash (gr. xv t.d.s. for three days) or by gently rubbing the chest with 'iodex' or tincture of iodine may be used as a 'counter irritant'. At the same time, should the entrance or exit wounds of a bullet appear infected, great care should be taken to cleanse them locally and to allow free discharge, either iodex or carbolic acid 1 in 20 should be applied on fomentations. No attempt should be made to probe the wound in the hope of finding a bullet or sequestrium of rib, for such a procedure will effect nothing and will only carry the infection deeper. If there is reason from local signs and symptoms to believe that there is an extension of sepsis towards and round the ribs, any operation should be most carefully conducted, leaving the wound open and allowing for free drainage.

Results of Moderate Hæmothorax.—As I have said, most of these cases leave the hospital or are invalided

without perfect recovery and, indeed, with only a remission of symptoms. Their temperature chart shows at any rate that there is no recurrence of hæmorrhage, nor is there any infection of the hæmatoma; but their physical signs show quite clearly that if there is no longer a hæmatoma, there is at any rate a greatly thickened pleura and but partially expanded lung beneath it, and so they return home. It would be of great interest to know the after statistics of such cases; from my own experience of isolated cases, I believe them mostly to turn into chronic invalids, with constant pain, chronic cough and emphysema, and it is not too much to say that many of them fall victims to tuberculosis—*a priori*, what better nidus could be found for the attacks of organisms of all kinds?

Signs and Symptoms of Severe Hæmothorax.—Few, if any, patients die from the amount of blood shed into one pleural cavity, for the pressure of the distended pleural cavity will check the bleeding before a fatal result ensues, provided that the bleeding is not so sudden and profuse as to cause profound shock and cardiac failure; as we have seen, this is only likely to occur when one of the great vessels is pierced and bleeds freely into the pleural cavity; even when there is extensive parietal bleeding the amount of blood lost into the pleural cavity is not sufficient. When there is an extensive or severe hæmothorax, the following are the signs and symptoms, most of them being more marked than in the slighter cases:—

There is marked increase in the pulse-rate. The

patient usually looks and feels really ill, and is blanched ; the temperature is irregular and raised, and there are probably the general signs (tongue, skin, &c.) of a temperature which has been raised for some time. The physical signs of effusion into one pleural cavity are marked. There may probably be complete dullness, except in the apex of the lung, extending perhaps downwards to the second space. In addition there may be effusion into the opposite pleural cavity, but, obviously, this cannot be so extensive and the patient survive. The secondary or slighter effusion is limited to the base. There is dyspnœa, which is greatly increased if the patient is turned towards the sound side. Last, and most important of all, we have the evidence of displacement of the heart by the quantity of fluid. The heart's apex-beat may be displaced to the left with a right pleural effusion and to the right with a left pleural effusion. Again, along the mid-sternum, the area of dullness will overstep the middle line ; to the left in the case of a right pleural effusion and to the right in the case of a left. It is difficult to lay down any hard and fast rule as to the amount of fluid which will displace the heart. The late Dr. Gee considered that it took at least a pint of fluid, and probably a pint and a half, to alter the position of the heart's apex-beat.

In children a less amount may produce the same effect, but not so much as we might otherwise imagine, owing to the yielding character of the chest wall. In considering the diagnosis, it is well to remember

that the heart itself may be hypertrophied before the injury, and other signs of hypertrophy of the heart should be looked for. As a rule, a hæmothorax very rarely depresses the liver and spleen, and an ordinary serous effusion hardly ever. It may be taken that such cases of extensive hæmothorax are quite rare. Further, I would suggest that, certainly in view of recent cases, the larger the hæmothorax, the greater is the risk of infection. There is no difference in the treatment of these cases. An interesting fact is the very large amount of blood that may be found in the pleura without death. In one case, where there was a suppurating and stinking hæmothorax of the left side, I drained off at least three pints of foul, stinking, brownish liquid; the bullet entrance was three inches from the middle line through the third left space and third rib; there was no exit; the bullet was found loose in the pleural cavity between the diaphragm and the base of the heart and readily removed.

Use of Aspirating and Exploring Syringe.—I have purposely left this consideration till last, for I feel personally strongly opposed to the use of the syringe in all cases. In a serous effusion there cannot be any doubt that, if the effusion exists, the lung is probably pushed back, and the surgical expedient of an exploring syringe will confirm the observation of the physician. (Perhaps one should not venture to suggest that, in most pleural cases, diagnosis should be fairly certain without this.) In dealing with a hæmothorax, there is a very considerable difference

and the plunging of a syringe into the chest can hardly be considered an entirely safe procedure nor even a sure test for diagnosis. To begin with, the needle is most liable to be blocked with clot and, even before it enters the thorax, it has to pierce a thickened pleura and, possibly, an imperfectly healed blood-space communicating with damaged intercostal vessels. Time after time the needle may have to be cleared, and the clot inside, with equal frequency, returns to the eye of the needle. Again, the drawing off of blood in the chest can hardly be considered as a sure proof of the blood being in the pleural cavity. It may come from the chest wall or from a punctured lung itself. Again, there is practically no chance of knowing the exact position of the diaphragm, and this may be penetrated. It is obvious that, if we are agreed on the treatment of hæmothorax, our first and greatest care must be to protect the blood-containing space from infection, and, however careful our methods of sterilization may be, the flurry of repeated attempts to clear the needle, coupled with the annoyance of failure in confirmation of our physical signs, must always be a fruitful source of error in technique. Of aspiration of fluid in hæmothorax I have nothing to say. All will be agreed that, in a moderate hæmothorax where there is probably a good deal of clotting, aspiration will probably fail, and is always strongly to be deprecated; while, in the case of an extensive hæmothorax, aspiration of the fluid will probably cause recurrence of the bleeding owing to lessening of the pressure in the thorax.

The Risk of Sepsis.—Long ago Gee expressed his strong opinion that many cases of pyothorax of all kinds contained pus from the beginning and that serous effusions do not easily tend to become purulent but remain serous throughout. I feel that this is still true in the use of the needle. Consider that no attempt is, or should be, made to penetrate into the chest along or near the septic track of the bullet, but that a definite puncture is made where the physical signs are most marked, it is surely easy, with our present knowledge, to sterilize the skin carefully and shut in the area of puncture from all surrounding tissues with sterilized towels. If this can be done carefully, I should greatly doubt that there is any possibility of infection of the thorax. It is perhaps hardly necessary to deal with minutiæ in technique of such a simple procedure, but, in all cases, I would suggest that the towels used should be boiled for at least 15 minutes in preference to the possible risks of inefficient dry sterilization, the skin to be prepared and painted with tincture of iodine and a minute nick made in the skin by a knife and the needle then inserted into the wound. The wound should be covered in, preferably with a mixture of equal parts of collodion and tinc. benzoin co. made with ether, not alcohol. To this mixture 5 per cent tincture of iodine is added.

CHAPTER V

PYOTHORAX

I ADMIT that an uncomplicated pyothorax as the result of a bullet wound is most rare. I have never seen such a case, and can only conceive it being due to a pneumonia and consequent pneumococcal infection of the pleural cavity ; this pneumonia must have been developed before or after the bullet wound and must, obviously, be on the same side. It is hard to conceive that the bullet wound, *per se*, could produce pneumonia, for, as I have said, the wound of the lung is a comparatively trivial matter and almost immediately recovered from. When we consider the occurrence of a hæmothorax, as well as its comparative frequency, the matter becomes different, and here I will use the term pyothorax for what is really a pyo-hæmothorax ; that is to say, I believe that suppuration and breaking-down of clots with possible discharge internally or externally is the end of many cases of hæmothorax. As I have already said, infection can only too readily reach the hæmothorax (1) from the septic wound of entrance ; (2) from the septic wound of exit ; (3) the track through the pleural cavity, which may be itself septic from the beginning ; (4) from fragments of clothing or foreign bodies carried in with the bullet ; (5) from open infection from the outer air (it should be

understood that 4 and 5 are much more common in the case of shrapnel bullets or shell splinters); (6) from undetermined causes of infection either through the lung or through the general circulation; (7) in very rare cases, by communication with the œsophagus or through the diaphragm with the stomach, liver, or intestine. It may be observed that septic infection in this last class is more acute and the result uniformly fatal. In the majority of cases infection takes place, first in the fluid part of the hæmothorax, spreading externally; at first the septic process is shut in by the general circulation, and this probably explains why the general symptoms of septic infection are not obviously acute and make their appearance at a comparatively late date. It would seem, in the cases I have seen, that cases of acute sepsis do not appear to originate within the thoracic cavity, at any rate from bullet wounds. As I have said, the conditions of the present war would seem to lend themselves to the formation of empyema, for Makins (*Surgical Experiences of the Boer War*) in his very wide experience 'saw one case of primary empyema'; here a subcutaneous bullet had been removed below the right nipple. He continues that he has seen 'many secondary empyemata after *incision* of the chest or aspiration'. On the other hand, during a much more limited experience in 1914 and 1915, I have seen many cases of empyema all of which, to the best of my knowledge, originated in septic infection of a hæmothorax. I find it very difficult, for the reasons I have already given, to understand

why aspiration or exploration of the thoracic cavity, when conducted with rigorous care, should induce infection. On the other hand, it is difficult to find a reason (except when there are strong grounds to believe that an empyema is present) to explore or otherwise interfere with the chest. In my own clinical experience, I have not seen a case of hæmothorax caused by a bullet wound of the thorax become septic after aspiration, but I must admit that I have very seldom explored the chest under these conditions.

It would seem difficult to understand how the removal of a subcutaneous bullet can predispose to empyema, always provided that it is a genuine case of subcutaneous bullet and that the little operation is conducted late in the history of the case, at a time when we are reasonably sure that the pleural cavity is thoroughly well shut off—to dogmatize—not less than two weeks after the wound. Such subcutaneous rifle bullets are rare at the present time, and no one observer is likely to have removed a great number. In my personal experience, under the restrictions I have given, the operation has proved always quite trivial and has been unattended with any complications. As an example, I may take an Irishman whose entrance wound was in the second left space, in front, rather far out; there was no exit wound, but there was marked tenderness internal and below the angle of the left scapula, with possible fracture of the ninth rib. There was no sign of a superficial bullet. On X-ray screen examination, the bullet

was reported to be in the chest, immediately to the left of the spine, probably behind the lung root. The man developed a moderate-sized hæmothorax rather late ; within a fortnight his physical signs were improving and, on examining the back one day, the bullet was found lying under the skin in the spot where the original tenderness had been. The man was most anxious to remove the bullet himself and, by my obstinacy in refusing his request, I failed to retain the bullet ; it was quite unchanged in shape ; recovery was uneventful. Such 'subcutaneous bullets' usually lie in a little cavity containing some pus which has evidently a very feeble toxicity, for, so far as I have seen, on removal of the bullet the wound dries up and heals at once.

Signs and Symptoms of Empyema.—The signs and symptoms of pus in the chest are (1) firstly the general symptoms of fluid in the chest, with certain differences in the course of the case ; there is, however, (2) a second and important matter in the diagnosis, for it should be proved to the surgeon's reasonable satisfaction that the fluid is pus or is at any rate a septic fluid ; for then, and then only, should the proper radical treatment for empyema be undertaken. As we have seen, the type of empyema which most concerns us in the treatment of gunshot wounds of the chest, is not a pure collection of pus, as in pneumococcic empyema, but rather suppuration occurring in an original hæmothorax which has become infected. As I have myself failed to make out any marked difference in physical signs

in suppurating hæmothorax, I can only detail the observations of others as to *physical signs*. The appearance of the patient is often very characteristic—he looks ill and 'septic', the face has an unhealthy waxy yellow tinge, in strong contrast to his former ruddy bronzed colour; no longer does he want to return to the fray, and, short though his breath may have been before, he now feels himself ill; he wastes; takes and sleeps badly, and sweats profusely during and after short sleeps, his pulse is raised in frequency and his breathing is rapid and difficult; the alæ nasi often working; his hands are waxy yellow, and the ends of his fingers often clubbed —this last is a very important symptom; he coughs; his tongue is dry and furred and his bowels constipated; he may have albuminuria. The patient is evidently going downhill and, if this is his condition two weeks after the beginning of a hæmothorax, I should say that the pleural cavity was almost certainly infected.

Turn now to his temperature chart; this is raised and 'hectic' in character; it may or may not be very high. I have seen a stinking hæmo-empyema with a temperature whose greatest height was 99·6.

'The temperature is no guide to the nature of pleural effusion, whether serous or purulent' (Gee). On the other hand, in a case of hæmothorax, if the temperature is markedly raised in each 24 hours over two weeks from the origin of the hæmothorax, it is probable that the hæmothorax is infected.

The physical signs, as I have suggested, show little

change from those of the original hæmothorax. On inspection the affected side of the chest looks fuller, and there may be bulging of some of the intercostal spaces and perhaps redness and infiltration of the skin at some point of the chest; this, if present, makes the diagnosis of suppuration certain, and, coupled with the evidence of an old hæmothorax, it is almost certain that there is suppuration in the pleural cavity, although it is just possible that there may be acute inflammation originating in the chest-wall in an extensive hæmatoma.

As to the physical signs, absolute dullness and resistance are usually present unless the empyema is localised, interlobar or diaphragmatic; none of these conditions is at all likely to occur in a hæmothorax caused by a bullet wound of the chest.

In an empyema, signs of solid lung are often obtained, and an error in diagnosis can readily be made through ignorance of this fact.

Thus we may have tubular breathing all over the area of dullness and increased voice sounds amounting even to whispered pectoriloquy; these physical signs, however, are much more likely to be found in children than in adults. 'Bacelli's sign'—that whispered pectoriloquy can be transmitted through a serous pleurisy but not through pus—is a symptom of very doubtful value. In empyema, especially of the left side, a pleuro-pericardial friction sound is often heard; this has a dual time, being both synchronous with the heart beats and with respiration—the respiratory sound ceases on holding the breath, while

the cardiac sound continues; with these exceptions, the physical signs are the same.

We have now advanced far in the diagnosis of empyema, and if there is still any doubt in our minds, two measures still remain.

A blood count, if circumstances permit: in cases of suppuration of the pleural cavity, there is found to be an abundant leucocytosis with an iodophilous reaction of the polymorphonuclears.

Lastly, we should consider the question of an exploratory puncture. With the evidence already before us, this is as important as it can be, for it will make our diagnosis certain, and it is strongly indicated, as strongly indeed as it is contra-indicated in the early days of a hæmothorax.

A glass syringe should be used with a *sharp* platinum-iridium needle; if possible, with some arrangement to clear the barrel regularly and cover the point when the needle is in the chest cavity. (See Figure 12.)

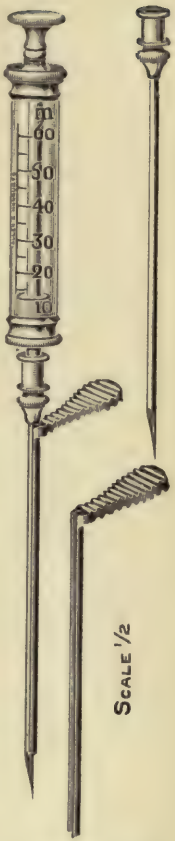


FIG. 12. A convenient form of exploring needle.

The puncture should be made in the sixth or seventh spaces in the mid or posterior axillary line—the skin is sterilized as before and surrounded by towels.

In the average muscular soldier, at this point, the depth of the pleura from the surface may be taken at 1–1½ inches—rather more than the posterior axillary line; the needle is held by the fingers at this distance from the point and plunged straight in to this depth, the skin being first steadied and drawn taut by passing the index and middle fingers of the other hand above and below one of the ribs of the space selected; the needle is usually felt to enter the pleural cavity—it may be blocked with clot as before mentioned (p. 59), and perhaps must be cleared repeatedly and turned from side to side. If the case is one of a suppurating hæmothorax, dirty brown pus will be drawn off or blood in various stages of degeneration and liquefaction—sometimes a little altered, sometimes a foul chocolate-coloured fluid, but always teeming with micro-organisms. The wound is now sealed as before and the contents of the barrel examined.

The Flora of Suppurating Hæmothorax.—First let us clearly recognize that it is very probable that there is no such thing as an entirely sterile serous effusion into the pleural cavity. As bacteriological methods become more extended, the tubercle bacillus has been discovered in *serous* effusion. B. coli, streptococci, staphylococci, the pneumococcus—each of them in considerable variety—have all been found. Investigations under war conditions cannot be very profound or lengthy from the very pressure of work. We attempted, as far as possible, to examine the contents of each suppurating hæmothorax; the

report given to me was that in nearly every case streptococci were found in all sorts of short and long chains; staphylococci were conspicuous by their absence. In most cases the infection was a mixed one, coliform bacilli being also present. In one very foul case 'B. fœtidus' was identified; but, in most of the stinking cases, the organism did not belong to any recognized type. Thus it would certainly appear that in my group of cases the skin was not the source of infection, but rather the track of the bullet and the alimentary canal or circulation, coupled with the weakened resistance of the body.

Treatment of Pyothorax.—In all cases, the last arbiter of treatment for this condition should be the exploring syringe. If the fluid in the pleural sac is found to be septic and teeming with organisms, whether it be pus or slightly altered fluid blood, one course, and one only, should be pursued. That is that the pleural cavity should be freely drained by the excision of one or, if necessary, two ribs. It is hardly necessary at the present time to point out that a small incision in an intercostal space is ineffective, and, moreover, is liable to give rise to a wound in the vessels which may be quite difficult to check, whereas, in subperiosteal removal of a rib, deep hæmorrhage is of the rarest occurrence. This will be seen to be of considerable importance.

Anæsthetic.—I am most strongly opposed to any attempt at performing this operation without a general anæsthetic. Like many others, I believe that local anæsthesia militates greatly against the healing of

the wound afterwards, and certainly a very severe cellulitis is frequently found after its use. I shrink from spinal anæsthesia above the diaphragm. I think it will be found that the objections to a general anæsthetic usually come from inexpert anæsthetists. In the hands of the expert, I have not had to fear for the patient's safety. Too much should certainly not be given; the patient should be barely under and allowed to 'come round' as soon as the pleura is opened. Most anæsthetists have their own special favourite anæsthetic. Some give A C E, some chloroform, some chloroform with warm oxygen given in varying quantities throughout the administration. From the surgeon's point of view the last mixture seems to give the best after-results. It is most important that the patient should not be disturbed in any way by noises, moving the clothes about, squeezing the hands, &c., while he is being anæsthetized. There should be no delay as soon as the anæsthetist gives the word. One of the essentials to success and speedy recovery in this operation is rapidity. The patient is turned over on the sound side as far as the anæsthetist will allow; the skin is rapidly painted with iodine and surrounded with sterilized towels; the skin over the rib selected for excision is steadied and fixed by the index and middle fingers of the operator's left hand and one bold incision made right down to the rib from before backwards. This incision should divide all the tissues right down to and including the periosteum and should be 3–3½ inches in length.

Now, with regard to the rib chosen, the 7th, 8th, and 9th are all excised by surgeons for this purpose. I would suggest the 8th as being probably the best—of course, always provided that physical signs of fluid are well marked in the place chosen. The mid-axillary line should be taken, for, if we excise the rib further back, our wound is surrounded by thick muscles which may obstruct the tube, as may also the lower angle of the scapula when drawn down. Our definite object is to drain the most dependent part of the pleura, but it is impossible to directly drain the pleura much lower down, as the movements of the diaphragm will interfere with drainage and the diaphragm itself will be close against the parietal pleura and may be injured; it may be possible by going further back, but here the operation is rendered much more difficult, owing to the position of the patient, and, when lying on his back afterwards, drainage will be obstructed.

Before returning to the operation, a word of caution may be allowed. The operator will do well to test his gloves himself before putting them on, and will do still better if he anoints his hands, before putting the gloves on, with the oily proprietary solution of iodine known as 'iodex', remembering that not a few valuable lives have been lost through a septic finger after this operation. Calmette's thick operating gloves (A. & H.) or actual post-mortem gloves may well be used.

As soon as the first incision is made, the assistant secures any bleeding-points and the operator ties

them with *catgut*; it is well to transfix the tissues at the end of the pressure forceps with a curved needle threaded with catgut and tie round the pressure forceps. This simple proceeding effectually prevents any subsequent slipping of the ligature. Retractors are now put in and the periosteum rapidly separated from the external surface of the rib with a flat or slightly curved periosteal elevator. Next it is cleared from the under surface of the rib and the subcostal groove, either with a curved elevator or much more readily with the admirable curved

FIG. 13. Doyen's elevator.

elevator of Doyen, first used by Sir Watson Cheyne. The beginner may fear injury of the intercostal vessels at this stage, but on the deep side the periosteum is thicker and strips very easily from the bone, and, even if they are injured, they can be secured with the greatest ease. The rib is now divided, preferably with large rib shears. The rib shears, though cumbrous, have the great advantage of speed and do not split the bone or leave ragged, pointed edges. *At least* 1½ inches of rib should be removed. The anæsthetist is now told that the pleura is ready for opening and discontinues the anæsthetic; the pleura is usually opened by plunging a blunt-pointed dressing

forceps through it in the middle of the cleared rib, penetrating and opening the blades in an antero-posterior direction. Now the pus or blood squirts out and the patient should begin to cough. The operator's finger should now follow the line of the pressure forceps and hook the edges of the pleural opening forwards; at the same time, the patient is turned as far as possible towards the affected side and allowed to cough the fluid out; fragments of clot and débris which may block the opening should be turned out. The operator's finger now sweeps round the pleural cavity without using the slightest force. By this he feels the expanding lung and the diaphragm and is able to estimate

FIG. 14. Rib shears (half-size).

the distance from the wound to the bottom of the pleural cavity (usually 4½ inches), which can be reached by pressing the intercostal space a little inwards. It is just possible that a bullet may now be felt and extracted, but no prolonged search should be made for it, nor should any attempt be made to clear away every fragment of solid débris.

Irrigation of the Pleura.—Personally I believe this is a dangerous and unnecessary procedure: firstly, because cases of sudden death have occurred on irrigating the pleura with an antiseptic, and such cases are few and far between when the pleura is not irrigated. Many surgeons still irrigate the pleural cavity with weak iodine or with 'antiseptic' fluid. I would submit the following:

(1) It is quite impossible for any injection to cleanse the whole pleural cavity.

(2) If it were possible, would it be desirable? Nature has established protective bounds which should not be interfered with, and man may, by his crude efforts, convey infection to the interlobar spaces and the diaphragmatic pleura.

(3) Irrigation often produces profound shock; sometimes sudden death.

(4) No satisfactory antiseptic fluid yet exists for irrigation. If it is really an antiseptic, it cannot but be a strong irritant to the pleura.

(5) Why has irrigation been entirely abandoned in septic peritonitis? Since its abandonment, has there not been a most marked change in the mortality?

Having, therefore, decided, as I hope, against irri-

gation, nothing remains for the operator but to put in a drainage tube and close the wound (leaving some space for drainage beside the tube) with a few points of strong silkworm gut. The tube should preferably be a strong rubber tube at least $\frac{3}{4}$ inch in diameter; small tubes are useless and a constant source of pain and annoyance. A good surgical rule in dealing with the thorax and abdomen is that if a tube has to be employed to drain a septic cavity, the larger it is the sooner everything is likely to heal up; metal and glass tubes are bad, and should be discarded, while the more complicated flanged rubber tubes will probably be found to have perished when we try to use them. The lower end of the tube should be cut on either side to allow drainage, and abundant large lateral openings should be made in the tube. The tube should at first extend to the bottom of the pleura, and its length, as I have said, should be usually $4\frac{1}{2}$ inches; care should be taken that the tube is not too long, or it will buckle up in the pleural cavity and cause much irritation.

FIG. 15. Cut empyema tube.

In many cases the parietal pleura of the chest rapidly becomes adherent to the parietal pleura covering the diaphragm, thus sealing up the lowest part of the pleural cavity, and, because of this, removal of the 9th rib is often recommended. It would appear that, so long as the tube is regularly shortened from the first and reaches to the lowest part of the pleural cavity, this should matter little. The whole operation should take about five minutes; perhaps a little longer, should the opening into the pleural cavity be blocked with clots or fibrin.

After-Treatment of Operation.—The dressings will probably be soaked through in a few hours and should be reinforced by more material. At twenty-four hours the dressings should be removed, and, if there is not a very great deal of discharge and the tube is freely open, I am in the habit of shortening the tube about an inch. Next day the tube should be shortened again about an inch, thus leaving $2\frac{1}{2}$ inches in the pleural cavity. On the third day, always provided the temperature is satisfactory and the wound draining freely, $1\frac{1}{2}$ inches should be taken off the tube, thus leaving the tube flush with the parietal wall of the pleura as before mentioned. In dressing these cases, a sterilized probe should be used with the utmost tenderness to feel the bottom of the tube and see whether it is free from blocks of fibrin. The length of the tube should be known each day, and the probe should be measured accordingly with the finger. No attempt at probing the pleural cavity generally should be made. If a clot is found blocking

the tube it can readily be detached with a circular movement of the probe, and the patient's cough will probably then waft the obstruction on to the operator's face. It is difficult to lay any hard and fast rule down as to when the tube should be removed ; as a general rule, at between three to five weeks, provided a sufficiently large tube has been used, there should be but little discharge and the lung should be expanding well. The tube, under these conditions, can be removed. It may be possible sometimes to remove the tube even when there is some cavity left, provided that there be very little discharge. In these cases it may be that the cavity between the chest and the lung contains air, the presence of which delays closure after the external wound has healed. In such cases a fine No. 4 catheter should be passed daily into the cavity, and, if only fluid then comes away, it may be left ; but if pus makes its appearance, a tube should be put in again. Godlee has described an ingenious method of drawing out the lung to the chest wall by the use of an india-rubber box filled to the chest wall and exhausted, as in Bier's method of treatment. I am myself against putting in a smaller tube in place of the original ; there is usually quite enough room in the wound for the remnants of drainage. If a sinus persists, it can be dealt with in the usual way by touching with silver nitrate, stretching with bougies or dressing-forceps, and by loosely packing it with iodex. The patient should be allowed to sit up quite soon (four to six days), and, if possible, kept in the open air from the beginning. There can be no

doubt that the open air is a very great factor in the rapidity of recovery.—Such is the treatment of a case which recovers without complications.

Double Empyema.—Double empyema may occur owing to a bullet or shell-fragment crossing the chest and infecting both pleuræ. One or other of the pleural cavities must be shut off from the pus-containing space, for it is obviously impossible that life can be maintained if both pleuræ are full of fluid. It is most unwise, if a double empyema be diagnosed, to attempt to operate on both sides at one and the same time. The worst side should be first drained in the usual way ; if there is any very great respiratory distress, the better side may be aspirated and part of the pus withdrawn in order to take off the pressure. The greatest care should be taken that this is done at the exact spot where the physical signs are most marked, and every endeavour should be taken not to break down adhesions and spread infection over the whole pleural cavity. At a later date the better side of the thorax can be drained.

Positive Air Pressure in Operating.—In this connexion it may be well to mention methods of Sauerbruch and Bauer, both of which are highly scientific and designed to prevent the formation of a hæmothorax and collapse of the lung on opening the pleural cavity. In Sauerbruch's chamber, the patient (except his head), operator and assistant, and general paraphernalia of the operating theatre are contained in an air-tight chamber, the pressure of air in which can be raised at will ; the patient's

head remains outside and receives the administrations of the anæsthetist. There is an air-tight covering round the neck. By means of this ingenious if somewhat impractical device cases of complete removal of one lung and, for aught I know, evisceration of the entire thorax have been reported. Mr. Bauer adopts another method by surrounding the patient's head and neck with an air-tight chamber in which the pressure is raised; it is not abundantly clear how the anæsthetic is given or how such inconsiderate acts as vomiting are dealt with. We may express the hope that their patients will continue to congregate in order to reap the benefit of our ingenious German confrères. I may be excused any further description, for they are both, of course, absolutely impractical in the surgery of war.

Treatment of Complicated Cases and Chronic Empyema.—Septic cases of empyema from bullet wounds may give the greatest trouble. (1) The patient's temperature and general condition may not be perceptibly relieved by the operation; (2) the wound may discharge without showing any signs of cessation for a length of time and the case drift into one of chronic empyema; (3) the lung may refuse to expand, and there may be considerable consolidation. In all these cases, the patients themselves know that some treatment is essential. Should the septicity of the wound continue, the possibility of assisting the patient's defensive organization to combat the hostile organisms should be at once considered.

Chronic Empyema.—Patients may be considered to have drifted into a state of chronic empyema when five to six weeks after the original drainage the discharge is still free and shows little signs of abating. By this time the patient's condition may have improved a good deal, but on examination a considerable cavity will be found between the chest and the lung ; in a second class the patient may have gone downhill a good deal and show all the signs of prolonged suppuration, enlarged liver, waxy appearance, clubbed fingers, albuminuria ; in yet a third, the patient may have suffered from intermittent attacks of high temperature due to a very septic discharge, probably pent up at times. The causes of chronic empyema are as follows :

1. Badly-situated opening.
2. Large-sized cavity.
3. Complete collapse of the lung before adhesions are formed.
4. Fistulæ communicating with the lung or through the diaphragm with abdominal viscera.
5. Tuberculous disease.
6. Foreign bodies.
7. Malignant disease.

It must be recognized that very many cases of empyema persist and almost defy a cure, and that the greatest care is necessary when complications ensue to prevent the case drifting into absolute chronicity. To all the above causes, another factor has to be added—that is, the virulence of the organisms present. The fight between the patient's vital fluids

and tissues can be assisted by gross mechanical means and by ' bacteriological therapeutic methods '.

To turn first to the Physical Causes where they concern us :

1. **Badly-situated Opening.**—The opening may have been too small in the first case, and a small and ineffective tube may have been inserted. If this is so, more rib must be excised and a proper tube put in as already described, taking care that the tube is not regularly blocked with some valvular deposit of lymph and that it really does drain the cavity properly. The muscles surrounding the opening may obstruct it ; if so, they must be fully divided. To prevent this form of obstruction, some have recommended a vertical instead of an oblique incision. I have not found it in any way superior, and it certainly makes the operation somewhat longer. The opening in the thorax may have been made too low down, and the diaphragm becoming adherent to the chest wall may have made the opening valvular, or else the opening may be too far back and have been obstructed by the patient's dorsal position. In both these cases a new effective opening must be made. Remember that, in all these cases, no good can come from ineffectual irrigations of an unknown cavity, with doubtful and dangerous antiseptics.

2. **Large Size of the Cavity.**—This is most difficult to remedy, for in these cases the pleural cavity is large and the lung completely collàpsed. Cure will depend, in the main, on the expansion of the lung. To aid this, we have in the first instance to see that

no pockets of pus remain in the cavity, and, at the same time, we should avoid breaking down adhesions which, by traction, may aid in the expansion of the lung. The patient should be encouraged from an early stage—say from the end of the third week—to persist in a series of expiratory efforts with the glottis closed, as by shutting the nose and mouth. Another excellent method is to make him blow a varying quantity of water out of one 'wash-bottle', provided with two glass tubes and a cork, into another and back again. At the same time, our efforts to get rid of the micro-organisms which infect the cavity will have a good effect; for the pleura, once it returns to a healthy state, soon forms adhesions which will probably afterwards be absorbed once they have done their work in aiding the expansion of the lung. Yet, despite all our efforts, we may in the end have to attempt thoracoplasty.

3. **Complete Collapse of the Lung before adhesions have formed.**—This is a very common cause of chronic empyema in traumatic cases; for the wound, if large, causes a rapid and complete collapse of a healthy lung, and this collapse is kept up by the pressure of the empyema. The same lines of treatment apply here as in the previous class.

4. **Fistulæ communicating with the Lung or Abdominal Viscera.**—In the first case, provided the lung is healthy and expands, the fistula will sooner or later close up without further interference. If, however, there is a foreign body in the lung, discharge will probably persist as long as the foreign body remains in

the lung. Fistulæ communicating with the abdominal cavity are very rare, seeing that the original infection is usually fatal. The attempt to close such a fistula involves finding and closing up the wound and the abdominal viscus, draining its surroundings and, if possible, closing the rent in the diaphragm. Part, if not all, of this ideal procedure may be found at the operation to be impossible, and an operation necessarily involves so much risk that it is open to doubt whether it should be undertaken at all, and free drainage in the chest kept up in the hope that the fistula may close.

5 and 7. **Tuberculous and Malignant Disease** do not here concern us.

Drugs have little effect on the treatment ; alcohol should be used when required ; good stimulating food and fresh air are the chief adjuncts to surgical treatment. I propose to deal later with what I may call ' bacteriological therapeutic treatment '.

6. **Foreign Bodies.**—It is probable that a foreign body may be present in a case where the discharge continues ; this may be a neglected shell fragment whose presence is unknown, or a bullet whose presence somewhere is a certainty. In such cases, it is important, if possible, to localise the foreign body by X-ray examination, either by a stereo picture of the chest, if an expert radiographer is available, or accurate localisation by Cox's localising screen. Amongst the many scientific methods of localisation, this appears to me to be the simplest, and to be reliable. It has one great advantage—that no calculation is necessary. The depth of a foreign body from a given

point on the screen can be read off on the index on the screen by altering the position of a cross wire, and the only movement required is that of the tube holder which is under the patient through a stereoscopic distance of about eight centimetres ; the actual distance need not necessarily be accurate. If a foreign body is found, the question of what to do with it is a very difficult one to answer. On the whole, every chance should be given for the patient's lungs and thorax to recover as far as possible under healthy surroundings, and any attempt to remove the bullet or other fragment should only be made after the patient has had the full advantage of home hospital treatment. It will be remembered that one very important aid will be obtained by waiting, for the bullet may alter its position and become quite accessible ; as in a case I have already mentioned, the bullet may possibly become fixed and all irritation subside ; thus there is abundant reason for waiting. If it has to be removed, there should be a subperiosteal resection of ribs in order to expose the area of operation thoroughly.

Thoracoplasty.—Expansion of the lung, the operation known as Estländer's operation from the *Swedish* surgeon, or Thoracoplasty, which consists of subperiosteal resection of several ribs in order that the chest wall may fall in and mould itself on the partially expanded lung, may be performed at home at a later stage. There is no doubt that its immediate results are sometimes good, but I question very much whether the later results of a large series will be found to be the same, although I make the assertion, well knowing

that I have no opportunity of verifying it by a large series. The operation must be considered as a very serious one, and one which will probably have to be done in various stages. Its aim is to bring the chest wall down to the unexpanded lung, and so obliterate the cavity, removing as much of the parietal pleura as possible, in order that the visceral pleura may adhere to the chest wall. The cavity must first be carefully mapped out by physical signs ; an oblique incision is made from the opening in the chest upwards and backwards to the level of the upper limit of the cavity and the ribs exposed. If the incision is made behind, enough of all the ribs even up to the first can be removed subperiosteally, but in any other part of the chest, this is impossible. The first stage will probably consist in the removal of some ribs, for it is to be remembered that the patient is in a very bad state and cannot stand an extensive operation at this late stage. More ribs are removed at a second operation, and probably at a third operation the parietal pleura and the chest wall are pushed inwards towards the lung. It is unwise to attempt to remove the ribs covering the heart on the left side. All methods should be employed to combat shock, such as injection of morphia before the anæsthetic, injection of pituitary extract, irrigation or swabbing with suprarenal extract, and above all by continuous injection of saline by the rectum or into the tissues during and after the operations.

The whole procedure is a very grave one, and it is quite useless unless it is done thoroughly by a surgical expert.

CHAPTER VI

PNEUMOTHORAX

PNEUMOTHORAX, or air in the pleural cavity, may be caused (1) by entrance of air from outside, as in the case of a large shell wound tearing open the chest; (2) by entrance of air from damaged lungs (this may be through a large opening in and out of which the air whiffs); (3) or it may be through the sudden breaking down of a large part of the lung, in which case the pleural cavity is filled quite suddenly with air; (4) again, and most commonly in phthisis, it would appear to be due to the sudden breaking down of a small fistula directly communicating with a bronchus. This track is valvular, and air is forced into the pleural cavity on inspiration and sucking air out of the pleural cavity is stopped on expiration; thus the pleural cavity becomes more and more distended with air. If there is already pus or decomposing blood in the pleural cavity, the condition is known as pyo-pneumothorax, or, under the best conditions of articulation, in cases of bullet wounds, as pyo-hæmo-pneumothorax. Pneumothorax, taken as a whole, may be recorded as a serious but not essentially a fatal complaint. It has been said by Makins to be exceedingly rare with bullet wounds, and to be sometimes seen in conjunction with pyothorax, while the issue of air from external wounds in the chest,

according to him, is rare, except in shell wounds. According to other authors, it occurs in less than 3 per cent of cases.

Be this as it may, I certainly have myself met with a large number of cases of pneumothorax, in my comparatively short experience. Let it not be thought that pneumothorax in bullet wounds of the chest at all resembles the same condition as is met with in phthisis. In tuberculous disease, air is suddenly admitted into the affected side of the chest and the air-pressure increases with every inspiratory effort, as I have pointed out. A sudden condition of collapse of the whole lung occurs, and this not unnaturally gives rise to most profound collapse on the part of the patient, and often sudden death. This is far from being the case in bullet wounds. Here pneumothorax is due to a gradual leaking from an injured lung either above or through a pyo-hæmothorax. The air-pressure would never appear to be excessive, and the air merely displaces the purulent collection for the time being, and it would seem to be rapidly absorbed. The patient is already ill and the affected lung already largely collapsed; at any rate, no profound constitutional symptoms are usually present. I cannot make out that the condition is more serious than I have stated. It does not lead to any grave complication that I know, and any bad results it may give rise to are entirely overshadowed by the presence of putrefying blood in the pleural cavity. A valvular opening into the lung is a very great rarity.

To deal with the causes seriatim. (1) *Air entering*

from the outside. This, as Makins and others have pointed out, used to be comparatively frequently met with in the days of leaden bullets. At the present time it is exceedingly rare in small-bore rifle bullet wounds. I have no personal experience of such a case. In wounds from shell fragments and shrapnel bullets, on the other hand, a large wound in the chest often allows air into the pleural cavity. So large can this wound be that the greater part of the thoracic cavity on one side can be seen. In some of the smaller openings, the noise of air entering and leaving the chest is most marked. I remember a somewhat imaginative countryman of mine making formal complaint that the whistling of another patient disturbed his sleep, the whistling in question being the wind passing in and out of his thorax. Such open wounds naturally suppurate, and there is more or less of an accumulation forming a pyothorax. All physical signs of pneumothorax, as such, are usually absent in these cases or cannot be heard owing to added noises. (2) The second class of case, *where there is injury to the lung and air passes through the injured lung*, I will return to. (3) The third class, being a pyothorax which produces gas-producing organisms, readily explains itself. I have not myself met with any such cases. A few cases have been recorded in which gas from a leakage in the stomach or part of the alimentary canal passes through the wound into the diaphragm and into the pleural cavity. We have seen that, in much the same way, bile or fæces may find their way into the pleural cavity. The end of such cases is manifest.

Symptoms of Pneumothorax.—On palpation the percussion note of the chest is tympanitic, and tympanites takes the place of an area which in pyothorax was previously dull. If there is much blood, the fluid-containing space at the base remains dull. On auscultation the respiratory sound is weakened in proportion to the amount of collapse of the lung. Sometimes no breathing is heard at all except in the vertebral groove when the lung has been solidified before, so that collapse cannot occur. In other cases distant faint tubular breathing is heard. A more or less loud metallic or amphoric sound will be heard irregularly over the pneumothorax. Amphoric sounds are present and the amphoric hum is heard while breathing, coughing, or talking. A mechanical tinkling is often heard over the pneumothorax. So long ago as the great Frenchman Laennec's time, the clear tinkling transmitted by the pneumothorax to the ear when one coin was struck on another over a distant part of the chest was recognized. (The same sound can, of course, be heard for experimental purposes in the normal person over the stomach area.) Even in ancient times, Hippocrates himself drew attention to the succussion heard on shaking the thorax over the pneumothorax when the pleural cavity contained fluid.

As Gee pointed out long ago, a pneumothorax can only be distinguished by auscultation, and, if a careful auscultation is made, nothing can be easier to recognize. If we reflect that this condition was once a frequent cause of sudden death, we shall readily

understand how carefully our predecessors watched for sure signs, and how skilfully they found them.

Over and above these symptoms, others may be remembered. Thus the inspiratory movements effect little expansion of the affected side of the chest. The heart is displaced away from the pneumothorax, or the heart's dullness is obliterated. The fine added sounds are echoed even where the breath sounds are completely inaudible.

A diagnosis can be made from an air-containing abscess below the diaphragm, especially on the right side, by the liver being very much displaced downwards in the second condition, whereas it is rarely displaced in pneumothorax.

Symptoms of Pneumothorax occurring after a Bullet Wound of the Chest.—Here there is generally no distension of the pleural cavity with air, so that the heart is not displaced, nor is the area of pre-existing dullness much altered. The condition can be guessed at by noticing the alteration in the shape of dullness above the pyothorax, and, on auscultation, the various sounds are readily obtained, as far as I have been able to observe. It may be taken as certain that if a pneumothorax develops in the course of such a case, the fluid in the pleural cavity is thoroughly infected. Quite often the signs of pneumothorax in such cases disappear in a couple of days, so rapidly is the air absorbed. In two cases the chest was thoroughly examined by several of my colleagues one morning, who agreed with me as to the existence of all the symptoms I have mentioned ;

the very next morning there was no question that these had all disappeared.

Treatment.—Aspiration of the air in a tuberculous case has been recommended. Following on what I have stated as to the pathology and course of pneumothorax in bullet wounds, it should be clear that aspiration would be perfectly useless. Nothing, however, is requisite except that the presence of an undoubted pyo-pneumothorax should be treated as I have already detailed. No other treatment should be admitted.

Pleurisy and Effusion.—These are said to occur sometimes after bullet wounds. A localised pleuritic friction sound is often heard in the neighbourhood of the wounds, but this rapidly disappears. Effusion, on the other hand, is very rare. It would require a good deal of proof to my mind that such cases are not infected from the first. An extensive serous effusion, if it occurs, should be treated by aspiration, but if the fluid is found to be infected, proper drainage should be established as in the case of pyothorax.

Pneumonia.—Very rare and very fatal. I have not seen a case, but I have personal accounts of several. All are agreed as to the fatality. Apparently it is purely accidental. The physical signs are marked from the first and there is very rapid collapse. In every other respect it is typical.

Gangrene and Abscess of the Lung is still to be observed with shrapnel and shell wounds. It was once comparatively common with the larger bullets. At the present time gangrene of the lung of such

magnitude as to give rise to definite symptoms, such as foul-smelling prune-juice expectoration, is practically unknown. That certain limited suppuration and breaking down of the lung must take place in many cases is shown clearly by the existence of pneumothorax, but it must be admitted that where the lung can be partially examined it is exceptional to find any trace of injury to the lung. If an abscess or localised gangrene of a lung is diagnosed, or actually observed in the course of an operation for empyema, an attempt should be made by curved Hagedorn needles and catgut to shut it off from the rest of the pleural cavity; it should then be opened and drained, a separate drainage being used for the empyema in the usual way.

Pericarditis.—Pericarditis is very rare in gunshot wounds. This should seem natural, for when the heart's area is perforated by a bullet, immediate death supervenes in the majority of cases. In those amazing cases of which every one who has any extensive experience of modern war surgery has collected one or two undoubted examples, the heart's area (speaking on anatomical grounds) must have been perforated, and yet there are usually practically no physical symptoms of any sort or kind afterwards. For want of better symptoms, some have referred to a slow heart-beat, whilst others, not to be outdone, have come across some irregularity. To the best of my knowledge, no scientific account has, as yet, been given of the irregularities of the heart's action due to bullet injuries, but no doubt this will follow.

There is no evidence to prove transposition of the viscera in such cases. The pericardium usually escapes, even though there is a close proximity to a septic pleural cavity. Attention has been drawn to the fact that a pleuro-pericardial murmur is not uncommon with a left pyothorax. If the pericardium is opened by a shell fragment, a suppurative pericarditis occurs, and pus is freely discharged externally from the pericardium. I have had one such case under my care. Here drainage of the pericardium produced a satisfactory result in a very few days. I have not enough experience to enable me to generalize, but from this case it would appear that, even with shell wounds, the pericardium is amenable to surgical treatment. It is, of course, well known that the results of draining the pericardium in rheumatic fever and pyæmic conditions are usually unsatisfactory. If I am correct, it may show that the pericardium can be dealt with readily unless there is a hæmic condition of sepsis.

Pneumopericardium has been described ; I cannot prove the entrance of air into the pericardium in the cases I have referred to. Beyond a graze of the heart's wall, I have no personal experience of injuries of the heart itself. There can be no reason why deep wounds of the ventricles or grazes of the auricles should not be sutured in the usual way. It is well known that it has been done over and over again successfully. It is obvious that the difficulties are enormous which have to be overcome. If a wound in the heart is actually diagnosed, Godlee recom-

mends that a flap with convexity inwards and downwards and base upwards and outwards should be separated, and the skin turned upwards and outwards. The cartilages of the 3rd to the 6th ribs are then cut through, and the flap of costal cartilages, ribs and intercostal spaces wrenched outwards. The pericardium is now exposed, and must be divided vertically and cleared of blood. Bleeding will naturally be furious. The wound of the heart is fortunately usually in front, and must be sutured with catgut. It was recommended to pass the stitches through the left ventricle when in systole, through the right ventricle when in diastole, but Godlee doubts whether this is of any practical value. The condition of the patient must be closely watched, pituitary extract should be injected, and suprarenal extract used locally. Continuous saline solution should be injected into the tissues and the rectum during and after the operation.

CHAPTER VII

GUNSHOT INJURIES INVOLVING THE THORAX AND THE UPPER ABDOMEN

THESE injuries, oddly enough, are according to most observers not very common, either because when a soldier is exposed the wounds are usually transverse, or else, when in a recumbent position facing the enemy, longitudinal bullet wounds tend to go backward across the chest towards the spine. Oblique wounds in the abdomen itself are, on the other hand, fairly common. What cases I have seen have all been puzzling in the extreme, but on the other hand, it is worthy of note that some of them presented absolutely no abdominal symptoms at all, and all of them recovered. The part of the wound which perforates the thorax need not here concern us. The same remarks apply to perforating wounds of the thorax in general. Next the bullet passes downwards through the diaphragm, and here it is important that two symptoms should be recognized as being of common occurrence. These are vomiting and hiccough. When either of these symptoms is marked or prolonged in the case of gunshot wounds of the thorax, it may be taken as pathognomonic of a perforating injury of the diaphragm. Other signs of perforation of the diaphragm are usually absent. It may be confidently affirmed that both

vomiting and hiccough in such cases are sure to give rise to a good deal of anxiety for about 36 hours, and that treatment by drugs has little effect on them. They will generally subside in 48 hours provided always that no other acute abdominal symptoms appear, but it is always possible that they may be gradually continued into the symptoms of acute perforative peritonitis. I have been in the habit of allowing a patient to wash his own stomach out with draughts of hot soda bicarb. solution ʒij ad Oj and keep him absolutely level rather than make any attempt to keep him in Fowler's position. I have thought that minim doses of tincture of iodine had occasionally a good effect, or large doses of sod. bicarb. with a few drops of tinct. chloroform co. Morphia gr. ½ and atropin gr. 1·150 hypodermically must remain as a sheet-anchor in all cases. The pulse-rate should be closely watched. The effect of the bullet after it has passed through the diaphragm is not a little remarkable. As a rule it emerges under one flank and, whatever it does perforate in the abdomen, it leaves little trace behind. In several of my cases, the bullet passed from the right chest to the left abdomen, passing in all probability through the stomach and spleen. In others it passed through the liver. In cases where there is no extensive hæmorrhage into the pleural cavity or abdomen, the pulse-rate will usually be little affected by the vomiting and hiccough. If, on the other hand, it is becoming more frequent (85–90), symptoms of hæmorrhage into the pleura should first be looked

for. If nothing is found in the chest the abdomen is inspected for rigidity of the upper recti muscles and for distension. If the pulse-rate is still increasing and muscular rigidity is present, I believe a longitudinal incision should be made through one or other rectus, and free abdominal drainage by tube and gauze established. An attempt may be made to find the source of abdominal bleeding and plug it with gauze, always remembering, however, that the shorter the operation by far the greater is the patient's chance of recovery. No extensive surgical procedure to suture the liver or repair holes in a viscus should be attempted. At the very most a very rapid purse-string suture may be put round a lesion if it is readily found, but nothing more is admissible. The usual treatment for shock should be thoroughly carried out, and above all the drainage should be effective.

In one most remarkable case, the bullet entered the third left space obliquely downwards and inwards. It may have passed through the heart. It certainly must have passed through the liver, and the top of the kidney, and it was found by X-rays present somewhere in the right iliac region. The boy had no ill effects whatever beyond vomiting and hiccough, a little hæmaturia, and a very profuse urticarial eruption which had probably nothing whatever to do with the case. Some days afterwards, he developed pain in the right iliac fossa with a temperature and a tender lump. Not unnaturally, this was considered to be probably in connexion with the bullet. It was cut down upon, with the result that a gangrenous

appendix of the most usual type was found; the bullet could just be felt embedded deeply in the psoas, quite far away from the abdominal abscess cavity. No attempt was made to remove the bullet, and the appendix abscess followed the usual course to recovery. These cases, which show little evidence of abdominal injury and are essentially so strange, would appear to be the rule. In others, the early acute peritonitis, coupled or otherwise with the symptoms of internal hæmorrhage, may suggest operation. It must be admitted that this is a last hope. The patients are so ill that any attempt at plugging a rent in the liver or closing the stomach and draining is only too often fatal. Still, such interference, provided the patient is in a hospital, gives the only hope of recovery, and, in my opinion, desperate though the outlook may be, it should be undertaken, as I have suggested. Other cases again may discharge upwards through the diaphragm into the pleura. Here the condition is rapidly fatal, and even an effective drainage of the pleural cavity is not likely to produce recovery. The probability, of course, remains that such cases which come to the base hospital or hospital ship are really 'freak' cases, and that the great majority die immediately through injury of some large abdominal vessel.

Subphrenic Abscess.—A collection of pus below the diaphragm is not an uncommon later sequel of cases of bullet wounds of the chest and abdomen. Its presence is due to the fact that the movements of the diaphragm on respiration have a kind of

suction whereby infective material in the upper abdomen is drawn up into the subphrenic space. In the case of perforating bullet wounds, the abscess is usually intraperitoneal, and the source of infection may have come from above through a rent in the diaphragm; indeed, the abscess may directly communicate with a pyothorax of the same side. In this respect a traumatic subphrenic abscess differs unduly from those due to a septic peritonitis of the lower abdomen, where the chest is usually quite free and the abscess may be extraperitoneal. The abscess may also result from a perforation of the stomach, duodenum, or colon, or even from a wound in the liver or bile-ducts. It may contain air from the alimentary canal or bile from the liver. Its contents are nearly always intensely septic, and contain streptococci, the colon bacillus, and some anærobes.

Clinical Symptoms.—The abscess may be acute, following immediately on the wound, or it may appear some time after the wound. There are the usual symptoms of abscess formation, among which the presence of marked leucocytosis is of importance. There is usually local pain, profuse sweating, and rigors, and there is usually a good deal of dyspnœa. With a screen examination the diaphragm on the side of the lesion will be found to move very badly. There is a swelling in the upper abdomen on the affected side which does *not* usually move on respiration. The liver is usually much displaced downwards, and may form most of the swelling.

Right-sided Subphrenic Abscess.—The liver dullness

is extended upwards with convexity marked like a saucer. This dullness is caused by displacement of the diaphragm upwards by the pus beneath it. Unless there is a pyothorax in addition (as there probably may be) the breath sounds are heard clearly immediately above this area of dullness, if there is gas in the pleura, and in the subphrenic abscess we may find from above downwards tympanites (due to air in the pleural cavity), dullness of the pyothorax, tympanites of subphrenic abscess, dullness of subphrenic abscess merging into the liver dullness. It is needless to say that this condition is very difficult to diagnose.

Left-sided Subphrenic Abscess.—Usually contains air. The heart is displaced upwards, the left lobe of the liver downwards and to the right. The abscess very often forms a fluctuating swelling just below the left costal arch. The same areas of tympanites and dullness may be found, but the tympanites of the stomach resonance is found below instead of the liver dullness. It is most important in these cases that the presence of pus below the diaphragm should be demonstrated. An exploratory puncture should be made with a long needle, at least 3 inches in length, with a guarded point and provided with a blunt stylet and connected with a suction syringe or an aspirator.

Treatment.—The patient should be put under a general anæsthetic, and the usual preparation of the skin made. The needle is pushed in through the intercostal spaces, in the mid-axillary line from below upwards, beginning at the 10th. Its passage

through the diaphragm can usually be felt, and it is possible that some serous fluid may be extracted at a depth of 1 to 1½ inches from the pleura. On the other hand it is to be remembered that the diaphragm is usually closely adherent to the parietal pleura in the lower spaces, and as a matter of fact, even when a rib is excised and the abscess cavity drained, it may be most difficult in some cases to be sure whether we are below the diaphragm or not, and the foul and somewhat fæcal smell of the abscess will usually decide us. Diagnosis is still further complicated by the presence of a pyothorax. However, in such cases we are greatly assisted by our knowledge of the previous injury. Once pus is found, the operation should be carried out at the same time. The rib nearest to the needle is excised, the point of the needle being guarded and kept in position by an assistant. If a pyothorax is present it is now drained. The needle is then examined, and if it goes through the diaphragm, the diaphragm is fixed as firmly as possible to the intercostal muscles surrounding the opening. (This will be found most difficult, as the stitches cut out very readily.) The diaphragm is now incised, and the abscess beneath it drained as well as possible. If there is no pyothorax, and the needle passes through the diaphragm, the pleural cavity is shut off in the same way, and the abscess drained. If it cannot be shut off from the pleural cavity, an attempt may be made to shut it off by packing the edges of the wound with gauze, in the hope that pleural adhesions will form.

If there is a pyothorax, and there is still doubt as to the presence of a subphrenic abscess, it is proper to needle the diaphragm and thus discover the presence of an abscess. If no abscess is found the wound should be kept partly open, as another attempt may have to be made later.

In the majority of cases, the transpleural route must be adopted. It must be admitted that it is unsatisfactory. In cases of doubtful subphrenic abscess, it is well to wait till the lung is definitely pushed up. In all cases where the abscess would appear to be pointing in front, it is much better to open it from in front, packing off the rest of the abdominal cavity most carefully with gauze, and draining freely. In some cases where the abscess is behind the liver it may be necessary to attack it by excising the 12th rib, and working upwards behind the peritoneum. It must not be forgotten that in all such cases the patient's condition is grave, and a fatal result in the end is to be feared in many cases.

CHAPTER VIII

SURGICAL TREATMENT OF WOUNDS OF THE THORAX

It may be convenient to take together the various treatments which should be adopted in wounds of the thorax. Treatment of such wounds may be divided into three stages,

1. Immediate.
2. Primary.
3. Secondary.

Under **Immediate Treatment,** I have already discussed the importance of rest above all, where possible, and of morphia hypodermically, partly to ensure this rest. Unfortunately, it may be impossible for the patient to receive this from any but the medical officer's hands. Such a course is to be deprecated, although the dangers of administering morphia by unskilled hands are not to be ignored. Also, covering the wound immediately, so that the organisms which abound in sweat and elsewhere may not reach the wound. For this purpose both wounds of entrance and exit should be sealed with the emergency dressing with which the soldier himself is provided. If possible the inner part of the pad may be moistened with tincture of iodine, obtained by breaking an ampoule of iodine if it is at hand. The first-aid dressing

varies little in our services, the main point for the soldier or his attendant to know is that the blue sal-alembroth gauze should not be touched, and should come next to the wound, and that neither the gauze nor the wound should be touched whether blood oozes through or not. The orderlies are instructed how to exert compression as far as possible with bandages, and in no other way to interfere with the wound until expert advice is obtainable. The iodine can be taken from a 'shell dressing', usually provided. It may well be made clear that it should be used in wounds of the thorax whether due to shells or not. The wounded man is then brought to the medical officer as soon as circumstances will allow, and here discretion may be worth more than valour, for if he is protected from further injury he had best not be moved at all until the officer can give instructions—at all events carrying a case of wound through the chest, over the back or without some form of stretcher cannot be considered good treatment unless in the presence of dire necessity. Thus it is to be hoped that the patient will reach the dressing station, and come under the medical officer within twelve hours of the wound being received. If it has not been possible to give him morphia before, he is now given a hypodermic of morphia. The medical officer, in wounds of the thorax, must first judge of his own surroundings. In ships, the wound can most probably be adequately attended to at once. On land he will probably best do as little as possible if he can

get the patient to the field ambulance at once. Thus if there is little hæmorrhage, the first-aid dressing had best be left alone, the bandages readjusted, and more dressing put over the wounds. The patient is then transferred to the casualty station, where the wounds can be thoroughly dealt with. If, on the other hand, there is much bleeding, the wounds should be looked at, and, if possible, bleeding-points secured. This becomes the more necessary should the wound be extensive or caused by a shell fragment or bayonet. In such cases some attempt must be made to cleanse the wound from organisms which must obviously be there.[1] This treatment must be rapid and moderately effective; it is obvious that it cannot be complete and thorough. (The malachite-green mercury mixture of Fildes, Rajchman, and Cheatle would seem admirably adapted for this purpose, see p. 109.) Iodine will probably be the best means of doing this. The wound should be swabbed out with iodine, and a further dressing applied. The patient is then sent (1) to the field ambulance, (2) to the casualty clearing station, (3) from there to the ambulance train to a stationary hospital or hospital ship. Adequate provision for dealing with the wound will in all probability be found in all of these, but what can be done must necessarily depend on the presence of cases, and especially the greater necessity of other more serious operation cases.

[1] The amount of immediate surgical cleansing that can be done to the wound, and the best method of dealing with it, are of great importance. To this I will return again (pp. 107, 113).

Let us, therefore, take it that the patient has reached, within the first twelve hours after a wound, a dressing station of some sort where adequate surgical attention can be given to his wounds. The wounds may now be considered under the treatment of primary wounds. In dealing with a primary surgical wound of the chest, the surgeon's hope is that he may be able by treatment to prevent the occurrence of suppuration by destroying the germs *in situ*, and obtain a wound which will then heal without further trouble, or he may hope that in the stress and exigencies of field treatment he may be able to put some antiseptic mixture on the wound that may inhibit or delay the growth of organisms there, although it is not potent enough to destroy the organisms already present. For this purpose Sir Watson Cheyne has used cresol paste and other agents. Numerous attempts have been made to obtain primary healing, and the treatment varies in the hands of different surgeons. More recently, in his Majesty's navy, Sir Watson Cheyne, after long and painstaking scientific research, has formulated the following treatment. In immediate cases, where time can be given for proper surgical treatment, the wound is enlarged under an anæsthetic, the skin having been previously cleaned with 1 in 20 carbolic acid lotion and ether soap. Hairs are shaved away, and a towel wrung out in 1 in 20 carbolic is placed over the surrounding skin so as to protect it from the strong carbolic about to be used, and continue the process of disinfection. Blood is cleared away from the wound,

and the wound made roughly dry and cleaned from dirt and other foreign bodies. All ragged edges are then cut away, all pockets opened up, and the wound made into a single surgical ' crater '. A piece of sponge dipped in pure liquid carbolic acid is then applied carefully to the entire surface of the wound, taking especial care to touch all deep pockets, the edges of the wound being protected so that the strong caustic used should not touch the skin surrounding the wound. Under this strong caustic the tissues are turned grey, the wound is dried and the carbolic acid is applied a second and even a third time. In ten minutes' time the wound is washed out with 1 in 20 carbolic and then with normal saline solution to avoid absorption of carbolic acid. A drainage tube is inserted if necessary, and no attempt is made to close the wound except by a few loose stitches. An antiseptic dressing of salicylic or cyanide gauze is now put over the wound, and if the wound is quite clean and dry, a powder of equal parts salicylic acid and boric acid known as ' borsal ' is dusted over it (see *Lancet*, ' Treatment of Wounds in War ', 1914, vol. ii, p. 1185). The author claims for this treatment that it is found that pure carbolic acid is really the only satisfactory and thorough antiseptic. That by these means the organisms on the surface of the wound itself and its depth are destroyed and not pushed along into deeper planes. The treatment is claimed to be devoid of severe pain, the carbolic acting itself as an anæsthetic. On the other hand, it is to be noticed that the dead tissue acts as an irritant, and there is a consider-

able amount of inflammatory reaction surrounding it until the scab separates. I cannot say that I have had any extensive experience of this method. All cases which usually reach the surgeon have existed as wounds for more than the period laid down by Sir Watson Cheyne, and in such cases the organisms have usually penetrated into the deeper layers. The objection to this treatment appears to me, in the case of wounds of the thorax, to be that if it is hastily or carelessly done, infected planes between the muscles may readily be overlooked and an excess of what is after all a strong caustic and irritant may be left in the depths of the wound in close contact with the damaged pleura. There is no doubt that, in skilled hands such as the author's, this treatment gives excellent results, and when advocated by such an authority, it is obviously worthy of an extensive trial in suitable cases.

Immediate Treatment of Cheatle, Fildes, and Rajchman.—Very recently these authors (*Lancet*, July 24, 1915, pp. 165 et seq.) have described a mixture for the immediate treatment of wounds, and very particularly applicable to the later treatment of actually suppurating wounds. They very properly insist on the fact that there can be no single treatment applicable to all wounds, but rather a combination of surgical treatment, opening up the wound, draining, use of vaccines, and use of local antiseptics. They suggest spraying the wound with a mixture of antiseptics dissolved in spirit 80 per cent, using spirit because it rapidly evaporates and the tissue

fluids become the ultimate solvent of the antiseptic. Their antiseptic is perchloride of mercury 1–100, with pure malachite-green added to it. Malachite-green is itself a strong antiseptic and absolutely non-toxic. It would appear to have some peculiar action on organisms when mixed fresh with sublimate. They show also by clinical results that sublimate in the strength of 1–100 when applied to either granulating or fresh raw wounds is *not* poisonous. They advise that fresh wounds and granulating wounds alike should be sprayed out with the mixture. The fresh wound afterwards is covered in, the granulating wound treated with fomentations. They emphasize the fact that the wound is not *washed out* with the mixture, but *sprayed*, care being taken that all pockets are sprayed. Their formula is as follows :

(*A*) Perchloride of mercury cryst. 1 gram, spirit (industrial) 80 % 100 c.c. ; (*B*) Malachite-green (pure) 1 gram, spirit (industrial) 80 % 100 c.c.

These are kept in separate bottles and equal parts of each mixed just before use. The malachite-green must be pure ; so far as the authors are aware, it can only be obtained from Baird & Tatlock, Ltd., 14 Cross Street, Hatton Garden, E.C. A certain amount of smarting follows the spraying, but only lasts for 1½ minutes. The authors use a spray of glass made by Rogers, 327 Oxford Street, W.

The clinical results of treatment which they give are not a little remarkable, and the mixture has evidently great value, and would seem to be peculiarly

applicable to the treatment of wounds in war from its concentration and readiness of application.

Treatment by Antiseptic Lotions.—Most surgeons will now agree that swilling the wound out with lotions of various so-called 'antiseptics', all of which are probably useless for the immediate destruction of germs, is not only absolutely inadequate but has the following great disadvantages :

(1) Active living germs are forced into muscular planes and recesses where they can thrive in pockets of pus, and amongst them may be anærobic germs; (2) the barrier of lymph and leucocytes just beginning to be laid down by Nature is interfered with; (3) there is danger of fluids being actually carelessly forced into the pleural cavity. The authors rightly condemn the use of mercuric lotions, weak lotions of tincture of iodine, tarry preparations, and hydrogen peroxide, all of which are to some extent antiseptic, but not sufficiently strong for the purpose intended. It should be pointed out that another great disadvantage of nearly all so-called antiseptics is that they precipitate albumen, forming an inert compound, and thus they act on the blood of the wound and effectually check the entrance of more antiseptic to the deeper parts where the organisms have taken up residence and protect the organisms from the protective resources of the body. Moreover, every investigator who has attempted to test the bactericidal value of 'antiseptic' lotions in the presence of pus or albumen is agreed as to their absolute inefficacy. To quote one instance only, the authors just quoted report

the killing power of corrosive sublimate solution on staphylococcus.

Tested in serum	1 : 15,000
+ corpuscles	1 : 5,000
Tested in pus	1 : 1,200.

It is wellnigh impossible to attempt to eradicate the notion of the value of antiseptic lotions, but facts show that they are in the main useless, and may be dangerous in the wounds we have under consideration.

Iodex in Immediate Treatment.—It is very probable that another substance will prove of wide value in this immediate treatment of wounds of the thorax, that is the compound of iodine now known as ' Iodex '. This is guaranteed to contain 5 per cent of pure iodine ; so far as I can observe, it is the only solution which does not precipitate proteids when brought into contact with it. On the other hand the iodine it contains penetrates into a proteid such as gelatin. Certainly in later wounds I have the strongest belief in its efficiency. It is quite painless when applied, and though I have not had the opportunity of testing it in *immediate* wounds of the thorax, I should do so without hesitation.

Use of the Probe.—One last word of caution is necessary : if one instrument in military surgery ought to be relegated to the past, that is surely the probe. If there is one dangerous process, it is the probing of a wound of the chest, either in its immediate or primary stages. No good can possibly be effected by

this, and the gravest harm is likely to ensue, for the probe will probably open up and spread infection into intermuscular spaces and, indeed, even into the pleural cavity and along the track of the bullet, rendering everything septic that it comes across. It is not likely, moreover, that a surgeon who persists in the use of the probe against all warnings is likely to be over-delicate in handling it, and thus still further mechanical damage may be done.

Treatment of Primary Wounds of the Thorax

Here suppuration is taken as certain to occur, and, after the first 12 to 48 hours, this is practically certain to be true. No attempt can, therefore, be made to destroy all the organisms present; the efforts of the surgeon must be made (1) to do as little as he can; (2) to assist Nature in his surgical treatment as far as possible; (3) to prevent suppurating discharge being pent up in the depths of the wound, and, of course, to prevent the access of new organisms. In a case which appears before the surgeon at this time, if time and surroundings will allow, it is probably wise to obtain at once part of the discharge in a sterile tube or to inoculate a culture medium from the wound, and to send it to the pathologist, who will then be able to report what are the important organisms which cause the infection. The pathologist will then be able to have, at a later stage, an autogenous vaccine ready. The skin is now cleansed as before or painted with iodine up to the edge of the wound. The wound itself is examined, and any dead tissue or

foreign bodies which readily come to view are removed, but no attempt is made to explore the depths of the wound for further oddments. Overhanging edges of skin are cut away and intermuscular planes opened up ; a free opening is made in these in order to ensure that no discharge can be pent up. If the discharge is already foul and offensive, a little hydrogen peroxide, 1 in 5, may be placed in the wound or dropped in. This will render the discharge sweet, but it is not to be considered in any way as disinfecting the wound. In the end, Nature and Nature alone must be our disinfector. The same reasons appear to me to hold good against the swilling out of the wound with various antiseptics. If there is still any dirty discharge, it can be sponged away with swabs moistened with hydrogen peroxide or 1 in 20 carbolic. It is my practice then to smear over the wound with iodex. I believe that this penetrates into the path of the wound, causing practically no irritation and acting as an effective disinfectant where it reaches, but—let me not be misunderstood—I believe far more in the patient's own lymph for destroying organisms, provided there is no pus pent up in the depth of the wound, than any antiseptics. The bactericidal powers of lymph are well known. It is equally sure that lymph mixed with pus becomes innocuous to organisms. Up to the present, we have removed what pus and dead tissue we can, and have been careful not to interfere with Nature's barrier of fibrin and leucocytes. The flow of lymph into the wound, we know, can be stimulated with warmth and

moisture, and by these we can prevent the caking of discharge and allow the lymph full play.

Lymph Lavage Treatment (of Sir Almroth Wright). —This treatment is not designed to kill organisms but to promote the flow of lymph by the application of hypertonic solutions of sodium chloride. A 5 per cent solution of common salt in sterilized water is used with ½ per cent of sodium citrate to prevent coagulation of the lymph—stronger solutions of sodium chloride can be used up to 10 per cent where the wound surface is dry or infiltrated. The hypertonic solution is applied continuously in solution or in fomentations until the wound is granulating and has 'cleaned up'.

Moist dressings appear to me to be strongly indicated in every septic wound, and dry dressings to be an abhorrence. The wound should, therefore, be treated by fomentations. These can be the ordinary boracic fomentations, or carbolic fomentations 1 in 20. I, personally, have used boracic fomentations smeared on the inner side with iodex. Whatever antiseptic be used in the fomentation, the essential point to remember is that the warmth and moisture and, above all, frequent change of the fomentations, are the important points, and no reliance can be put on any antiseptic which is merely applied to the surface of the body, except in so far as it prevents the access of more organisms. It is clear that iodex penetrates to some extent into the tissues, and, for that reason, I apply it to the fomentation, and I have found no reason to be dissatisfied with this treatment. It is essential,

once more, that fomentations should be applied often, in order to prevent any soakage of discharge on the surface of the wound, and that, when taken off, they should be destroyed by fire, if possible, to prevent the risk of further infection in other cases. It may be needless to point out that those who apply the fomentations should be warned that they should not be touched when wrung out in the cloth, and the most scrupulous cleansing of the hands should be gone through before and after applying the fomentation; indeed, the whole process should be conducted in just the same manner as if they were applying dressings to a clean surgical case. If this is done, the old terrors of spreading infection will not occur. If treated by fomentations from the beginning, it will be found that these superficial septic wounds in the chest heal up readily by granulation and give but little trouble, while many of those treated immediately and found to be dry when the surgeon examines them really require no further attention. The troublesome cases will naturally be those caused by irregular fragments rather than bullets and those in which there are extensive comminuted fractures of the ribs. The remaining details of treatment in this stage are rest and good food. Examination is, of course, made as to whether an early hæmothorax has been established, and, if physical signs of this are found, it is watched carefully from day to day. In other, more extensive wounds, the same thing applies. Fragments of ribs must be removed and perhaps a large opening into the pleural cavity fearlessly cleansed. It is possible

there may be an opening into the pericardium. In very deep cases it is well to put a large tube in, leading to the depths of the wound with side openings. If there is very much bleeding, the wound round this tube is, for the first twenty-four hours, lightly packed with gauze soaked with iodex, or on to which iodex has been rubbed. If the pericardium is open, it must also be drained. It may be well to repeat, in primary wounds, Cheyne's carbolic treatment is not applicable, syringing with ' antiseptic ' lotions not to be thought of. The method of spraying with Cheatle's malachite-green mercury mixture obviously is well worthy of a trial in addition to fomentations.

Secondary Surgical Treatment.—The local treatment of wounds which are still septic at a later date is the same. By this time it may be well to consider the possibility of obtaining an autogenous vaccine or the use of a stock antisepsis vaccine. If the pleural cavity is septic, as soon as this is recognized, it must be dealt with, as I have said, by effective drainage after free excision of a rib. Before undertaking any of these later operations, the assistance of an expert radiographer should be obtained in all cases. Fragments of rib are thereby recognized and the position of the bullet or fragment in the chest localised. Even at this date, no exploration should be made for the bullet, but, as I have said, if it appears to be quite subcutaneous, I cannot see any objection to its removal. It is naturally impossible to go into the radiographer's established province, but, in the hope that they may be useful for comparison, I have, through Professor

Robinson's courtesy, reproduced two radiographs of the normal chest, from the front and from the back, taken by my friend, Dr. Gouldesbrough.

Treatment of a Long-continued Empyema.—Fresh air and, if possible, sea air, and rich proteid food are strongly indicated. The patient may be taught to expire forcibly as soon as the sinus in the chest shows signs of healing and the lung is beginning to expand.

It is of special importance that there should be no delay in treating the case as one of chronic empyema. If the discharge remains septic and the patient's temperature shows no signs of steady improvement, bacterial therapeutic methods should be decided on and carried out steadily. It is well to remember that cases of continued sepsis are apt to fall into a hopeless state of apathy, and this is specially true in vigorous, robust young men. With continued injections, the patient feels that something is being done for him, and, in this way, vaccines or other injections undoubtedly have a good mental effect. It is obvious that, if an expert pathologist is at hand, he should be called in to advise, and, if his advice be followed, it will be well for all concerned if he is invited to treat the case himself from his point of view.

At the same time, there must be no neglect of gross physical methods. If the opening is at fault it should be dealt with as already described (pp. 107, 113). If the lung is not expanding, breathing exercises to endeavour to assist in its expansion should be persevered in. The patient should be sitting and, if possible,

moved about in the fresh air. A shut-off abscess cavity must be opened and, if there is reason to suspect the presence of subphrenic abscess, it should be explored and drained. It is most important that the bowels should be kept regularly opened, preferably with salines if these are sufficiently strong.

A very common cause of chronic empyema is too early removal of the tube. Speaking generally, the tube should not be removed while there is definite purulent discharge, not unless the discharge is thin and watery and about half an ounce in the twelve hours.

Last of all, from the nursing point of view, it is important to remember that there is rapid loss of flesh and consequently that bedsores are liable to form. The usual scrupulous care of the skin should be adopted from the first, and a water-bed or, failing this, an air-pillow for the sacrum and buttocks used from the first. The last operative treatment to be adopted is Thoracoplasty. I have already insisted upon the seriousness of this operation.

Treatment of Shock.—It is impossible to exaggerate the importance of the adequate treatment of shock, both in the more serious wounds of the thorax in war and in all the more important later operations. I may therefore be allowed a few words on the subject. Treatment for shock may be considered under: (1) Preventive.—There should be no prolonged period of starvation before the operation, two hours being quite sufficient. The last meal should be a cup of beef tea or Bovril; morphia ($\frac{1}{4}$ grain) and atropin ($\frac{1}{150}$ grain) should be given *hypodermically half an*

hour before the operation, or at once in case of shell wounds; 'Omnopon', one ampoule, is excellent before later set operations. During the operation the 'Trendelenburg' position should be used if possible; in chest cases, however, this will not be advisable; unnecessary delay should be avoided in the operation and as light as possible a degree of anæsthesia should be kept up. Above all, there should be no pulling or dragging at adhesions, lung or pericardium, or at the intestines or stomach, and no unnecessary exposure of the viscera. The patient is kept as warm as possible, and, if the viscera are exposed or there be a very large extensive wound, as in shell injuries of the chest, the wound is covered with towels wrung out in hot sterilized saline solution. At the same time it is to be remembered that if these towels are allowed to get cold they are worse than useless. In cases where it is obvious that an anæsthetic must be given, no dressings should be disturbed until the patient is under the anæsthetic. (2) After and during operation.—Bandaging the extremities; warmth; brandy (℥j in starch mucilage) per rectum; raising the foot of the bed if necessary; digitalin and strychnine are often recommended hypodermically, but it is probable that neither of these has any effect. Continuous fluid by the rectum provides by far the best gradual method of combating shock. Pituitary extract, there is no doubt, has a powerful effect in combating shock by its effects on both the blood pressure and the plain muscular tissue of the whole body; thus, by the contractions of the plain muscular tissue of the blood-

vessels and intestinal tract, more fluid reaches the rest of the circulation; it has also a considerable effect on the heart muscle. Most are agreed that the posterior lobe of the pituitary gland is alone active, and it should be always used; indeed the anterior lobe has been shown to *lower* blood pressure. The rise in blood pressure with pituitary extract is continued half an hour or more for the first dose; successive injections of pituitary extract are followed by less and less rise in blood pressure until no rise at all occurs. The rise of blood pressure is not so rapid as that produced by adrenalin, but it is maintained. Pituitary extract does not affect the action of adrenalin. I am in the habit, in severe cases of shock, of giving a dose of adrenalin at once, then a hypodermic of pituitary extract in about ten minutes' time; this is to be repeated every three hours if necessary until four doses have been taken; if there is not recovery, the injections can be repeated, but it is doubtful if they are now very active. It may be noted that the action of pituitary extract in removing flatus after abdominal operations is very remarkable. It is, at any rate, more lasting than that of adrenalin, but the action of adrenalin is more rapid, thus it may well be given first.

Infusion of fluids into the tissues. In grave cases of shock, where no other apparatus is available, two pints of fluid may be injected by a large saline syringe with a needle into the loose tissues such as the axilla. This may be saline solution, i. e. salt one teaspoonful to the pint; to this an ounce of brandy may be added

and 10 min. of solution of 1 in 1,000 adrenalin. The temperature of the solution, if it is in a jug, should be 120–130° F., as it cools rapidly. It is to be observed that if the circulation is at all adequate this will be rapidly absorbed. The method of injecting fluid into a vein is now considered by many to be absolutely dangerous, as it produces too rapid a change in the circulation, and may be the cause of sudden heart failure. The old method of transfusing blood from one patient to another is now obsolete. It is well to remember that nothing can be gained by rapid injection of fluid into the tissues if there is no absorption. Caffeine and sodium benzoate three to six grains to the pint have also been used as an injection into the tissues, also glucose 5 per cent. Recently American surgeons have used a mixture of one pint of champagne to two pints of sterilized solution for injections into the tissues, and they speak highly of the extraordinarily stimulating effect of such a mixture. In giving fluid continuously into the rectum it is necessary to remember the following points: (1) in most cases the rectum should have been cleared out first by an enema; (2) a small rubber catheter should be used, and should be inserted quite six inches into the bowel; (3) the fluid to be administered should be kept in a Thermos flask at about 120–130° F., and this should be raised more than six to eight inches above the bowel; (4) the fluid to be used can hardly be allowed to run too slowly into the bowel. It should be allowed to run at the rate of about half a pint an hour. It should be controlled by a drop valve which

allows the rate of the fluid dropping through to be seen; (5) very nearly 20 per cent of adults will not retain fluid per rectum despite all the care of the administrator.

I have personal experience of the following extracts of the pituitary gland, all of which are most reliable:

Pituitrin (Parke, Davis), supplied in ampoules containing 1 c.c. or 16 minims. Of this, I use 1 c.c. as above, injected into the muscles.

Infundin (Burroughs, Wellcome & Co.), in vaporoles of 1 c.c., injected in the same way.

All the preparations I have used have one defect in common: that is, that they are exceedingly costly. Still, they can be kept for an indefinite time; their use is only indicated for pressing emergencies, and under such conditions expense cannot be grudged.

Messrs. Allen & Hanbury supply an ingenious little syringe which can be fitted on to both ends of their 'Azoules', thus shortening the operation.

With regard to an initial dose of suprarenal extract the following may be given:

Adrenalin 1:1,000 (Allen & Hanbury), min. 10, for single intramuscular injections.

Hemisine 1:1,000 (Burroughs, Wellcome), min. 10, for single intramuscular injections.

For local applications for mere checking hæmorrhage, both are combined with eucaine or cocaine in varying strengths.

Treatment of shock by continuous injection of saline by the rectum or into the tissues is admittedly of immense importance, and it is widely used. There

can be no doubt that every surgical ward or operating theatre should have an adequate apparatus at hand *and ready* for any emergency. Simple injection through a funnel or from a syringe is often recommended, for, in the words of a well-known poster: 'It 's so simple'; but then it is never ready, and while the expert and inexpert are preparing it the patient is dying. To me it hardly seems credible that an operating theatre, whether on land or sea, should be allowed to be without apparatus for such injection to be kept ready for every major operation and to be considered as necessary as the sterilized drum of dressings or the scalpel. Two forms of apparatus may be considered: Souttar's 'Thermos' arrangement, and the rubber bag apparatus.

The only disadvantages in Souttar's apparatus is that the 'Thermos' flasks are liable to break, especially if boiling water is suddenly put into them; reserve flasks should be kept. The apparatus is a little cumbersome, but the stand is made to fold. I cannot do better than quote the inventor's use of this apparatus verbatim.

The apparatus consists in a vacuum flask, a syphon, a water-gauge, and a three-way tap. The vacuum flask is the ordinary 'Thermos' pattern, and holds either one or two pints. The syphon has two limbs, one a rubber tube reaching to the bottom of the flask, the other of plated copper, reaching down outside to a point below the flask and terminating in the tap. Parallel with the syphon tube and connected with its lower end above the tap, is a water-gauge of glass

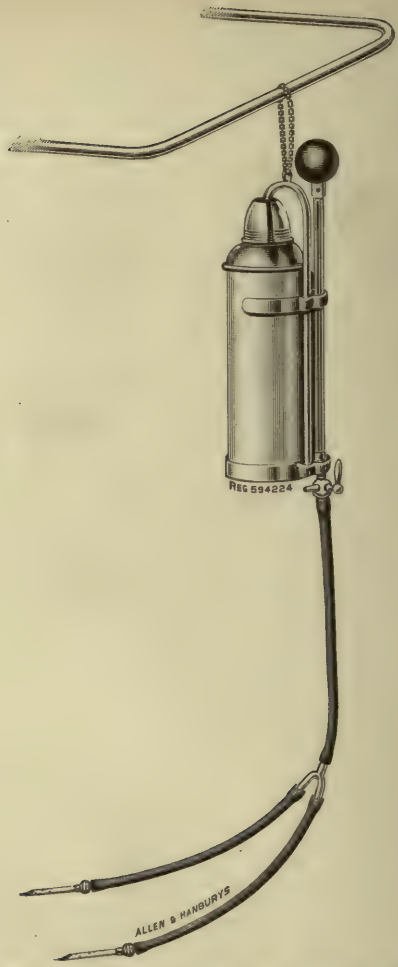


FIG. 16. Souttar's apparatus for saline injection into the tissues.

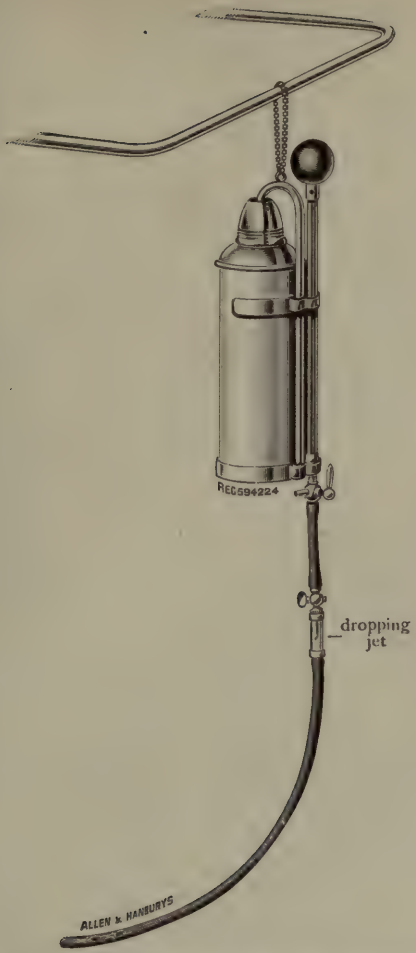


FIG. 17. Souttar's apparatus for continuous injection of rectal saline.

tube, protected by a metal guard. This gauge carries above a rubber ball used for filling the syphon. The flask stands upright in a small tray, and may easily be detached. It is closed by a tap which may be removed for refilling without disturbing the syphon.

FIG. 18. Dropping jet for Souttar's apparatus for rectal infusion.

The method of use is as follows : The flask is filled with hot saline, the syphon, &c., being already attached. The tap is closed. The rubber ball is compressed, a small hole below it is closed by the finger, and the ball is released. A rush of fluid follows round the syphon and up the gauge, and the apparatus is ready for use.

The flask is hung by means of the chain from any convenient support above the patient's bed, and the needles for subcutaneous infusion or the rectal tube are connected by a rubber tube with a nozzle below the tap. The rate of flow is regulated by the tap and observed on the gauge. Should it be desired to discontinue the flow for a short time the tap is closed, and, before restarting, the syphon is emptied of its now cold contents by the side nozzle on the three-way tap.

The temperature at which the saline should be poured into the flask will, of course, depend upon

the rate of flow, the length of tube exposed, and the temperature of delivery required. It is found that if the saline in the flask is 125° F., the rate of flow one pint per hour, and one foot of rubber tube is exposed, the temperature of delivery is about 105° F. in a room at 60° F. At a rate of half a pint an hour the initial temperature should be 130° F. These figures are only approximate, but are sufficiently accurate for all practical purposes. The temperature of the saline in the flask is almost constant, falling about 1° F. per hour. If, then, the flow remains constant, the temperature of delivery will be unaltered so long as the apparatus is not disturbed.

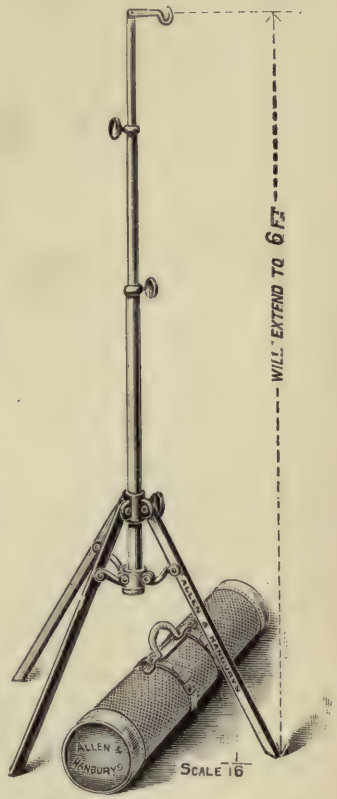


FIG. 19. Portable stand for Souttar's apparatus.

For subcutaneous infusion it is necessary that the apparatus should be sterilized. This is readily accom-

plished by filling the flask with boiling water and running this out through the tubes in the ordinary way. The needle should be separately boiled.

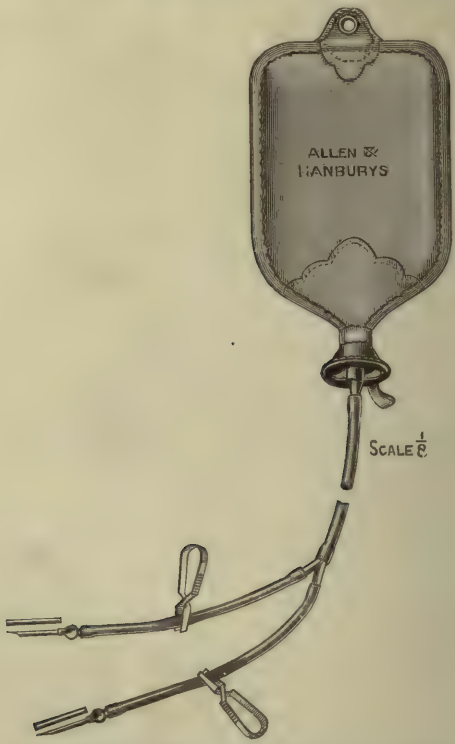


FIG. 20. Rubber bottle arrangement for continuous infusion of saline into the tissues.

The great advantages of this apparatus are its extreme simplicity, both in construction and action,

its absolute reliability, and the fact that it can be readily sterilized. The flask being upright, there is no risk of leakage and no danger of breaking the glass lining by inserting a stopper. The whole apparatus can be in action within five minutes of the moment when it is requested, and it requires no further attention.

A very remarkable feature is the enormous quantity of saline absorbed by this method. Owing to its constant high temperature it is taken up at once into the vessels, there is rarely any swelling of the legs or return by the rectum, shock is successfully combated, and renal excretion is increased. We constantly, at the London Hospital, give five pints subcutaneously by this method in as many hours, and occasionally twice that amount, with no result whatever other than a very remarkable improvement in the patient's condition. In critical cases we use temperatures higher than those mentioned with striking success. Any excess of fluid given is at once balanced by its rapid excretion—in marked contrast to the water-logged subcutaneous tissues so often resulting in the older methods, where the temperature of delivery too often was merely that of the atmosphere. The apparatus has been constructed to my design by Messrs. Allen & Hanbury, Ltd. (*Lancet*, June 1, 1912.)

The rubber bottle apparatus has the advantage of greater portability and the whole can very readily be carried as a routine in the surgeon's bag. The strong rubber bottle is first boiled and then filled with hot

sterilized saline. The tube leading to the Y piece is now screwed on and the rubber pieces going to the needles clipped. The bottle can now be fixed at any elevation, and can be covered with flannel. The saline retains its heat very well, losing about 3° F. each hour. The needles are very well guarded and the rubber good. I know of one set which has been in constant use in a busy surgical home for two and a half years.

After-Effects of Wounds of the Thorax.—It is difficult to generalize on this subject. There is little doubt that if a bullet is left in the chest, after-effects of some kind continue. These may be somewhat functional, or may be quite organic. Most patients complain of localised pain where they think the bullet is, but radiography will show that the bullet is entirely altered in position. I recollect a case where the end of an exploratory syringe was lost in a patient's right base, and, very properly, the surgeon made no attempt to remove it. The patient obtained much subsequent advice, and suffered from localised pain, but a radiograph some two years afterwards showed clearly that the foreign body lay lengthwise in front of the lung root and behind the heart, and was firmly fixed in position. It was obviously doing no harm there, and any attempt at removal would have been to the last degree dangerous. All foreign bodies have a tendency to travel at a late date. I have already quoted a case where a bullet travelled to the surface at a very early date. This travelling of bullets is as exaggerated in the lay male mind as are ante-natal impressions in the

female, and it is perfectly idle to attempt to remove the impression. A real after-effect is shortness of breath. It is very naturally complained of on exercise for a long time, even extending to years after the wound, and if there is any question of failure of expansion in the lung or of the presence of a foreign body.

Another after-effect is localised pain in the ribs which is worst in change of weather. In those cases where the lung has retained the bullet, the patient may, as I have said, ultimately succumb to phthisis, but I am quite unable to estimate the frequency with which this may occur.

Last of all, we may consider the possibility of a small localised empyema not having been absorbed but having burst through the lung. In these cases a cough with purulent discharge continues for a great length of time, and the lung may show symptoms later on of bronchiectasis.

It might be imagined that the discharge of pus from an empyema would give rise to urgent and dangerous symptoms. Such is not the case, for an empyema discharges internally into the lung, when the gradual character of the process itself is very characteristic.

CHAPTER IX

RARER SEPTIC COMPLICATIONS

Tetanus and Gaseous Gangrene.—Both of these are caused by anærobic organisms, and it is to be remembered that these flourish in suppuration. Fortunately both are now rare, at any rate in infections of the thorax and malignant œdema. In all cases it would appear that suppurative organisms extract the available oxygen from the tissues.

Tetanus.—I have not myself met with a case of tetanus in connexion with a wound of the thorax, but those I have heard of were much the same except that the incubation period was usually short, from five to ten days, and the mortality very great. The symptoms do not begin early, for the organism is an obligatory anærobe and cannot flourish until the suppuration organisms have removed all oxygen from the wound. In all cases where mud[1] of the battlefield is found in a wound of the thorax, there can be little doubt that a prophylactic dose of 1,500 units of antitetanus serum should be given at once and another 1,000 within the first 24 hours. If the abdominal muscles are examined, they will often be found in a state of tonic contraction some hours or days before the patient complains of symptoms. *A priori* one would imagine that as the bacillus of tetanus is an anærobe it would flourish in the sup-

[1] It is quite possible for cases of tetanus to occur without contamination with mud. I have seen two cases of tetanus (both fatal and in both the organism was found) which occurred from shell wounds on board ship, and in the ships there had been no shore leave for months.

puration which may exist in deep muscular places. It is worth remembering that the bacillus flourishes in 1:20 carbolic acid.

If the spasms have actually begun, hypnotics should be regularly given to relieve symptoms—chloral bromide or chloretone—and the patient kept in the dark and absolutely undisturbed if possible. An injection of antitetanus serum ought to be given into the spinal space by lumbar puncture. 1,500–3,000 U.S.A. units should be given in this way every 6–12 hours. The Lister Institute provide a glass syringe, holding 10 c.c. to 100 c.c., containing 1,500 units of the antitoxin, which are given at once into four parts of the body. 100 c.c. are repeated the following two days. A final dose is advised, even in favourable cases, 10–14 days after the first injection. There is little doubt that enormous doses should be used if possible. Recently Major Embledon recommends 10,000 units on appearance of symptoms, 3,000 every 2 hours until symptoms have abated for 3 days.

As a prophylactic, the Lister Institute recommend 20 c.c. They attach no importance at all to rashes occurring after antitoxin, and state that the liquid antitoxin will keep perfectly well for a year if kept on ice. A solid product is obtained by drying the liquid *in vacuo*. It is better for use in the tropics. Intrathecal injections of magnesium sulphate have been recommended. Messrs. Allen & Hanbury supply a sterile solution of Magn. sulph., 1 gramme in 4 c.c. 2½–6 c.c. of this solution are injected into the spinal space; 3–4 doses can be given at intervals of 12 hours. This has not proved very reliable.

Gaseous Gangrene.—This is caused by the bacillus aerogenes capsulatus, a Gram-positive, spore-bearing anærobe, very fatal and very widely distributed. It should be suspected in cases of thin foul gaseous discharge associated with Gram-positive bacilli. Here again the infection does not seem at all prevalent in wounds of the thorax. If it occurs, it should be dealt with by the principles laid down. I have no experience of the action of vaccines against this particular organism. To obviate against both of these infections, hydrogen peroxide should be used in all very dirty cases. An antitoxin can be obtained commercially, 1,500 units in strength, in ampullæ of about 9 c.c. each, for prophylaxis. Most important of all, the wound should be at once opened up under an anæsthetic, thoroughly cleansed by scraping, and then treated with hydrogen peroxide, followed by hypertonic saline or other antiseptic treatment.

Fleming (*Lancet*, Aug. 21, 1915) has very recently reported the results of an investigation of thirty-two cases. He shows that there is a remarkable symbiosis between the organism and both staphylococci and streptococci, and that the organism growing in blood produces lactic acid, which inhibits leucocytosis.

Treatment he considers to be summed up in the words, 'Free drainage from the first': granting this the disease will probably not occur. He suggests a prophylactic dose of ærogenes capsulatus and streptococcus vaccine and points out that enormous doses of capsulatus vaccine are harmless and have no negative phase.

General Conclusions

1. Modern bullet wounds of the thorax usually keep a straight course along the line the bullet has entered the thorax.

2. The entrance and exit wounds are usually much the same in size. An expansive exit wound is uncommon, unless the bullet strikes the spine or the shoulder.

3. The wound is probably uniformly septic from end to end, but this sepsis is of a mild character and in the deeper parts is usually overcome by the body itself.

4. The danger of probing bullet wounds of the thorax is extreme and real.

5. Bullets usually lodge in the posterior part of the thorax. If they become subcutaneous they can readily be removed, but otherwise they should be left alone.

6. Comminuted fracture of the ribs is usually very septic.

7. An uncomplicated hæmothorax should be left alone.

8. It is by no means uncommon for a hæmothorax to become infected, especially where there has been much movement of the patient, and such cases should be dealt with and given the proper drainage.

9. A localised pneumothorax is not uncommon.

10. The immediate treatment of wounds of the thorax differs considerably from the treatment which should be adopted at a later stage.

11. The employment of bacterial therapeutics should never be neglected, for, even if the results are sometimes disappointing, no harm to the patient can ensue.

CHAPTER X

BACTERIOLOGICAL THERAPEUTIC METHODS

At the outset, in all cases of septic wounds, the pathologist will be asked two questions by the surgeon :

1. What is the infection ?
2. How can it be combated ?

The Causes of Infection.—These can easily be found out by an immediate film preparation taken as early as possible from the wound, if possible before healing has begun. This is especially important, as nearly all cases of wound infection are caused by a number of different organisms—cocci, bacteria, saprophytes, ærobic and non-ærobic organisms. During the process of heating these are killed off either by the tissues of the unwilling host or by each other, usually in a definite order. Thus, only at the beginning can we discover all the various forms present and what are causing septic symptoms. At the same time, a culture on agar is made and a tube of serum inoculated. By these means the bacteriologist can prepare later an autogenous vaccine from the growth of the actual strains of organisms present in the wound.

Importance of Film Preparation.—Where possible a film preparation should always be taken in the

usual way. This is stained by Gram's method and examined for Gram-positive bacilli. If these are found, they are probably anærobic bacilli, and, though we are not very likely to recognize the drumstick tetanus bacillus nor the capsuled bacillus of gaseous gangrene, we can at any rate infer their presence as possible if not likely. In all such cases a prophylactic injection of tetanus antitoxin should be given at once. The wound should then be opened up freely and treated with hydrogen peroxide or oxygen; but, above all, there should be no danger left behind of discharge being pent up in pockets. It is right to say that the bacillus coli is also Gram-positive, but it does not seem to exert a very toxic action in the wounds. The Gram-positive streptococci and staphylococci can also be recognized and their relative numbers estimated, having in view treatment by a stock vaccine. The answer to the second question, How can the infection best be combated? is, By establishing immunity in the body from the organisms present in the wound.

Immunity is either natural or acquired.

Natural immunity is rare and explains itself. Some animals are naturally immune from one affection which may be very toxic in others.

Acquired immunity is seen after the body has recovered from an infectious disease. It may be artificially produced against any infection by small doses of the actual organism, but this is far too dangerous and lengthy to be of any value as a therapeutic method.

Acquired immunity may be either Passive or Active:

Passive immunity may be produced by injecting varying doses of the serum of an animal which has been rendered immune to the particular infection by steadily increasing doses of the actual organism. An example of this form of immunity is shown by the prophylactic use of diphtheria antitoxin or antitetanus serum. In passive immunity, immunity is established rapidly, but it is very evanescent, lasting at most but a few weeks. Moreover, there is a great objection to the use of all antitoxic serums, in that, with the serum, something foreign is introduced into the body which often establishes a great hypersensitiveness in the cells of the body to other injections. To these phenomena the names anaphylaxis or serum sickness are given. The symptoms usually occur about the second week after inoculation, when there may be fever, skin eruptions, joint pains, or even more serious symptoms. In such cases, a second injection should not be given. Calcium lactate in 10–20-grain doses is recommended twice a day as a preventive drug.

List of Antitoxins

Parke, Davis, & Co.

Antitoxins, unit Behring. Smallest dose of toxin fatal to a standard guinea-pig of 250 grammes weight and the least quantity of serum that would protect the guinea-pig against ten times this minimum fatal dose. This quantity of serum, multiplied by ten, is the antitoxin unit.

Antistreptococcus serum. Results vary considerably. According to Emery, it is mainly, if not entirely, bacteriolytic and not antitoxic. This serum is polyvalent, obtained from the blood of horses immunized against various forms of streptococcal infection; it is tested in the Pathological Laboratory of the University of Cambridge. Dose in severe cases, 20–40 c.c. every 6–8 hours. The temperature should come down in 24 hours; 1 bulb = 10 c.c.

Antitetanus serum. Supplied in bulbs containing 1,500 units, volume about 9 c.c. Tested as in the case of antistreptococcus serum.

Antitetanus serum globulins, dry. Each bulb contains 1,500 units. A sealed bulb of sterile water is sent out to dissolve the globulins.

Allen & Hanbury. Under the authority of the Lister Institute.

Tetanus antitoxin. Strength not given; supplied in tubes of 10 c.c.; but 30 c.c. are recommended to be injected intravenously as treatment, and 100 c.c. subcutaneously, and dose repeated on two following days in 33 bulbs. Two bulbs are sufficient for prophylactic treatment.

Antistreptococcic serum. Polyvalent, 20 strains of streptococci used. This has an opsonic (bacteriolytic) action. Dose 33 c.c. in an acute case, repeated in 6 hours; supplied in tubes of 10 c.c.

Burroughs, Wellcome & Co.

Tetanus antitoxic serum. In phials of 10 c.c., each 1,500 units.

Antistreptococcus serum. Polyvalent. In phials 10 c.c. and 25 c.c.; 25 c.c. 'probably proper dose'. Strength unknown.

Antistaphylococcus serum. Polyvalent. In phials containing 10 or 25 c.c. Dose same.

Active immunity, on the other hand, is formed by the inoculation of cultures of the organism killed by heat. It is seen in the prophylactic injections against cholera and typhoid. Its advantages are that the immunity, when obtained, lasts a long time, probably some years; its disadvantages, that it takes a long time with increasing doses to obtain immunity, that after each injection there is a certain amount of constitutional disturbance, and, in particular, that there is a 'negative phase' or period when the bodily resistance to the organism is actually lowered; after each injection this negative phase is naturally a period of danger; it varies in duration, but it has been shown that it can be greatly lessened by carefully raising the dose in small amounts and never giving an overdose.

Active immunity by vaccines. Vaccines may be either (1) autogenous—prepared from the actual organisms contained in the infection to be treated in the relative amounts that existed in the fresh infection approximately; (2) stock prepared from mixtures of known septic organisms in laboratories elsewhere and sent out in definite numbers of organisms per c.c.

Preparation of an autogenous vaccine. A suspension is made in sterilized normal saline solution from

a forty-eight hours agar culture of the organisms contained in the wound. These are counted and the suspension is killed by heating to 60° C. or by addition of 5 per cent carbolic acid.

The suspension is then diluted so as to contain a definite number of million organisms per c.c. It is then sent out in small glass vials, the end of which can be broken and the needle of a hypodermic syringe inserted.

Dose of an autogenous vaccine. This varies with the nature of the organisms, the chief point being that the initial dose, when streptococci predominate, must be small and the climbing in dosage very gradual, whereas, when streptococci predominate, the first dose can be comparatively large, and it can be rapidly increased. As a general example, the following may be taken as an average :

Streptococci :

First dose, 2½–7 millions.
4–5 days interval.
Second dose, 15 millions.
Increase to 200 millions with same intervals.

Staphylococci :

First dose, 50 millions.
Second dose, 100 millions.
Increase to over 1,000 millions with three-day intervals.

Stock Vaccines

Parke, Davis & Co. Prepared under the supervision of the Director of the Department of Therapeutic Inoculation, St. Mary's Hospital, Sir Almroth Wright, F.R.S.

Antigangrene vaccine. Prepared from cultures made from cases of gaseous gangrene in military hospitals; a mixed vaccine of B. ærogenes capsulatus and streptococcus, 200 millions B. ærogenes capsulatus and 20 millions streptococcus per c.c. First dose, 5 c.c.

Antisepsis vaccine. 25 millions streptococci and 500 millions staphylococci per c.c.; prophylactic 1 c.c. at once. For therapeutic purposes dilute vaccine tenfold, and give 1 c.c. of dilution every three days; if there is serious constitutional disturbance give 5 c.c., and in very serious cases 25 c.c. of the tenfold solution.

Staphylococcus vaccine. 100, 500, and 1,000 millions per c.c. Minimum dose, 50–100 millions, increasing to 250 or 1,000 millions.

Streptococcus vaccine, 5 and 20 millions streptococci per c.c. Minimum dose, 1 million; medium, 5–15 millions.

Allen & Hanbury. Prepared under the authority of the Lister Institute.

Staphylococcus vaccine (from staphylococcus aureus, also from aureus, citreus, and albus). First dose, 500 millions cocci; a second of 2,000 millions after

ten days. An interval of ten days should always be allowed. Prepared in vials :

White, 500 millions.
Amber, 1,000 millions.
Blue, 2,000 millions.

Multivalent streptococcus vaccine. For first dose, 2½ millions cocci ; second, similar after ten days, subsequently increased to 5 millions. An interval of ten days should always be observed between injections.

White vial, 2½ millions cocci.
Amber vial, 5 millions cocci.
Blue vial, 10 millions cocci.

Burroughs, Wellcome & Co.

Staphylococcus vaccine. Aureus.
1 c.c. = 200 millions.
1 c.c. = 1,000 millions.

Streptococcus vaccine. Polyvalent.
1 c.c. = 10 million organisms (initial dose).
1 c.c. = 50 million organisms.

Amongst a large series of cases of wounded, it is almost impossible to expect autogenous vaccines to be prepared and given. If this can be done, no doubt the results would be better ; but personally I have no experience of autogenous vaccines in war. I would strongly advise, in septic cases, the mixed stock vaccine prepared by Fleet-Surgeon Bassett-Smith and used in His Majesty's Navy.

In my own series of empyemas it was regularly

given. I was frankly sceptical at first as to whether the good result was due to the vaccine or to the operation. It was soon given some days after operation, owing to press of work, and then continued. In every case both temperature and discharge showed a marked improvement, which continued, and it became impossible, in spite of this, to believe that the result could not be due to anything else but the vaccine treatment.

Fleet-Surgeon Bassett-Smith has kindly allowed me to incorporate his notes as to the use of this vaccine.

'The Antisepsis Vaccine is made here (R.N. College, Greenwich) from 5 strains of streptococcus and 5 strains of staphylococcus; all of these were obtained from actual fresh wound cases isolated at R.N. hospitals at Plymouth and Deal.

'1 grain in glucose broth.

'2 on agar (Roux bottles) for 24 hours standardized, killed 1 at 50, 2 at 60 for 1 hour, diluted down with saline and 3 per cent Lysol added. It is examined frequently for sterility and 1 c.c. inoculated into a guinea-pig for further test—no abscess formation. I am making fresh cultivations about every three months, and intend to renew all ships about the end of the year.'

Instructions Given with Bassett-Smith's Antisepsis Vaccines

Wounds received in war-time are especially prone to be infected with non-pathogenic and pathogenic micro-organisms, particularly those producing suppuration. It is very desirable to do everything possible to increase the defensive forces of the body against these septic organisms so introduced.

Our method of raising the resisting power of the person is to favour the development of antibodies against these organisms by the use of Antisepsis Vaccine.

The samples supplied may be used either as prophylactic or therapeutic agents. For the former, $\frac{1}{2}$ c.c. (8 min.) should be injected subcutaneously in a position not liable to friction or pressure. It should be used, if possible, *in all cases of wounds before suppuration has set in.*

Instructions for Prophylactic Use

It would be advisable to inoculate every severely wounded man without delay with a prophylactic dose of antisepsis vaccine. This would be advisable also in the case of every man who has to undergo a surgical operation.

Instructions for Therapeutic Use

For the treatment of cases which are already septic, the vaccine ought to be diluted tenfold in sterile water, 0·5 c.c. ought to be injected every second day.

In cases which are very severely infected, one-quarter of the tenfold dilution ought to be injected every day.

In considering the results of vaccine treatment, it must always be remembered that they are useful only as a help to assist the healing of septic wounds, and then only after all proper surgical procedures have been undertaken.

Sir Almroth Wright, who may be regarded as the distinguished originator of vaccine treatment, has recently enumerated the classes of cases that are benefited by vaccine treatment and those that are not. His remarks may be put very shortly.

1. Prophylactic use of vaccines is far the best.
2. Localised bacterial infections—results uniformly good.
3. Unopened abscesses and closed infections—vaccines useless.
4. Localised infections with very heavy amount of auto-inoculation—results very poor.
5. Undrained wounds—results poor.
6. Septicæmic infection—very disappointing.

Wound Infections in War

1. Prophylactic use of 'antisepsis vaccines'—doubtful.
2. Employment where organisms tend to make an irruption into the surrounding tissues—results excellent.
3. In well-drained wounds, most excellent.

4. In imperfectly drained wounds, results doubtful, may help the surgeon in conservation treatment.

5. In septicæmic cases, useless.

It is interesting to compare this straightforward statement with the various 'Notes' on the subject in the Lay Press.

Sensitized Vaccines

These combine the antiserum treatment and the vaccine treatment.

When organisms are brought into contact with their own specific immune serum, the antibodies of the serum become fixed to the organism and can be separated out with them.

Preparation of sensitized vaccines.—A suspension, say, of streptococcus vaccine is mixed with a reliable antistreptococcus serum in a centrifugal tube. Some time having been allowed for the absorption of the antibodies from the serum by the organisms, the suspension is centrifugalized and the fluid above it replaced by normal saline. The process is repeated so that all the original serum is now taken away. The vaccine is now killed by carbolic 1%, counted and separated into the necessary dose. It is usually made in bulk (*a*) 100 million per c.c., (*b*) 1,000 million per c.c. For convenient strengths *a* and *b* may be chosen. The sensitized vaccine is contained in a rubber-capped bottle with molten paraffin wax on the top through which the hypodermic needle can be plunged.

Advantages of Sensitized Vaccines

1. Immunity is greatly accelerated.

2. There is no lowered resistance or negative phase.

3. There is no local or general reaction, no serum sickness, or anaphylaxis. The results are said to be most striking. The dose is large and rapidly increased.

Initial dose 100 millions, 250 millions, 1,000 millions, on successive days.

Sensitized vaccines are not at present on the market.

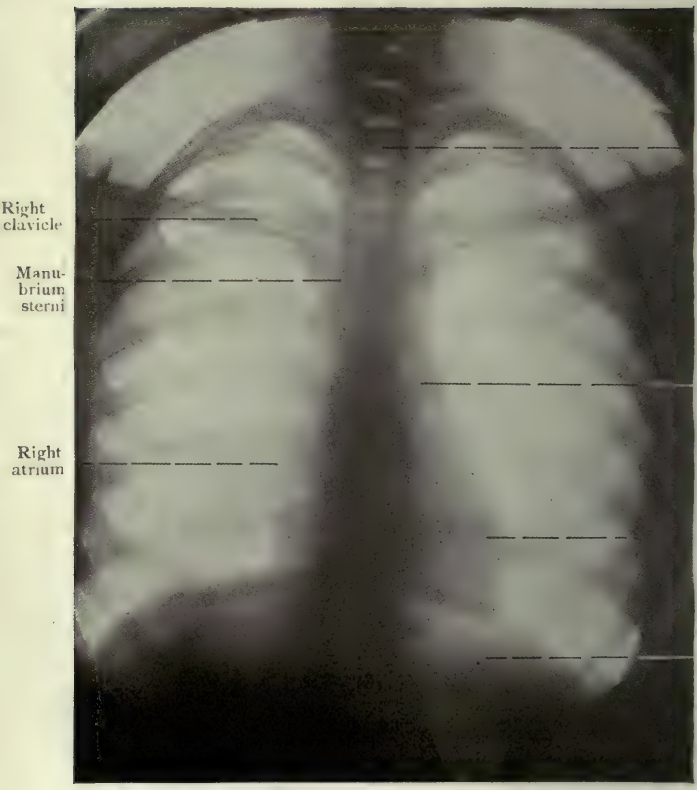


PLATE I. Normal thorax viewed from in front. (Gouldesbrough.)

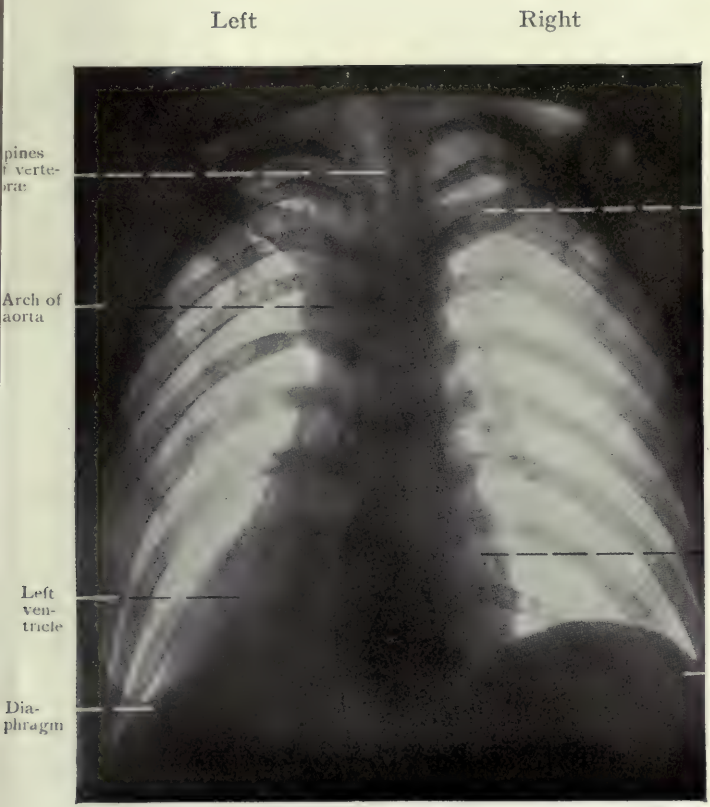


PLATE II. Normal thorax seen from behind.
(Gouldesbrough.)

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