

A Clinical Lecture

ON

GUNSHOT WOUNDS OF THE LUNGS.

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By W. HALE WHITE, M.D. LOND.,

F.R.C.P. LOND.,

SENIOR PHYSICIAN TO GUY'S HOSPITAL; LIEUTENANT - COLONEL, R.A.M.C.(T.), NO. 2 GENERAL HOSPITAL, LONDON; CHAIRMAN AND CONSULTING PHYSICIAN, QUEEN MARY'S ROYAL NAVAL HOSPITAL; PHYSICIAN, KING EDWARD VII. HOSPITAL FOR OFFICERS.

GENTLEMEN,—Many of you are either just qualified or soon will be qualified, and therefore will shortly be engaged in military work. Consequently I thought it might interest you if I gave you some account of bullet wounds of the chest, for in ordinary civil practice many doctors never see one, yet in warfare they are very common, and I chance to have seen a large number since the war began.

EFFECTS OF BULLET WOUNDS OF THE CHEST.

What will strike you most is that the effects are not more serious. Of course some patients are killed at once or die soon after, others have grave results as empyema; still, if you have to do with large numbers you will be impressed with the extreme good fortune of many who are hit in the chest. This was not always so, for according to Colonel L. A. Lagarde, U.S.A.,¹ the mortality of penetrating wounds of the chest in the French army during the Crimean War was 91·6 per cent., in the English army over 70, and among those which survived to reach hospital in the American Civil War it was 62·5 per cent. But with the introduction of small bullets of high velocity it began to fall. Thus in the Spanish-American War it was 27·5 per cent., in the Boer War 14 per cent., and among the Japanese in the Mukden battle 3·67 per cent. In the present war, although the mortality is low, it is probably not as low as the last figure.

Escape of Important Structures.

Some bullets seem almost to thread their way through the important structures in the thorax and so evade them. If the wound is at the upper part of the chest it appears almost impossible, considering the position of the entrance and exit wound, that the spine, the large arteries and veins, and the aorta should be uninjured, yet we can detect no signs of damage to them.

I have seen a man who had his left recurrent laryngeal nerve damaged by a bullet in the chest and yet the large vessels were unhurt, and in another instance the only evidence of damage to any other structure than the lung was that the pupil was larger on the damaged side than on the other. In a man of about 30 years of age a bullet entered the back, going through the body of the right scapula just below the outer part of the spine. It passed forwards and upwards through the lung, fractured the sternal end of the right clavicle into several pieces, and emerged at the right sternoclavicular joint. It damaged no artery or nerve of sufficient size to give any evidence of such damage.

Here is another instance of a narrow escape. A man, aged 54, whilst waving his arm was hit by a bullet at a point on the inner margin of the left

deltoid 2 inches above the insertion of the muscle. The X rays showed it to be lying in the posterior part of the chest 6½ inches from the skin on the front behind the superior vena cava; it moved up and down with respiration and from side to side synchronously with the heart. At first after the injury there was severe pain in the chest; dyspnoea and inability to lie down lasted a week. On arrival in this country less than three weeks after the injury there were no abnormal physical signs, he breathed easily and could lie down and walk about with comfort. A case in which the bullet went in the opposite direction was the following. It entered the second left intercostal space close to the sternum and lay under the skin close to the insertion of the right deltoid muscle. Here there was no evidence of damage to any important structure except the lung.

This possible good fortune may not only attend those who are hit in the upper part of the chest, but those who are hit in the lower part. For example, a young man was hit by a bullet close to the sternum in the fifth left intercostal space. The bullet could be seen with the X rays to lie in the upper part of the liver near the tip of the eleventh rib, or more probably in the deeper part of the abdominal wall at this point. Immediately he was hit he had a pain in the chest, but he neither coughed nor vomited any blood. For a short time he had dyspnoea, but that soon passed off; and when examined in this country two and a half weeks after the injury there were no abnormal physical signs in the chest, and he seemed well. In another case a bullet entered over the heart, but did not as far as could be discovered damage it. Passing to the right it caused what was concluded from X ray examination to be a large blood clot on the top of the liver. As showing how bullets may travel, I have seen a bullet which entered the chest found lying in the psoas; here, too, no important structures were damaged.

Slight Harmful Effects on the Lung.

The following are of interest, not so much because of the avoidance of important structures as that the effects are not more severe.

One of the most remarkable examples was that of an officer, aged 47, who was hit by a bullet at a range of 100 yards. He estimates that at the time it struck him it was travelling at the rate of over 2000 feet a second; it passed through a silver cigarette case and then straight through the chest. He was able to walk a mile before he reached medical aid but felt short of breath on arrival. At no time had he any pain or discomfort, and so little did he feel the effects of his wounds that at the end of half a mile he declared he had not been wounded, but his servant said he had for he had blood on his clothes. At the end of his walk he coughed up a little blood, and this hæmoptysis continued for two or three days, but he had no other effects of his wound. The wound of entrance was between the left fifth and sixth ribs 1½ inches external to the nipple line; that of exit between the ninth and tenth ribs in the line of the angle of the scapula. When I saw him a fortnight later both wounds were healed. There was absolutely nothing wrong to be detected in the left chest, and he made no complaint whatever. The air entered equally on the two sides, the physical signs were normal, and he breathed easily and normally; he was not short of breath.

Another case was that of a man who was hit by a bullet that entered the chest in the left axilla and

¹ Gunshot Injuries, 1914.

passed out at the middle of the back on the same side. He had slight hæmoptysis, but when I saw him a few days later I could find no abnormal physical signs, and at the end of four months he returned to active service at the front. A man was hit by a bullet which entered the chest just below the inner end of the right clavicle; the point of exit was below the angle of the right scapula. He had a little hæmoptysis, and when seen here he had signs of a moderate degree of hæmothorax. Nine months later he wrote to me saying: "The wound through my lung has gone completely as a dream at night. I am just off to the Dardanelles."

In another case the bullet entered through the scapula just below the spine, and the X rays showed it lying in the lung at the level of the tenth rib. He was very dyspnoeic for some time, and there was some collapse of the lung causing flattening of the left chest. Yet seven months later he is doing light duty, and he writes: "I am now quite all right, although very short of wind after violent exercise. My left side has filled out until it is practically the same as the right. The shrapnel has not been removed. I am I hope shortly returning to the fray." In a young lieutenant a bullet went straight through the left chest, passing out through the scapula. There were hardly any abnormal physical signs. Six weeks after being hit he was passed as fit for light duty, and a month later as fit for active service. I heard from him after he had been doing this four months, and he said he had been working hard without any ill-effects. In another lieutenant the bullet entered just below the right subclavian and passed out through the right scapula. He had a good deal of hæmorrhage from the lung, but four months later he writes: "I am glad to be able to tell you that my chest has made a perfect recovery, and now I suffer from no ill-effects of my wound."

Here is one other case. A young officer was hit by a bullet which passed right through the right chest from back to front. He had hæmoptysis, but when seen here three weeks later except for a little dullness at the right base his chest seemed healthy; the entry of air and movement of the chest were normal. Five months later I heard from him, and he said: "My chest has made a perfect recovery, and I now suffer from no ill-effects of my wound."

I might, if time allowed, give you many more instances illustrating, firstly, that bullets may, even when it seems almost impossible, considering their track, avoid damage to nerves and vessels; and, secondly, when they pass right through the lungs the harmful effect on the lung may be slight.

SYMPTOMS.

We may now turn to the symptoms. Usually there is some pain felt when the bullet enters the chest, but exceptionally the patient may be hardly aware he is hit, and then he suffers neither from pain, hæmoptysis, nor dyspnoea. Perhaps the last is the commonest symptom; sometimes it takes months to pass away, sometimes it is very severe for a few days and then quickly goes. Both in intensity and duration it is most variable. Often there is a hæmothorax or other reason for it, but often the explanation is difficult, for it may exist when there are no abnormal physical signs in the chest. Not infrequently I have been able to convince myself that the dyspnoea is partly functional; the patient does not move the affected side properly because he is apprehensive. None of my

patients have been livid, and all breathed quietly and easily when in bed, even when they have been seen a few days after the infliction of the wound.

HÆMOPTYSIS.

Hæmoptysis is very common; from what the patients tell me it occurs in at least three-fourths of the cases, probably more. The amount of blood coughed up is naturally very variable, for it must depend upon the size of the vessels damaged, and will, other things being equal, be greater in proportion as the bullet goes near the root of the lung, as there the vessels are larger than at the periphery. Doubtless it is sometimes immediately fatal, but if it does not kill soon it rarely, if ever, does later, for I have had no case of fatal hæmoptysis in this country. The bleeding usually stops in a few days and does not recur, but one officer had a recrudescence of hæmoptysis several months after that which followed the wounds had ceased. No reason for this could be found: there was no evidence that he had phthisis.

HÆMOTHORAX.

Hæmothorax is frequently seen. The physical signs are those of fluid—viz., impaired movement, impaired or absent entry of air, dull note, diminished voice sounds, and displacement of the heart. Once I have seen a large effusion of blood in the wall of the chest around the entrance wound, and in one case there was a considerable degree of subcutaneous emphysema around the wound; this gradually disappeared in a few days. From the physical signs above it would be impossible to tell these cases from ordinary pleuritic effusion; we only judge that the fluid in the chest is blood from the history of the wound. In one patient in whom we decided that the amount of fluid necessitated aspiration we were surprised to find only clear fluid without any blood; it was evident that the wound had led to a pleuritic effusion, not a hæmothorax.

You might think that pyrexia would not be present with a hæmothorax, but you must remember that pyrexia is quite common with a hæmothorax, the cause being in many cases infection of the clot and fluid, and in many others no doubt rapid absorption of altered blood from the extensive pleural surfaces. Pyrexia does not always mean microbic infection of the effused blood, for the patient's illness often does not suggest a general infection, and he gets perfectly well without removing any of the fluid from the chest by aspiration or laying it open. The temperature in the cases in which there is no evidence of infection of the effused fluid may be normal, but may be raised for any time from a few days to a few weeks. Commonly it is about 99° F. in the morning and 100° or 101° in the evening, and the chart is very regular, often remaining at the same height every evening for some time. Gradually both morning and evening temperatures decline for some days until normal is attained.

This pyrexia has often led to an erroneous diagnosis of pus. This was so in the case of a civilian accidentally shot with a revolver whom I saw recently. The matter can always be settled by a bacteriological examination of some of the fluid removed by an exploring needle. After a bullet wound of the chest leading to hæmothorax, microbic infection of the contents of the pleura should be suspected when the evening temperature is high and the daily excursion wide; the general symptoms are more severe than they are in cases of a sterile

hæmothorax, and a leucocytosis may be a guide. The amount of pus or the odour of the fluid removed with an exploring needle will often settle the diagnosis, but a bacteriological examination may be necessary. An empyema has occurred in about 10 per cent. of my cases, but other collections made abroad give, I believe, a higher percentage, for naturally cases severely ill would not be sent over here quickly.

Aspiration.

e In the greater number of instances of hæmothorax seen in this country it is quite unnecessary to put a needle in the chest; the diagnosis can be made without this. Many of the patients get quite well without aspiration and without any medicinal treatment, but the physical signs return to normal much more slowly than with an ordinary pleuritic effusion. This is what we should expect, for it is only likely that altered fluid blood and clot, if any forms, are reabsorbed more slowly than clear fluid.

When the amount of blood in the chest is considerable it should be removed by aspiration, but this should be done slowly with only a moderate diminution of pressure in the exhaust bottle. In one case which I saw there was strong reason to suspect that too rapid emptying of the chest led to a pneumothorax from the tearing open of the wound in the lung. The removal of some—say half—of the fluid in the chest may accelerate the absorption of the rest, but it is usually wise to take away as much as possible. After aspiration of blood there is no reaccumulation of fluid. In forming an opinion as to whether to aspirate we pay attention to the degree of displacement of the heart and the extent of the physical signs. Hitherto I have not withdrawn the blood unless the heart is well displaced, and the physical signs are those of a large amount of fluid reaching as high as the spine or even the top of the scapula. Physical signs, however, are an uncertain guide to the amount of fluid, for it is impossible to estimate the degree to which the lung is compressed.

As a matter of fact, in all my cases which have been aspirated the amount of bloody fluid withdrawn has been 40 fl. oz. or over; the largest amount has been 80 fl. oz. The fluid, if sterile, has always been of the dark chocolate colour of altered blood. It is very doubtful whether it is pure blood, for a bleeding of 80 fl. oz. of pure blood into the pleural cavity would probably kill the patient outright, and not one of the patients I have seen has by the time he has reached this country had the appearance of a person who has lost a very large quantity of blood, yet we know that a patient who has had, say, a severe post-partum hæmorrhage or a severe hæmatemesis will look pale even a month later. These facts suggest that bleeding into the pleural cavity leads to the effusion from the pleural surface of clear fluid, and hence the very large quantity that may be removed on aspiration. In connexion with this you will remember that one case has already been mentioned in which we expected blood, but found only clear fluid.

Effects of Aspiration.

Although the physical signs over the lung change after aspiration, as they do when clear fluid is aspirated, yet I think they do not alter as rapidly—for example, dullness remains longer after the withdrawal of this bloody fluid than after the withdrawal of the same amount of clear fluid, and it is quite certain that the displaced heart does not return at once to its normal position. Immediately after the removal of the bloody fluid the impulse of

the heart is in much the same position as before aspiration, and it is many days, or even a few weeks, before it reaches its proper place. Perhaps this is because the heart is held out of place by blood clots, which may also explain the persistence of physical signs for longer than after the removal of an ordinary pleuritic effusion, but the persistence in hæmothorax is partly due to the same causes as is the persistence after removal of clear fluid—e.g., the slow expansion of the collapsed lung. That the presence of blood clots explains the long while that elapses before the physical signs disappear and the heart returns is only a suggestion. I have no post-mortem evidence of this, and the effects of a large sudden bleeding into the pleural cavity would well repay experimental investigation.

I have been so impressed with how well cases of hæmothorax do when left alone, the blood being slowly absorbed, that probably I have erred on the side of not aspirating enough of them, and it may be that it would lead to more rapid recovery if all in whom the fluid was over 20 fl. oz. were aspirated. At the beginning of the war we were all feeling our way in the treatment of conditions rarely seen in civil life. Anyhow it is probably wrong to withdraw the fluid shortly after the injury. This might lead to fresh bleeding and to the reopening of the wound in the lung, which in its turn might cause a hæmopneumothorax or a pyopneumothorax. We shall learn from those who see these cases abroad as to how soon it is wise to withdraw the fluid. This, however, is certain, that if after considering all the points here mentioned, and remembering that the less severe cases get perfectly well if left alone, it is decided to withdraw the fluid, do not delay too long, for a lung that is compressed for some time takes a long time to re-expand.

FRACTURE OF RIBS AND OTHER RESULTS.

In very few of the patients with bullet wounds of the chest that I have seen has the bullet struck a rib and run round it; probably the modern bullet has too high a velocity for this. The bullet is small enough to go through the intercostal spaces without hitting a rib. Generally there is no fracture of the ribs, and when it occurs except for the pain it does not seem to matter, but the pain is occasionally troublesome. There has been among my series no case of dangerous external hæmorrhage from the wound. Whether, in any given case, the hæmothorax is due to hæmorrhage from damage to an intercostal artery or to bleeding from the lung there is during life no evidence to show. Considering that the bullet has traversed the clothes it is surprising how often the wounds are clean. Commonly they heal up at once, and indeed many are quite healed by the time we over here see them.

It is remarkable that in cases of hæmothorax air is very rarely present in the pleural cavity. Only twice has it been found in my cases. Once, as already mentioned, it followed aspiration; in this instance it was absorbed without any ill-effects. In the other the patient was admitted with signs of fluid and air in his pleural cavity; he was very ill with high fever. The chest was opened by removing a piece of rib, and a huge quantity of dirty blood-stained fluid escaped which contained a pure culture of the influenza bacillus, showing that it had been infected from the lung. The operation improved his general condition a little, but he continued very ill with high fever for many weeks; ultimately he got quite well. He was the worst

case under my care, and out of about 50 I have seen none have died.

PROGNOSIS.

The outlook for these patients is good, and here are a few instances to illustrate this.

A middle-aged officer was hit by a bullet which entered the left sixth space behind 3 inches from the spine, and came out in the second left space 1 inch from the sternum. There were signs of a considerable hæmothorax, which was not aspirated. I saw him eight months after he was wounded. He was breathing well and said that last week he shot three days and played golf on a fourth. He has been doing light duty for two and a half months. All that can be detected wrong is that in the immediate neighbourhood of the entrance wound the entry of air is somewhat impaired; otherwise the damaged chest is perfectly healthy and similar to the sound side.

In another officer of about the same age a shrapnel bullet entered the chest 1 inch to the right of the lower end of the sternum. X rays showed it to be embedded in the lower part of the right lung. He had signs of a moderate hæmothorax; he was not aspirated. Six weeks after the wound he was passed as fit for general service and left for Flanders a week later. Six months later he writes to me saying: "I have had no medical advice, no symptoms or trouble of any description. I have been leading my ordinary life since I returned to this country, walking, riding, &c., and am able to carry on just the same as before I was wounded. I still have the bullet in me as a souvenir."

The next, a younger man, was hit by a bullet which entered the back 1 inch above the right posterior superior spine and came out in the right axilla. Two pints of bloody fluid were aspirated, and when he left the hospital the right chest was flattened, it moved badly, the air entry was poor, and there was considerable dullness. He went into the country, and six months after he was wounded he was passed as fit for active service. He returned to Flanders and wrote a few weeks later to say he was quite well and at work in the trenches. Before he left England he was able to "go up hills easily in a long day's shooting."

A man, aged about 40, was hit by a bullet which entered the chest in the right anterior axillary fold and passed out behind through the eighth right space. He had signs of a moderate degree of hæmothorax, which was not aspirated. Six months after he was wounded he was passed fit for active service and returned to Flanders. After he had been there a month he wrote home that he had been very much in the thick of it and felt "right enough." Another officer was hit by a bullet which entered the left posterior axillary fold and embedded itself in the ninth dorsal vertebra, from which it was removed by Mr. J. Sherren. He had signs of a left hæmothorax. An exploring needle revealed only bloody fluid, the needle being put in to make quite certain there was not an empyema. No aspiration was done. I saw him seven months later and found that, except that the voice sounds in the left lung were slightly diminished, the left chest was perfectly healthy and quite like the right.

This case is of great interest. In an officer, aged 33, the bullet entered 1 inch above and a little to the right of the right nipple, and passed out nearly in the middle line close to the twelfth dorsal spine. Twelve days later 78 fl. oz. of bloody fluid were aspirated. He had some fever, but it left

him soon after aspiration. At no time had he any signs of a re-collection of fluid, but there were very evident signs of pulmonary collapse, with falling in of the right side of the chest and drooping of the right shoulder. Three months after the injury he could walk three miles. A month later he could play a round of golf, and as a result of diligent breathing exercises the falling in of the chest and drooping of the shoulder were less; the lung was expanding much better and appeared healthy. He would probably have recovered faster but that he always seemed afraid to move the right chest.

An officer had a considerable hæmothorax on the right side as the result of a bullet which entered the second right space in the front fracturing the third rib, and it passed out in the sixth space behind. There was pyrexia; the hæmothorax was aspirated. Seven months after he was wounded he writes: "I only feel my lung when I yawn or breathe very deeply, and I am able to play racquets."

The next is a severe case. A major was hit by a bullet which, passing in at the right anterior axillary fold, passed out just to the right of the middle line at the level of the eighth rib. He had severe hæmoptysis and a large hæmothorax; 60 fl. oz. of bloody fluid were aspirated. Six weeks after he was wounded he left the hospital, and two months later was able to walk a "good many miles." Five months after his wound he was passed as fit for home service, and a month later as fit for general service. He complained that he still got out of breath climbing hills and walking fast; still, after all, most of us do that.

Of the few cases of empyema after a bullet wound of the chest one was passed as fit for home service nine months after he was wounded. At that time he wrote to me to say: "I feel practically all right now." His was a troublesome empyema, and a second operation was necessary to drain it properly. It is interesting to notice that this patient thinks walking far superior to breathing exercises as a means of re-expanding the lung.

The following is of great interest. A man of about 35 was wounded by a bullet which entered through the middle of the sternum at the level of the fifth rib and passed out through the fifth right space 2 inches posterior to the posterior axillary line. Except for a large hæmothorax no harm appears to have resulted. Seven days after he was wounded I aspirated 56 fl. oz. of bloody fluid. His physical signs and general condition improved rapidly. Five months after his wound he was passed as fit for light duty, but he writes that even then "I feel quite fit as long as I don't do too much, but I still feel a certain tightness across my chest and an occasional catching of my breath."

The last case seen shows how well they may do. Four or five pieces of shrapnel entered the right chest of an officer, aged 18, on Sept. 25th last. About three weeks later 80 fl. oz. of bloody fluid were removed from the chest. Three weeks afterwards I saw him. His temperature was normal and the entry of air into the right chest was somewhat impaired. Still, he was using the right lung quite well and seemed to get more air into it each day.

Bullet Embedded in Lung.—Perforation of Diaphragm.

Although we have had several cases, some without signs of hæmothorax, in which a bullet has been embedded in the lung we have had no case of

abscess in the lung. In every case the bullet has been left alone, and in no instance has its presence done any harm. One officer who was hit at 4 A.M. had no hæmoptysis and went on working for eight hours digging hard after he was hit. The X rays showed the bullet in the base of the right lung. Recently an officer who had a bullet in the base of the right lung was admitted very ill with a temperature between 103° and 104°F. Except that there were no physical signs to indicate pneumonia the case behaved exactly like a pneumonia, the temperature falling suddenly by crisis, after which he was perfectly well.

The following shows how little harm a bullet in the lung may do. A colonel was hit by a bullet which passed through the sternum $\frac{1}{2}$ inch below the level of the nipple, and was located by the X rays in the middle of the right lung behind the nipple. There was a slight hæmothorax which was not needed. He returned to work in France six weeks after his wound. I saw him a year later. He had been perfectly well ever since, working 14 hours a day, was not conscious of any dyspnœa, but the air entry was not quite so good on the right as the left. The bullet is still in the lung.

Occasionally the diaphragm has been perforated. I have mentioned some examples already. In another the bullet entered the abdomen just below the xiphoid cartilage, slightly to its left and passed upwards through the right lung. In no case have we been able to discover that the perforation of the diaphragm mattered. In one case a bullet lay just outside the pericardium, so close to it as to move synchronously with the heart. In another the bullet lay in the pericardium, but bullet wounds of the heart and pericardium would need a separate lecture. One patient told us that he had suppression of urine after he received a gunshot wound of the chest and for several days he only passed a few ounces, but suppression of urine may occur after any severe shock—for example, it may occur with severe gall-stone colic.

TREATMENT.

We in this country have no opportunity of treating these patients shortly after the wound, so I cannot give you illustrative cases. The chief danger arises from hæmorrhage, either hæmoptysis or hæmothorax. Therefore, after moving him gently you will keep the patient at rest in bed, give him for a time no food and but little to drink, and sufficient morphia to keep him quiet and to diminish the respiratory movements without endangering his life. If he has a hæmothorax which the general signs or the examination of the fluid removed with an exploring needle show to be infected with micro-organisms, a piece of rib should be removed and the pleural cavity drained as soon as possible.

We have already discussed the question of aspiration of sterile hæmothorax; but whether the fluid is removed by incision or aspiration or whether it is left to be absorbed, remember that fluid in the chest always means compression of the lung, and you must as soon as possible exercise the patient so as to re-expand the compressed lung. As we cannot see the wound in the lung we cannot tell when it is healed. Probably in such a vascular organ the wound heals quickly, and if neither hæmoptysis nor hæmothorax has been severe I have often directed the patient to take deep breaths several times a day three or four weeks after the infliction of the wound. In patients who are severely damaged great good can, as I have often

seen, be done by the breathing exercises recommended by Mr. C. MacMahon in THE LANCET of Oct. 2nd, 1915.

When he is well enough to be up the patient should be told to take short walks, increasing the distance each day; and he may walk gently up hills, increasing gradually the distance he goes and the steepness of the hills. Some say they do better with breathing exercises; others, perhaps the majority, find that walking and gradual ascent of hills are best. But whatever means you adopt you must impress upon them the great importance of expanding the affected lung. Occasionally the patient seems to dread moving the affected side; for such, breathing exercises are best.

Since I put this lecture together I have read an article on Hæmothorax by Sir John Rose Bradford and Dr. T. R. Elliott.² I should advise you to read it, for my lecture is founded on experience gained in this country. They, working at Boulogne, have seen their patients earlier and their cases have been more severe, but the conclusions at which we have arrived are fundamentally the same.

UREA AS A BACTERICIDE, AND ITS APPLICATION IN THE TREATMENT OF WOUNDS.

BY W. ST. C. SYMMERS, M.B., C.M. ABERD.,
PROFESSOR OF PATHOLOGY, QUEEN'S UNIVERSITY, BELFAST;

AND

T. S. KIRK, M.B., B.Ch. R.U.I.,
PRINCIPAL MEDICAL OFFICER, ULSTER VOLUNTEER FORCE.

I.—Laboratory Notes by Professor SYMMERS.

SOME years ago, while working with meningococci, I observed a phenomenon which was new to me. Suspensions of living meningococci were added to 5 per cent. suspensions of blood corpuscles. The mixture of cocci and blood was then placed in an incubator (37° C.), and after 15 minutes it was seen that the blood had darkened, had become venous in tint. This change of colour, as proved spectroscopically, was due to the reduction of the oxy-hæmoglobin. In the next place, this reduction did not occur if the cocci were killed (60° C. for one hour) before being added to the blood suspension.

A large number of tests showed that the living cocci, and also living bacilli of various species, possess the power of removing oxygen from the oxy-hæmoglobin of the red cells. The phenomenon can also be demonstrated when laked blood is used, the dissolved hæmoglobin being still capable of combining with, and of being deprived of, oxygen. Incidentally, I observed that bacteria when suspended in certain solutions of urea lost completely this deoxidising power. In other words, the urea appeared to be bactericidal, and therefore the bacteria were no longer able to reduce the oxy-hæmoglobin.

It was now a simple matter to determine whether the urea was, or was not, a bactericidal substance, and a number of tests showed that urea readily kills non-sporing bacteria. In the first place it was shown that urea kills such germs when these are suspended in water—e.g., the whole of a 24 hours old agar culture of bacillus typhosus was suspended in 2 c.c. of water; this was then saturated with dry urea, and after standing at room temperature for

² British Journal of Surgery, October, 1915, p. 247.