CLINICAL NOTES ON PENETRATING WOUNDS OF THE ABDOMEN.*

BY

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I PROPOSE to mention some points in connexion with wounds of the abdomen and to read notes on some cases which have been treated recently at the special hospital at — (5 kilometres behind the firing line).

The extent of the visceral injury caused by a rifle bullet in the abdomen depends to a large extent on the distance which the bullet has travelled before impact. The most extensive wounds are caused when the range is less than 500 yards. Intestine may be torn completely across or show large open wounds with everted edges. Solid organs present radiating lacerations. These wounds, besides being extensive, bleed profusely. With a range of over 500 yards, however, the wounds are more limited in extent, but still bleed freely. As the range lengthens the damage becomes more confined to the actual track of the bullet.

It is interesting to consider the cause of this influence of range on the character of the wound. At first I thought it was due to instability of the bullet which is known to exist during the first portion of its flight. The diagram shows by means of a curve the relation between velocity and range. It shows how rapidly the velocity diminishes during the first few hundred yards of a bullet's flight.

Velocity range curve of rifle bullet.

I think high velocity is the cause of the extensive character of visceral wounds at short ranges. The term "velocity" is meant to include both the translation and the spin of the bullet, and it is probably the latter which is the more destructive force.

The importance of primary haemorrhage lies in the fact that there is little tendency towards spontaneous arrest. When seen, three or four hours after receipt of the injury, small arteries in the wounded bowel are still spurting vigorously. In fatal cases death is almost invariably due to primary haemorrhage. It becomes obvious, therefore, that on this account alone every effort should be made to convey abdominal wounds with the least possible delay to a place which is equipped for their operative treatment.

Peritoneal Perforation without Visceral Injury.

Apart from those cases in which a bullet has only a short intraperitoneal course, it is possible for a bullet to traverse the peritoneal cavity in an area occupied by intestines without causing perforation of the viscera with which it must come in contact. One such case has passed through the hospital.

CASE I.

The entrance wound was in the mid-Poupart line, just below the level of the umbilicus. The exit wound was behind in a corresponding position.

When seen, two and a half hours after the injury, signs of internal haemorrhage were present; the abdomen was rigid and tender. Operation revealed intraperitoneal haemorrhage.

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which was proceeding from torn ileo-colic vessels adjacent to the caecum, but there was no perforation of any viscus. No sign of abrasion or bruising could be discovered in the small intestine. Bleeding points were ligatured. Recovery was uneventful.

This case is unique in my experience.

Wounds with a very short intraperitoneal course may implicate omentum only. In these cases the omentum shows a great tendency to prolapse through the wound. If the injured omentum is excised and the peritoneum closed, these cases do uniformly well. There is apparently little danger of suppuration occurring in the peritoneal cavity, although the rest of the wound may be badly infected.

Peritoneal Perforation with Visceral Injury.

Wounds of the small intestine are generally multiple, but are usually confined to one segment of bowel.

CASE II.

Cpl. H., of the S. Staffs Regiment, was hit in the abdomen at about 250 yards range. He made the interesting statement that he felt no impact. His right leg suddenly became useless and he fell to the ground. About ten seconds later he experienced agonizing pain in the abdomen. This continued without remission until operation was performed. He arrived at the special hospital within one hour of being hit. The abdomen was then rigid. There was a small entrance wound in the middle line below the umbilicus, and an exit wound, about the size of a halfpenny, in the right buttock.

At the operation seven perforations were found in small intestine. There was a large quantity of free blood in the peritoneal cavity. A segment of lower ileum, measuring 24 in. in length, and containing all the perforations, was excised. End-to-end anastomosis was performed. The peritoneum was mopped dry and then closed without drainage. There was some vomiting for three days, but the patient rallied well. A letter from England six weeks after the injury informs us that he is walking about and feeling quite fit.

Another case of uncomplicated small intestine injury:

CASE III.

Pte. R., Northumberland Fusiliers, was hit by a bullet which ricocheted off an iron roof in the front line trenches. He described the impact as a blow without any pain.

This patient arrived at the hospital in a little over an hour from the time he was wounded. There was a large entrance wound, with bruised edges in the anterior abdominal wall, below and to the left of the umbilicus. At the operation this wound was excised and converted into a vertical incision. A distorted bullet was found lying free in the peritoneal cavity, adjacent to four perforations in small intestine. Intraperitoneal haemorrhage was small in amount; 3 ft. 2 in. of ileum was excised, and end-to-end anastomosis performed. Portions of clothing were found scattered throughout the peritoneal cavity, mostly adhering to omentum. After irrigation with eusol and saline the abdomen was closed without drainage. Some infection of the abdominal wall occurred. This remained local and quickly subsided. The clinical chart indicates the progress. Five weeks after the injury this patient wrote from England to say that he was walking about, but still felt a little weak.

It is surprising how frequently injury to small intestine is complicated by injury to the iliac veins or inferior vena cava. The large arteries either escape damage or more probably produce a fatal result before the patient can be moved; on the other hand, injury to the great veins is often found. This additional source of haemorrhage has in my experience always led to a fatal result.

Wounds of the colon are often complicated by injuries to other viscera. These cases show a high mortality. If, however, the injury is confined to the colon, the outlook is more hopeful provided that operation is performed before widespread peritoneal infection has occurred. The lax wall of the colon allows instant escape of contents, in direct contrast to the small intestine, in which there is little tendency for leakage to occur for several hours.

CASE IV.

Lieut. I. was operated on within one hour of being hit in the left flank. The bullet which caused this wound had travelled more than a thousand yards.

The visceral haemorrhage was slight. There was a single linear wound of the descending colon, with faecal contents soiling the surrounding peritoneum. A Paul's tube was tied into the colon. Rubber drainage tubes were inserted into the subphrenic and iliac regions. Peritonitis remained local and a good recovery ensued. Preparations are now being made in England for closure of the artificial anus.

CASE V.

Lance-Cpl. E. Two and a half hours elapsed between injury and operation.

The descending colon was almost completely severed. There was profuse internal haemorrhage. Division of the colon was

completed. A Paul's tube was inserted into each end. A supra-pubic drain was used in this case. Recovery was rapid and uneventful.

CASE VI.

The case of Private T., Suffolk Regiment, was complicated by the fact that the bullet had entered the abdomen through the innominate bone. There were six perforations of the caecum and ascending colon, varying in size and mostly caused by fragments of bone. The edge of the liver was lacerated, two pieces being completely detached. The edges of the caecal wounds were trimmed, sutured, and invaginated. A drain was inserted into the right flank. The exit wound through the anterior abdominal wall was filled with gauze, which passed down to the wounded liver. A few hours later, during an attack of vomiting, the patient felt something give way. Examination revealed the transverse colon and omentum lying in the dressings. The prolapse was reduced under an anaesthetic. The anterior wound was then completely stitched.

In spite of this unfortunate event the patient made a good recovery. No leakage occurred from the caecum. He wrote the following from Calais three weeks after the injury:

Dear Sir,—I am pleased to be able to write you to say I am getting on quite well, and know you will be pleased to hear this, for I think you thought I'd have a rough journey to pull through. Well, I thought I might with luck, but I was bad for two weeks. . . .

Wounds of the stomach bleed freely, but, if uncomplicated, respond well to operative treatment.

CASE VII.

Corporal D. J., Yorks and Lancs Regiment, was struck in the back by a small fragment of shell. He arrived at hospital two and a half hours after receipt of the injury.

There was a small entrance wound over the left erector spinae at about the level of the first lumbar vertebra. The abdomen was rigid and tender. He had vomited once. Operation revealed perforations of both anterior and posterior walls of the stomach, two perforations of the jejunum close to the duodeno-jejunal flexure, and perforation of the thin anterior edge of the liver. The shell fragment was found imbedded in the diaphragm beneath the left costal margin. The visceral wounds were trimmed, sutured, and invaginated. The only drain used was a wick of gauze down to the wounded liver.

Recovery was uneventful. A message from Calais states that the wounds are healed and the patient well.

Wounds of the Solid Organs.

Wounds of the liver give the best results. In simple perforations haemorrhage is slight; bile drains away for a few days; recovery is the rule. A bullet at short range will split open the liver as though with a knife. In such cases haemorrhage is free, but is easily controlled at operation. Extensive necrosis of the neighbouring liver substance sometimes occurs. This is often seen in fatal cases.

The spleen is seldom injured alone. Its injury is often associated with that of the left kidney, pleura, and lung. The following are the notes of such a case:

CASE VIII.

Rifleman T., 11th Rifle Brigade, felt a sudden blow in the abdomen while lying behind a cart in front of our wire. He arrived in hospital about five hours later, and was then blanched, cold, and collapsed.

There were signs of intraperitoneal haemorrhage. There was an entrance wound in the side over the left lower ribs. On opening the abdomen the peritoneum was found to contain a large quantity of free blood. The spleen and left kidney both showed lacerated perforations. The splenic pedicle was partially severed. The bullet track passed towards the muscles of the back to the left of the vertebral column. Profuse haemorrhage was taking place from the splenic pedicle and from the vertebral region. The spleen and left kidney were excised. The region of the spine was firmly packed, as no bleeding points could be seen. The bullet was not located.

The patient was now so collapsed that the operation was curtailed by simply filling the left loin with gauze and leaving open the centre of the abdominal incision.

Chest symptoms prevented further operative measures until the eleventh day, by which time infection of the loin had already occurred. Drainage tubes were inserted through a posterior counter opening. Eight ounces of sterile blood were aspirated from the left pleura. Signs of septic absorption still continued, and on the twenty-fifth day a rib was resected in order to drain the left pleura. No infection was established.

On the twenty-seventh day the lower posterior wound became faecal. The patient was now in an almost hopeless condition. All the wounds were infected. The temperature averaged 102° F. at night, 100° F. in the morning. The pulse-rate varied from 120 to 140. The respiration-rate varied from 26 to 40. Generalized bronchitis was present. Faeces were constantly escaping from the left loin.

The pleura was irrigated twice daily with eusol and saline. On the thirty-eighth day the temperature remained normal for twenty-four hours for the first time since the injury. From this point improvement was rapid and continuous.

A medical officer from Calais writes to say that the patient was transferred to England nine weeks after the operation, and that he was then in a very satisfactory condition.

It will be noticed that all the cases I quote have had a successful result, and I want to make it quite clear that such cases are looked on rather as brands plucked from the burning than the normal result of these injuries.

One point on which too much emphasis cannot be laid is the importance in these cases of operation at the earliest possible moment. To secure this end perfect co-operation is essential. At the special hospital the operating theatre is kept in constant readiness, and the operation is usually commenced within fifteen minutes of the patient's arrival. But, of course, the most difficult task lies with those responsible for the transference of the case from trench to hospital.

DISCUSSION.

Colonel SKINNER said he was particularly interested, more from an administrative point of view. The speed with which the cases were transferred from the trenches to the hospital greatly added to the chances of recovery. This speeding up rested with the medical officers. He had read Sir A. Bowlby's Bradshaw lecture, published in the *BRITISH MEDICAL JOURNAL*, where he pointed out the greater damage done by bullets when fired at shorter ranges, advancing the theory of compressed air in front of the bullet. Also that the bullet probably has an "explosive" effect. Frequently the bullet also turned over on its course. Its velocity must be imparted to surrounding structures; so much so that Sir A. Bowlby mentioned a case in which the bullet had travelled across the abdominal wall not entering the abdomen, but *post mortem* the bowel was found disorganized. In cases of wounds of back and buttock where the wounds might not suggest an abdominal injury it was wisest to send them into the abdominal and chest department of the field ambulance. He said that Mr. Sampson had had 60 per cent. of recoveries, including cases brought in moribund.

Captain FRASER said that it was often difficult to know when the peritoneum was opened. Recently he had found by experiment that if the blood pressure was low it was probable that the peritoneum was opened. As to injury due to the proximity of the wounded person to the discharged rifle, he described a case in which, accidentally, a soldier was shot through the abdomen at 250 yards without any extensive injury of the bowel. Probably the amount of injury depended a great deal on the position of the bowel when hit. He had tried various kinds of anaesthesia—spinal, ether, chloroform, and lately intravenous ether; here the results are good; not only was there an anaesthetic effect, but a volume of fluid given at once to replace the loss of blood.

Lieutenant-Colonel PICKARD said that he had read in the *BRITISH MEDICAL JOURNAL* a paper in which the damage done by a bullet penetrating the abdomen was regarded as analogous to the splash of a hard substance striking a fluid. He described the well-known trick of throwing a stone up in the air and into a pond trying to make the least amount of splash; here the splash was least when the stone dropped vertically.

Captain SOLTAU asked why Mr. Sampson used a Paul's tube in two of the colon cases and invaginated the wound in the other, and whether he had swabbed out with ether.

Captain McNEE had examined livers pierced by bullets and noticed necrotic changes in the tissues at least two inches from the track. In one kidney case the bullet had pierced the upper pole, and the lower pole showed necrotic changes, although there was not any damage to the intervening tissue. In one 8 in. loop of small intestine he had seen one rosette wound and about nine linear slits; it was highly improbable that the bullet pierced through ten places. He suggested that possibly the slits were due to muscular action.

In reply to Colonel DUNN, Captain FRASER said that he did not use any elaborate apparatus for intravenous injections, only a Lane's bag.

Mr. SAMPSON said, in reply, that in doubtful cases of peritoneal entrance he opened up away from the wound to prevent sepsis. If the compressed air theory of causing damage to abdominal organs was correct more damage at the entrance wound would be expected. The Paul's tubes

were used in the two cases because two-thirds of the circumference of the colon was injured; in the other case the caecum had two or three small perforations. He had not used ether as a peritoneal dressing.

TWO CASES OF REMOVAL OF A BULLET FROM THE UPPER SURFACE OF THE DIAPHRAGM.

BY

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WHILST the lessons of war surgery have thrown much light on the immediate treatment of penetrating wounds of the chest and have prompted some most valuable additions to surgical literature, the later consequences of these injuries have received little notice.

It is a fortunate fact that not a few of these seriously wounded men recover, but some still carry in their chests the agent, whether shell or bullet, which caused the injury. These foreign bodies show a tendency to fall to the bottom of the thorax, coming to rest there on the upper surface of the diaphragm. In this position they may give rise to no trouble and no surgeon would suggest their removal. There are found, however, from time to time cases in which the foreign body is a cause of persistent and distressing symptoms.

In the first case which I report the man's life was made miserable by a constant "pricking" pain, and in the second case the soldier was quite incapable of any exertion, owing to the fact that an increase of respiratory movement beyond the normal produced at once a crippling amount of pain. The two cases are reported, not merely as examples of removal of foreign bodies from an unusual situation, but rather as instances of the help afforded to the surgeon by a simple method of "positive pressure anaesthesia." Thanks to this method, most ably handled by Major A. Wilson, the recovery of a bullet from the pleural cavity was carried out with perfect safety to the patient and was rendered, from the operator's point of view, little more than a minor surgical procedure. The details of the cases are as follows:

CASE I.

G. W. C., aged 24, was wounded in the right side of the chest by rifle bullet fired at long range. The bullet entered through the third right costal interspace three and a half inches from the middle line. Free haemoptysis occurred at once and continued in considerable quantity for twenty-four hours. He reached England at the end of five weeks, and during this time he had much pain in the lower part of the right chest, with frequent cough and daily haemoptysis. Although he stated, on admission to the 2nd Western General Hospital, that he had lost 2 st. in weight since his injury his general condition was excellent. The chest expanded well, and beyond a few moist sounds there was no physical sign of disease or injury. Cough was frequent, and the sputum always contained a little dark blood. The patient, though apparently well and comfortable in a sitting posture, was not able to lie down with ease, and was rendered very breathless by slight exertion. He complained constantly of a "pricking" pain, which he located deep to the sixth right costal cartilage.

Radiographic examination by Captain Bythell disclosed an intact rifle bullet lying on the upper surface of the diaphragm. The bullet was localized at a depth of two inches beneath a point marked over the sixth right costal cartilage and distant one half inch from the line of the right border of the sternum. As the pain continued after a month in hospital, and the patient's condition remained without change, save that the haemoptysis had ceased, it was decided to attempt the removal of the bullet.

Anaesthesia was induced by chloroform, and the tracheal catheter of the Ehrenfried's positive pressure apparatus having been introduced, the operation was carried out under ether vapour introduced under pressure by bellows. Through a curved skin incision the sixth and seventh right costal cartilages were exposed and denuded of their muscular and tendinous coverings, which were reflected downwards in one piece. A portion, $1\frac{1}{2}$ in. in length, of each costal cartilage was then excised. The opening thus made gave abundant access, and through it the parietal pleura was incised in a horizontal direction. A healthy, well-inflated lung presented itself on opening the pleura. The lung appeared and felt absolutely normal, showing no trace of adhesions.

On packing off the lung with a strip of gauze there was disclosed at once on the upper surface of the diaphragm a rounded eminence, in size and shape like the half of a small walnut shell. An incision into this yielded a few drops of turbid fluid, and the bright, unbroken nose of the bullet at once presented. This was seized and extracted without difficulty; it was lying

on the upper surface of the diaphragm, and had become covered and encysted by pale, friable fibrous tissue.

The gauze was removed and the parietal pleura closed tightly by a continuous stitch of fine chromic gut. The tendino-muscular flap was replaced by chromic gut sutures and the wound closed without drain. The colour and general condition of the patient were perfectly satisfactory throughout the operation.

Beyond a slight tracheitis, probably traumatic, which cleared up completely in three days, the convalescence was uninterrupted. The patient was discharged from hospital in four weeks. The "pricking" pain disappeared from the first and the man was able to move freely without breathlessness.

CASE II.

T. J. E., aged 21, was hit by a shrapnel ball at Suvla Bay. He stated that very free bleeding followed the injury—"blood running out of his mouth without cough." He gradually recovered, and does not appear to have suffered from any complications of the injury beyond occasional slight haemoptysis, which continued up to the time of his admission to the Manchester Royal Infirmary, six months after the injury. At this time the chest showed no abnormal physical signs and his general condition was excellent. The scar of the wound of entry lay over the inferior angle of the left scapula. The patient complained of much pain on exertion and located the pain at a point on the tenth left rib, a little in front of the mid-axillary line; he stated that the pain was very severe on deep breathing.

A radiogram by Captain Barclay showed an intact shrapnel bullet lying deep to the rib and fixed in the angle between the diaphragm and chest wall.

Anaesthesia was carried out, as in Case I, by Major A. Wilson with the help of Ehrenfried's apparatus. The operation was of the simplest nature. A portion of the tenth rib, about $1\frac{1}{2}$ in. long, was resected and the pleura opened by a horizontal incision. The bullet was at once evident and was picked without effort off the upper surface of the diaphragm. The edge of the well-inflated lung was well seen, and as far as it could be inspected through the limited opening the lung appeared to be quite healthy and free. The pleura was closed with fine chromic gut.

The after-history of the case was quite without incident; the patient was discharged in a fortnight in excellent condition, having had neither haemoptysis nor his former pain since the operation.

TIME IN SURGERY.

BY

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THE priceless value of time in surgery is often overlooked, and fleeting opportunities of successful action are frequently allowed to pass with disastrous consequences. Again and again diagnosis is delayed or operation deferred until it is too late either to save life or to secure the best result. For instance, the early signs of grave abdominal diseases are too often attributed to trivial ailments, and a "wait and see" policy adopted until such irreparable damage is wrought that complete recovery is impossible. In such cases the greatest vigilance is required to determine the proper time to "look and see."

Two typical cases of appendicitis serve to illustrate these points. They were very similar in their early signs, but treated differently and attended by very different results.

CASE I.

- (a) Diagnosis made within twelve hours.
- (b) Operation within thirteen hours.
- (c) Appendix removed, gangrenous, but not perforated.
- (d) General condition good.
- (e) Gridiron incision.
- (f) Abdomen closed.
- (g) Patient up from fourth day; taken to the country on the ninth day. Quite well three weeks from operation.
- (h) Patient has been in perfect health since the operation.

CASE II.

- (a) Diagnosis, abdominal influenza. After nine days, appendical abscess diagnosed.
- (b) Operation after ten days.
- (c) Large abscess opened. Appendix not found owing to the large size of abscess and the grave condition.
- (d) General condition very bad.
- (e) Battle incision, as the surgeon thought he could get more room in this way.
- (f) Drainage on and off for six months; then appendix removed at second operation. Drainage another two months.
- (g) Patient up after ten months. Large gap in abdominal wall with hernia at the end of twelve months. General condition too bad for operation to reconstitute the abdominal wall at present.
- (h) Patient has suffered much pain and misery.