attempt the needle encountered a free space in the sixth intercostal space in the posterior axillary line. The manometer oscillations were small but definitely negative -4 , -2 , accordingly 300 c.cm. of nitrogen were introduced, which had the effect of producing positive pressure of $+3$ $+1$. It was therefore obvious that one had entered a pleural sac. However, hope was entertained that one might be able to gradually break down pleural adhesions and eventually produce an effective pneumothorax. Frequent refills of small amounts were subsequently given until eventually a very satisfactory pneumothorax was produced without any pain or untoward symptoms. A pressure of $+18$ was reached and has been maintained. Figs. 2, 3, and 4 show three stages in the course of treatment. Fig. 3 shows extremely well the effects of compression of the left lung on the emphysematous right lung. A careful scrutiny of Fig. 4 shows that the left lung is partly bound down by adhesions to both the anterior and posterior chest wall. The faint line of shadow indicated by the arrow (a) marks the line of attachment to the anterior wall, whilst the arrow (b) shows the line of attachment to the posterior wall. The lung is evidently compressed inwards towards the mediastinum in the shape of a gutter between the two lines of adhesion. This case is at present doing well. The general condition is excellent, and the patient is living an ordinary life under home conditions, the compression being kept up by means of refills at varying intervals of approximately a month. The case is interesting as illustrating how even adhesions of long standing may be harmlessly broken down by the exercise of caution and perseverance in the treatment.

In conclusion I should like to express my indebtedness to Mr. T. R. Watson, radiographer to this sanatorium, for the production of the skiagrams illustrating this paper.

THE PATHOLOGY AND TREATMENT OF GUNSHOT WOUNDS OF THE SMALL INTESTINE.

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FOUR months' work in a casualty clearing station have given me the opportunity of observing a number of these cases, and though my experience is not wide enough to warrant any final conclusions, yet some points have struck me which may be of interest to others who have to deal with cases of this class.

PATHOLOGY.

Whereas in wounds of the colon and duodenum the chief feature is the progressive escape of contents followed by a more or less localized peritonitis, in the small intestine such an escape usually does not occur at all, and if it does is so slight as not to be an essential feature in the case. The cause of death in wounds of the small intestine is more frequently intestinal obstruction due to paralysis and distension spreading upwards from the injured coil. To make this contrast clear, I have appended notes of examples of cases of both classes.

In Case I there was a wound of the colon; the chief symptoms were general distension and localized pain. On opening the abdomen a large collection of faeces was found localized under pressure in a cavity formed by adherent intestines. Faeces continued to be discharged from this wound for five days.

Similarly, when the colon is wounded extraperitoneally, faeces are expelled under pressure into the surrounding connective tissue spaces to an almost unlimited extent. I have seen a wound of the colon on the left side (verified *post mortem*) cause faecal infiltration extending into the right loin and discolouring the skin on the right side of the abdomen before death.

In Cases II and III similar localized collections of intestinal contents under pressure followed wounds of the second and third portions of the duodenum respectively.

In wounds of the jejunum and ileum this progressive escape of contents has not occurred in those cases which I have seen.

Of course, if a full coil of intestine is widely opened, it stands to reason that the contents in it at the time must escape. Some undoubtedly escaped in Case IX. But where the coil is empty or the perforations small there is no escape even at the time; in any case, there is no progressive escape later, such as is seen in wounds of the duodenum or colon. The neighbouring coils and the omentum

rapidly become adherent, the injured portion becomes inflamed, immobilized, and shut off, and, although it becomes full, it is only when it is lifted from its bed at operation that the contents are discharged.

Case IV illustrates this point. The injured coil had retracted from the wound area, and was missed at the time of operation. At the autopsy, although it presented four fairly large wounds, it was so securely wrapped in omentum that no general coiling or inflammation of the peritoneum had occurred, although the coil itself was then quite full.

In Case V, where there were three wounds due to a fragment of shell, the condition was the same. In Case VI there was no escape till the coil was lifted from its bed, when the fluid contents spouted out freely.

In Case VII the injured coil was full of liquid faeces which had not escaped, and the same is true of Case VIII.

In Case IX, where the intestine was nearly divided, there was a limited escape, but no general fouling such as would be present after the rupture of an ulcer. A week later there was found a fairly widespread adhesive peritonitis with no suppuration.

So that it seems that the usual course of gunshot wounds of the small intestine, even when multiple and fairly large, is that they are sealed off at once in such a way that there is only a very small escape of contents, not enough to produce a general peritonitis or even a localized collection of faeces. All that is produced at the time is a very limited local peritonitis.

After this has occurred the intestine at and between the wounds becomes inflamed, immobilized, and paralysed; it slowly fills up and constitutes a functional block. The bowel above it becomes progressively distended, paralysed, and poisoned, just as it does in any other form of intestinal obstruction. The patient after a time develops distension and bilious vomiting, and ultimately dies.

This point is illustrated by Case VII, where the bowel was resected two and a half days after the injury, when bilious vomiting had already set in. The dilated intestine above the injury was emptied at the time of operation, and this gave temporary relief, but the symptoms recurred, and the patient died. *Post mortem* the bowel above the junction was found very much distended, that below it empty and contracted, and this although there was no physical obstruction whatever.

In Case IV, where the injured coil was not dealt with, the same condition was found at the autopsy.

The clinical course of these cases is in agreement with this view. Many of them—by no means all, but a large proportion—remain free from symptoms and apparently well for two or three days on starvation and morphine. At the end of this time, which often coincides with their transfer to a clearing hospital, they rapidly develop distension and vomiting, and ultimately die.

If these symptoms were due to an immediate escape of contents, one would expect immediate pain, rigidity, rising pulse, and vomiting. But the course they actually follow and the symptoms they present are rather those of an obstruction of gradual onset than those of a prompt general peritonitis.

The explanation of these differences in the behaviour of wounds of the duodenum and colon on the one hand, and of those of the mobile part of the small intestine on the other, is probably twofold. In the first place, the small intestine is so situated that it is very readily sealed off by omentum and adjacent coils. In the second place, it seems to be the case that the movements of the small intestine are more readily paralysed by injury and inflammation than those of either the colon or the stomach. So that although a passive dilatation occurs, there is no driving force behind it which could lead to escape of contents under pressure. If such a force were present recent adhesions would not prevent leakage, though they might limit its extent.

TREATMENT.

If the course of events is usually such as is suggested above, the bearing of it on treatment is obvious. For it is clear that simple suture of wounds of the duodenum and colon is both necessary and sufficient. If this is efficiently done the contents will be driven along their proper course; if it is not done, they will be continually forced either into the peritoneum or into the extraperitoneal tissue. In

neither case will there be stasis. The essential thing is to close the leak—there is no danger of obstruction.

In the jejunum and ileum, on the other hand, simple closure of the wound would be both unnecessary and inefficient. As regards the escape of contents, it would merely effect, with a certain amount of shock, disturbance, and fouling of the peritoneum, what Nature had already done. As regards paralytic obstruction, it would do much to increase it.

The proper course in such a case would be to resect not only the injured portion, but also as much bowel above it as is likely to remain out of action and constitute a functional obstruction. The point is not a new one; it was emphasized by Barker in relation to strangulated hernia, and is equally sound whether the obstruction is physical or functional. The longer the obstruction has existed the more important it becomes.

The amount to be removed depends, first, on the number and relative position of the wounds; apart from this it increases with delay, since the condition which makes resection necessary is one which progresses gradually and regularly upwards. In Case VII the resection of 12 in. after two and a half days was not enough to prevent stasis in the bowel above, as was evident *post mortem*. The patient probably died for that reason.

In Case IX, operated on ten hours after injury, the removal of 7 in. was sufficient to restore the function of the intestine. In Case V, where 2½ ft. were removed after thirty-six hours, the patient made a good recovery.

In Case VI, where 4½ ft. were resected after eighteen hours, the amount may have been unnecessarily great, but it was a fault on the right side, and did not interfere with the patient's recovery.

A sound principle can, of course, be made absurd easily enough by carrying it to extremes, and the earlier the operation the less the need for wide resection. But it is doubtful if the difference in shock is very great; and whereas the risk of an insufficient resection is death, that of an excessive resection is more likely to be indigestion.

TECHNIQUE AND AFTER-TREATMENT.

In view of the fact that injured intestine may move away from the wound and so be missed (as in Case IV), and that the course of the bullet is often unknown, it is wise to place the incision near the mid-line and inspect the whole of the small intestine. It is a disadvantage to include the wound in the incision.

After operation the sooner the bowels move the better. Enemas and divided doses of calomel are useful, and pituitrin sometimes acts like a charm. Apart from these points, the technique and after-treatment are those of a similar operation in civil practice.

The recovery of one case (VI) was interrupted by an acute dilatation of the stomach, and all three surviving cases had a varying degree of diarrhoea, which in one (V) amounted to a serious dysentery.

SELECTION OF CASES.

The majority of cases reach us after a varying period of rest in a field ambulance. The condition of some is so bad that operation is out of the question; in others the presumed intestinal injury is accompanied by others which render interference inadvisable.

In the rest the presence or occurrence of definite symptoms of injury in the intestinal area is a sound indication for operating at once. Some patients recover without any such symptoms, and to open all wounded abdomens as a routine measure would probably do more harm than good. But once symptoms become manifest there is not much margin for delay. If these cases are placed under observation in a clearing hospital soon enough after the injury, it should be possible to seize the opportunity when it occurs, provided always that the surgeon has the necessary equipment and experience for dealing with any condition he may find.

The common practice of withholding water from such patients causes much suffering. In cases of internal haemorrhage and during transport it is probably necessary. Once in hospital, if a man is definitely dying, no good purpose is served by adding thirst to his other sufferings, while if he has an injury which requires operation, the worst that water in reasonable quantities is likely to do is

to hasten the time at which he develops symptoms and is radically dealt with. The sufferings these patients endure from thirst cannot be doubted by any one who has ever seen them. The only consideration which could weigh against them is proof that men who would ultimately have lived have actually died because they were given water in hospital some time after the injury. As far as I know this proof is lacking.

Water does not produce flatus; it probably never reaches the wounded area, and if it does it is unlikely, for reasons already given, to cause any escape of contents.

RESULTS.

Makins (*Surgical Experiences in South Africa*, p. 460) concludes as follows: "Perforating wounds of the small intestine are very fatal injuries. Every patient in whom this condition was *certainly* diagnosed died." In dealing with such an injury it is not so much a question of how many cases will be lost, but rather whether any can be saved.

I have appended notes of the only cases, 5 in number, in which I have opened the abdomen and resected intestine in this hospital (Cases V, VI, VII, VIII, and IX).

Of these cases VIII died almost at once from recurrent bleeding, and VII after thirty-six hours with intestinal stasis, due, I believe, to an insufficiently free resection.

Case IX recovered and lived for a week, during which time he improved in condition and had his bowels open freely and often. He died at the end of this period from secondary haemorrhage from an artery outside the abdomen.

Case V recovered and was transferred to the base three weeks after operation.

Case VI recovered, was transferred to another hospital, and seventeen days after operation was reported well and on ordinary diet, on his way to the base in a barge.

The results thus are that out of 5 cases, 2 died outright, 2 recovered completely, and 1 recovered from the operation but died a week later from another cause.

The two who recovered completely happen to be those in which the largest amounts of bowel were removed (2½ ft. and 4½ ft. respectively).

CONCLUSIONS.

1. Death in uncomplicated cases of gunshot wounds of the small intestine is not usually due to escape of faeces and general peritonitis, but to a progressive intestinal paralysis and distension spreading upwards from the injured coil.

2. Operation in such a case should include the resection of the injured portion together with as much bowel above it as would otherwise remain in a condition of paralysis.

3. If this be done sufficiently early there is a prospect of saving a fair proportion of cases.

I wish to repeat that these conclusions are based on a small number of cases, those of which notes are given. Wider experience or the experience of other surgeons may perhaps modify or contradict them; meanwhile their practical importance at this time seems to me to justify their publication.

In conclusion I wish to express my great obligation to Captain H. T. M. Wilson, R.A.M.C., for his help with nearly all these cases, and for many valuable practical suggestions.

CASE I.—Wound of Colon: Localized Escape of Faeces: Drainage: Death from Secondary Haemorrhage Six Days later.

Private D., 2nd Scots Fusiliers. Shrapnel wound three days ago. Entry near navel; no exit. Distension, poor pulse, retention of urine, acute localized uncontrollable pain. No vomiting. March 15th, operation undertaken chiefly to relieve the pain. Incision near wound, splitting rectus. On opening the peritoneum semi-solid faeces came out under great pressure, issuing from a blackened cavity formed by adherent intestine, into which faeces were discharged from a wound of the colon. Faeces came away through the wound for the next five days. The pain was less, the general condition poor. On March 20th an enema was given and solid faeces were passed per rectum. Secondary haemorrhage then began, increased, and proved fatal on the 21st. As fighting was then going on no autopsy was made.

CASE II.—Wound of the Duodenum: Localized Escape of Contents: Drainage: Death.

Private H., East Lancs. Wound in the right flank three days ago. Biliary vomiting, very acute local pain, no signs of general peritonitis. Operation March 7th: Incision vertical in

upper part of right rectus, viscera adherent round a collection of dirty grey fluid and gas, which issued from a hole deep down in the inflamed lining of the cavity. This hole could not be closed. Drainage through the wound of entry; closure of the operation wound. Vomiting and pain ceased at once; the next morning the patient was reading the paper. Discharge free, reddening the surrounding skin; no faecal smell. The patient was transferred to the base six days later. While there the discharge diminished and ceased to be irritating, but he gradually sank and died.

CASE III.—*Wound of Duodenum or Beginning of Jejunum: Localized Collection of Fluid: Drainage: Death in Five Days.*

Lieutenant C., 2nd Leicesters. Shrapnel wound left loin two and a half days before. No symptoms till the night before admission, then vomiting, pulse 120, hiccough, and pain referred to testes. Operation May 24th: Incision splitting left rectus. On opening the peritoneum a dirty fluid, fetid though the odour was not faecal, issued under pressure from a cavity formed by adherent viscera. The hole in the intestine could not be demonstrated but lay apparently in the duodeno-jejunal flexure. A shrapnel bullet was found lying in the mesentery of the jejunum close to the bowel which was here intact. Closure in layers with a lumbar drain.

May 25th. The discharge is practically pure bile. This fluid, later on, reddened and excoriated the surrounding skin; the patient vomited a good deal, grew weaker, and died May 29th.

CASE IV.—*Injury to a Coil of Intestine which Retracted from the Wound and was Missed at Operation: Death from Haemorrhage.*

Private M., 2nd Leicesters. Wound in left iliac fossa; pulse 120. Operation May 17th: Vertical incision over the wound, large collections of clot inside and outside the peritoneum, that inside smells slightly faecal. Colon intact, two small punctures in the adjacent small intestine closed with sutures. Casing of ricochet bullet found loose. The patient died on May 19th.

Post mortem: Abdomen full of blood, wound of omentum. In the umbilical region, at some distance from the wound, lay a coil of jejunum completely wrapped in omentum, with four biggish holes. No escape of contents, no general peritonitis. The injured coil and the bowel above it much distended, the intestine below empty and shrunken.

CASE V.—*Resection of 2½ ft. of Small Intestine: Dysentery: Recovery.*

Corporal M., R.Y.R. Shell wound through right ilium thirty-six hours before in direction of pelvis. Slight abdominal distension; no pain on vomiting. Urine normal. Operation March 18th: Incision in the middle line. Three wounds found in a coil of ileum; the coil adherent all round. No escape of contents. The missile, a square piece of shell about ½ in. across, lay in the lumen of the gut. Two and a half feet of intestine resected, end-to-end suture, suprapubic drain. Two days later the bowels were moved with calomel, enemas, and pituitrin. A week after operation he developed diarrhoea, which later became a definite dysentery, with passage of blood and mucus. Treated with mag. sulph. hourly. Recovery. Transferred to base April 9th, three weeks after operation.

CASE VI.—*Wounds of Small Intestine: Resection of 4½ ft.: Acute Dilatation of Stomach: Recovery.*

Lieutenant C. F. P., 6th Duke of Wellington's. Entry wound—ricochet bullet—right iliac fossa. After eighteen hours, onset of local pain, rigidity. Bullet thought to be in wall. Operation May 24th: Incision vertical, crossing the wound. A coil of ileum found wrapped in the omentum, perforated near the mesenteric border in two places about 5 in. apart. There had been no escape of faeces, but the coil was full, and as soon as it was lifted from its bed the liquid contents spouted out. Intestine above much dilated with gas and liquid faeces, that below practically empty. A piece of bullet casing lying loose. Rest of intestine reviewed and found intact; no general peritonitis; 53 in. of bowel resected from just below the injury upwards; it was all dilated and inflamed. Bowel above emptied. End-to-end suture in healthy bowel. Inflamed omentum tied off. Suprapubic drain.

May 25th. Poor pulse. No vomiting.

May 26th. Enema—solid faeces. While this was acting half a pint of clear coagulable serum was discharged from the drain, and three measured pints of watery green fluid vomited. No further vomiting.

May 27th. Epigastric pain and distension, stomach felt swollen and tense, rest of abdomen lax. Stomach tube drew off 3 pints green fluid. In the evening same condition, about 1½ pints brownish sour-smelling fluid drawn off. Bowels opened four times naturally in the night; no further distension. Later there was a troublesome diarrhoea.

Our hospital moved away a few days later, and the patient was left in the care of Captain Frankau, R.A.M.C.(T.), who tells me that he sent him to the base in a barge on June 10th (seventeen days after operation). He was then on ordinary diet and doing well.

CASE VII.—*Excision of 19 in. of Intestine: Death Thirty-six Hours later.*

Private H., 4th Liverpools. Shot from root of penis to right lower ribs two and a half days ago. Bullet (shrapnel) felt under the skin. Bilious vomiting, rigidity, pain. Operation March 13th: Incision in right rectus. Small intestine wounded in two places, full of liquid faeces of which none had escaped.

Resected a foot and emptied the bowel above. The next morning the patient was better, later bilious vomiting came on again and he sank and died.

Post mortem: No other injury was found. No general peritonitis; no haemorrhage. The bowel above the union very much distended, that below it empty and contracted.

CASE VIII.—*Resection of 2 in. of Small Intestine: Death a Few Hours later from Recurrent Haemorrhage.*

Private D. B., 2nd Yorks. Bullet wound crossing abdomen from a point 2 in. left of the navel to the right loin. Operation January 28th: Median incision. The wound of exit lay just outside the ascending colon. The peritoneal surface of this was apparently intact, but the discharge from the exit wound smelt slightly faecal. The whole of the small intestine was inspected. In one place there was a complete perforation, mucous membrane protruded and blocked both entry and exit. There was no escape of contents. About 2 in. of the injured portion was excised and the intestine joined by end-to-end suture. Death took place some hours later.

Post mortem: The peritoneum was full of free blood, derived either from the omentum, which was slightly injured, or from the region of the exit wound.

CASE IX.—*Resection of 7 in. of Bowel: Recovery: Death a Week later from Secondary Haemorrhage from the Gluteal Artery.*

Private C., 2nd Gordons. Shell wound in right buttock ten hours before; vomiting, rigidity. A wide track leads directly through the ilium into the pelvis. Operation February 7th: Median incision. Bladder and rectum intact; a good deal of free blood and some peritonitis. The small intestine had four wounds, two of which nearly divided it. Missile not found. Seven inches resected. Closure with drain in entry wound. The patient nearly died after the operation, but rallied, grew stronger, and lived for a week, the bowels opening frequently. On February 13th he began to bleed from the drain, the bleeding recurred and increased, and proved fatal on the 14th.

Post mortem: Intestinal tract all sound, but generally adherent. Scarcely any blood in the abdomen. Bleeding had evidently come from the wound in the buttock, presumably from the gluteal artery.

"TRENCH BACK" TREATED BY SODIUM SALICYLATE IONIZATION.

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"TRENCH BACK" is the term applied to a variety of conditions arising from injury to the back in the lumbar or sacral regions. The injury is usually caused by the impact of large and heavy masses of matter, such as a quantity of earth or sandbags.

As the condition is of great importance on account of its frequency and the prolonged disability it usually entails, I venture to bring forward the following method of treatment, although the number of cases so far treated does not justify any dogmatic statement as to its utility or allow any final conclusion to be drawn.

The cases almost invariably come from the trenches. They complain of pain and rigidity in the dorsal-lumbar region. Various degrees of disability are represented—some can get about, others have to be carried on stretchers. Those who can walk do so with a pronounced stoop, and use a stick. Tenderness is generally present. Some cases show anaesthesia, and in these there is probably spinal injury. In the milder cases the clinical picture is that of marked lumbago, and would be indistinguishable except for the history. All cases of this condition should be examined by x rays before being treated in the manner suggested, and all cases of injury to the spine and pelvis excluded. Cases with anaesthesia of the lumbar and sacral regions are unsuitable for ionization, as they are very liable to be badly blistered during treatment. The majority have no spinal lesion, the symptoms being due to contusion or sprain of the muscles and fasciae alone. It is for cases of this class that I advocate ionization. In a certain proportion a pronounced psychical factor can be traced, and these cases present features similar in many respects to the condition known as "railway spine," and are always difficult to treat.

The cases that have come under my notice in the Electro-Therapeutic Institute of the Kitchener Indian Hospital, Brighton, have, as a rule, been medically treated in the wards for some time. I selected a number and treated them by ionization with sodium salicylate, and obtained good results in a short time.

I now apply the treatment to all cases of trench back