PENETRATING WOUNDS OF THE LARGE BOWEL

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Penetrating abdominal wounds still carry a considerable mortality. The 2 most important factors contributing to this mortality are shock due to haemorrhage, and sepsis. Sloan[1] analysed 146 civilian cases seen at the Johns Hopkins Hospital from 1925 to 1943. In the period 1925-38 the mortality was 31%, as compared with 10·1% in the period 1939-43, when sulphonamide therapy was available and the importance of adequate transfusion in these cases was more fully appreciated.

In addition, as Sir Gordon Gordon-Taylor[2] has pointed out in a masterly contribution to the subject, there are important differences between military and civilian cases which account for the higher mortality in the former. Factors to be considered in this connection include the explosive effect of missiles (which account for the vast majority of military wounds in contradistinction to those seen in civilian practice), the inevitable delays in treatment and the constant threat of infection, which are more significant in battle injuries.

The surgical management of injuries to most abdominal viscera has been standardized to a fair degree. Injuries to the large bowel are of considerable interest, not only because of their notorious mortality, but also because there is a difference of opinion regarding the best way of dealing with them. Gordon-Taylor[2] states that the routine use of exteriorization of colonic injuries was one of the great advances in the abdominal surgery of World War II. Handfield-Jones[3] states that the method of exteriorization was the 'greatest single contributory factor to the improved results in colonic injury'. However, Gordon-Taylor[2] also states that with considerable experience and careful judgment there is a place in minor wounds of the large bowel, especially of the right colon, for more conservative measures, e.g. simple suture with or without a proximal diverting colostomy. It will, therefore, be instructive to analyse the methods used, and the results obtained, in treating large-bowel injuries in a civilian hospital which receives a relatively large number of these cases.

CASE MATERIAL

During the 3-year period 1954-56, 27 cases with penetrating abdominal wounds admitted to the Coronation Hospital were found to have involvement of the large bowel with or without coincident injuries to other abdominal viscera. The relevant details of these cases are presented in Table I.

Age and sex incidence. As may be expected, the majority of patients were young, healthy adults. Ten cases occurred between the ages of 20 and 29 years, and 10 cases between 30 and 39 years. There were 3 cases under 20 years and 4 cases over 40 years of age. All the patients were males.

Nature of injury. There were 22 stab wounds and 5 gunshot wounds. The 4 fatal cases sustained stab wounds whereas the patients with gunshot wounds all survived. One cannot draw statistical conclusions from 5 cases, but it is noted that Sloan[1] found a much higher mortality in gunshot wounds in a series of civilian cases in which stab wounds and gunshot wounds were approximately equal in number.

Section of large bowel involved. The transverse colon (18 cases) was most frequently involved. The descending colon was involved in 6 cases, the caecum in 2 cases, and the sigmoid and rectum in 1 case each.

Treatment

Intravenous infusion was started in every case before operation, regardless of the clinical condition of the patient. A naso-gastric tube was passed, the stomach emptied and the tube left *in situ* because alcohol was a complicating factor in many cases. Whereas the necessity of early, vigorous and adequate blood transfusion in cases with haemorrhagic shock is fully appreciated, it must be emphasized that in the presence of evidence of continuing severe bleeding, preliminary transfusion must not be continued too long in the hope of getting the patient 'fit' for operation. In haemorrhage of this magnitude, the bleeding points must be secured as soon as possible, and resuscitation must proceed *pari passu* with the operation.

The administration of antibiotics, usually a combination of penicillin and streptomycin, was started pre-operatively in every case.

All the operations were performed by the surgical registrars on emergency duty. The need for adequate access in these cases is reflected in the choice of incision used. Paramedian incisions were used in 16 cases, transverse incisions

TABLE I. RESUME OF RELEVANT DETAILS

Case	*Age, Sex*	*Mode of injury*	*Portion of large bowel affected*	*Treatment*	*Other abdominal viscera affected*	*Extra-abdominal injuries*	*Complications*	*Length of stay in hospital*	*Final outcome*
1	M 20	Gunshot wound	Sigmoid 1 perforation	Simple suture	13 perforations in small bowel	Nil	Small bowel faecal fistula	7 weeks (readmitted for closure of fistula)	Full recovery
2	M 27	Stab	Rectum 1 perforation	Colostomy and drainage of buttock wound	Nil	Penetrating stab of chest	Haemothorax and empyema	4 months	Full recovery
3	M 16	Stab	Transverse colon 2 perforations	Simple suture	2 perforations of jejunum	Penetrating stab of chest	Transient bizarre hemiparesis	7 weeks	Full recovery
4	M 33	Stab	Descending colon 1 perforation	Simple suture	2 perforations of ileum	Nil	Pyrexial for 14 days	21 days	Full recovery
5	M 36	Stab	Transverse colon 1 perforation	Simple suture	1 perforation of ileum	Nil	Slight wound sepsis	17 days	Full recovery
6	M 30	Stab	Transverse colon 1 perforation	Simple suture	Laceration of mesentery of small bowel	Nil	Pyrexial for 6 days	15 days	Full recovery
7	M 40	Stab	Transverse colon 1 perforation	Simple suture	Nil	Superficial laceration of chest	Pyrexial for 9 days	14 days	Full recovery
8	M 30	Stab	Transverse colon 2 perforations	Simple suture	Jejunum Diaphragm Omentum	Penetrating stab of chest	Haemothorax	12 days	Full recovery
9	M 34	Stab	Transverse colon 2 perforations	Simple suture	Transverse mesocolon Mesentery	Nil	Pyrexial for 12 days	22 days	Full recovery
10	M 31	Gunshot wound	Transverse colon 6 perforations	Simple suture	Nil	Nil	Pyrexial for 12 days	18 days	Full recovery
11	M 54	Stab	Transverse colon 1 perforation	Simple suture	1 perforation of ileum	Penetrating stab of chest	Haemothorax	12 days	Full recovery
12	M 18	Stab	Descending colon almost completely transected	Simple suture	Nil	Nil	Nil	10 days	Full recovery
13	M 29	Stab	Transverse colon 1 perforation	Simple suture	Lacerated spleen Splenectomy	Superficial lacerations	Nil	20 days	Full recovery
14	M 36	Stab	Descending colon 1 perforation	Simple suture	Ileum 2 perforations	Superficial chest laceration	Nil	12 days	Full recovery
15	M 29	Stab	Descending colon 2 perforations	Simple suture	Nil	Concussion Lacerated scalp	Ileus for 5 days	10 days	Full recovery
16	M 27	Stab	Caecum 2 perforations	Simple suture	Nil	Nil	Nil	12 days	Full recovery

TABLE I. RESUME OF RELEVANT DETAILS (*Continued*)

Case	*Age, Sex*	*Mode of injury*	*Portion of large bowel affected*	*Treatment*	*Other abdominal viscera affected*	*Extra-abdominal injuries*	*Complications*	*Length of stay in hospital*	*Final outcome*
17	M 29	Stab	Transverse colon 1 perforation	Simple suture	Nil	Nil	Nil	8 days	Full recovery
18	M 26	Gun-shot wound	Descending colon 2 perforations	Simple suture	Ileum 6 perforations Resected	Nil	Pyrexial for 14 days	20 days	Full recovery
19	M 22	Stab	Transverse colon 2 perforations	Simple suture	Ileum 4 perforations Mesentery	Nil	Superficial wound dehiscence	38 days	Full recovery
20	M 17	Gun-shot wound	Transverse colon 2 perforations	Simple suture	Kidney (sutured)	Nil	Superficial wound sepsis	13 days	Full recovery
21	M 33	Stab	Transverse colon 1 perforation	Simple suture	Nil	Penetrating stab of chest	Haemothorax	13 days	Full recovery
22	M 25	Stab	Transverse colon 1 perforation	Simple suture	Kidney Liver	Nil	Nil	9 days	Full recovery
23	M 34	Gun-shot wound	Transverse colon 2 perforations	Simple suture	Nil	Compound fracture of finger	Wound sepsis	15 days	Full recovery
24	M 30	Stab	Caecum (2) Transverse colon (3)	Transverse colon sutured. Caecum exteriorized	Small bowel (4)	Nil	Nil after 1st operation	—	Died 4 days after closure of caecostomy
25	M 45	Stab	Transverse colon 2 perforations	Simple suture	Ileum (1) Mesentery (severe haemorrhage)	Nil	—	—	Died on table
26	M 20	Stab	Transverse colon 1 perforation	Simple suture	Ileum (1) Mesentery (severe haemorrhage)	Nil	—	—	Died 24 hrs. post-op.
27	M 45	Stab	Transverse colon (1) Descending colon (1)	Simple suture	Kidney Massive retro-peritoneal haemorrhage	Penetrating stab of chest	—	—	Died 3 hrs. post-op.

in 4 cases, while the original wound was enlarged in only 3 cases. The latter incision has a small place in the treatment of these cases, especially in gunshot wounds for it may lead to severely restricted access unless the wound is close to the mid-line. In lower thoracic wounds penetrating the diaphragm, an abdomino-thoracic approach is usually the most convenient and this was used in case 20, where a through-and-through gunshot wound involving lung, kidney and the right half of transverse colon was conveniently dealt with through this incision.

In 25 of the 27 cases the wounds in the colon were merely sutured in 2 layers without any proximal diverting colostomy. The suture material used was not specified in every case, but in the majority a 2-layer closure was done, using chromic catgut for the all-coats layer and interrupted silk sutures for the sero-muscular layer. The peritoneum was drained through a separate stab incision in the majority of cases. It must be noted that in several cases the wounds in the bowel were quite extensive, and in case 12 the descending colon was almost completely transected.

In the remaining 2 cases, 1 (case 2) had a wound of the buttock penetrating the rectum. A proximal diverting colostomy was performed and the buttock wound drained. The other (case 24) had 3 perforations of the transverse colon, which were sutured, as well as a through-and-through wound of the caecum, which was exteriorized as a caecostomy.

Post-operatively, naso-gastric suction and intravenous fluids were continued until the return of peristalsis. Antibiotics were administered until the patient was apyrexial.

In a few cases a member of the tetracycline group was given intravenously if the response to penicillin and streptomycin was not satisfactory (see below).

MORTALITY

Of the 27 cases 4 died as a result of their injuries—a mortality of 14·8%. The fatal cases are considered in some detail:

Case 24

This patient, an African male aged 30, sustained a stab wound producing 3 perforations of the transverse colon and 4 perforations of the small bowel, all of which were sutured in 2 layers. In addition there was a through-and-through wound of the caecum, which was exteriorized as a caecostomy. He made a good recovery and 4 weeks later an extra-peritoneal closure of his caecostomy was made. He was never well after the latter operation, and he died on the 4th post-operative day. At autopsy, the repair of the caecostomy was found to be competent. An unexpected finding (the cause of death) was gangrene of a large part of the small bowel from 2½ feet above the ileo-caecal valve, as a result of herniation through a tear in the mesentery which must have been overlooked at the original operation.

Case 25

This patient, an African male aged 45, had a stab wound of the right side of the abdomen, with small and large bowel protruding from it. He was in a desperate condition, requiring vigorous blood transfusion through both arms. At operation there was brisk bleeding from the root of the mesentery, a large perforation in the ileum, and 2 large perforations in the transverse colon. The perforations were sutured. The bleeding from the root of the mesentery was uncontrollable and he died on the table in spite of all efforts to resuscitate him. Post-mortem examination did not disclose any other injuries and the cause of death was shock.

Case 26

This patient, an African male aged 20, sustained a stab wound in the right iliac fossa. Small bowel was protruding from the wound on admission. He was extremely shocked; his blood pressure was 60/0 mm. Hg. At laparotomy a large amount of blood was found in the peritoneal cavity. One perforation in the ileum and another in the transverse colon were sutured. There was a large haematoma in the mesentery of the small bowel. At the conclusion of the operation the bleeding from this site appeared to be controlled, but a few hours later he showed signs of further haemorrhage, and died before anything could be done. At autopsy, an incision in the main trunk of the superior mesenteric artery, about 4 inches from its origin, was found. There was a massive retro-peritoneal haematoma, and about 1,000 ml. of blood in the peritoneal cavity. The cause of death was shock.

Case 27

This patient, an African male aged 45, was admitted with a stab wound in the left side of the abdomen. Bowel was protruding from the wound. There was also a stab wound in the left chest at the level of the tenth rib, with the physical signs of a haemothorax. He was very shocked. At operation, 2 perforations in the transverse colon were sutured. There was much bleeding from the retro-peritoneal space. He required vigorous resuscitation during and after the operation, and he died 3 hours after returning to the ward. At autopsy, there was a penetrating wound of his left lung with 300 ml. of blood in the pleural cavity. The sutured wounds of the transverse colon were satisfactory. There was a ½-inch incised wound of the left kidney surrounded by a large haematoma. The cause of death was shock.

Comment

In this series shock was the most important cause of death. In none of the cases was the cause of death directly related to the colonic injury, or the method of dealing with it.

Comparing these figures with the figures for battle casualties, the markedly lower mortality is obvious. During World War I, the mortality for large-bowel injuries was 48·7% (Cuthbert Wallace). For World War II, according to Gordon-Taylor,[2] the mortality ranged from 10% in small, solitary wounds to 70% in large or multiple wounds (total mortality in the region of 40%). According to Gordon-Taylor,[2] the greatest single factor in reducing the mortality was the policy of routine exteriorization. His mortality rate in a large series was 20-30%. Ogilvie,[4] reporting from the western desert, found the mortality for colonic injuries to be 51·5%. When uncomplicated by severe extra-abdominal injuries, the mortality was 43·9%. If the operation was performed within 12 hours of wounding the mortality was 40%. Unfortunately the time interval between the wounding and operation in the Johannesburg series reported in this article was available from only few of the records, so that no comparison can be made, but it is virtually certain that the interval was much less than 12 hours in the vast majority of cases.

COMPLICATIONS

1. *Pyrexia.* The majority of patients ran a temperature for a few days, and in 6 cases it was sufficiently prolonged to be noted as a complication. The duration of the pyrexia in these cases ranged from 6 to 15 days. In 3 cases the routine administration of penicillin and streptomycin was discontinued in favour of a tetracycline preparation.

2. *Wound sepsis.* Mild wound sepsis was noted in 3 cases. In case 19 a more severe degree of wound infection caused dehiscence of the superficial layers, a complication which kept the patient in hospital for 38 days.

3. *Paralytic ileus.* In 1 case only (case 15) was the post-operative ileus of any significant duration. He required naso-gastric suction and intravenous fluids for 5 days, after which he passed flatus, made a rapid recovery, and was discharged on the 10th post-operative day.

4. *Faecal fistula.* A faecal fistula developed in case 1. He had received a gunshot wound in the left iliac fossa. This produced 13 perforations in the small bowel and 1 perforation in the sigmoid colon. The peritoneal cavity was drained for 5 days. The fistula kept him in hospital for 7 weeks, after which the discharge was so small in amount that he was allowed to go home in the hope that the fistula would close spontaneously. However, this did not happen, and the abdomen was re-explored 3 months after the original injury. The fistula was found to lead down to a loop of small bowel. It was excised and he made an uninterrupted recovery.

5. *Pulmonary complications.* Apart from the 6 cases with coincident penetrating wounds of the chest (see below) pulmonary complications were strikingly few. Breathing exercises, early ambulation and the comparative youth of the patients probably contributed to this state of affairs.

One patient (case 3) developed a bizarre unilateral weakness, the cause of which was never determined and which disappeared spontaneously in the course of a few weeks.

Length of Stay in Hospital

Only 4 patients had to stay in hospital for prolonged periods. In case 1 a faecal fistula developed (7 weeks and a readmission); in case 2 a thoracic empyema developed owing to a coincident penetrating stab wound of the chest (4 months); in case 3 a transient and unexplained hemiparesis developed (7 weeks), and case 19 suffered from a superficial disruption of his wound (38 days). In the re-

mainder the average stay in hospital was 14 days. This is an important factor if one considers the length of stay that would have been required if the procedures had been carried out in stages for all the patients.

Injuries to Other Abdominal Viscera

Coincident injury to other abdominal viscera has an important bearing on the mortality figures. Ogilvie[4] found that in colonic injuries unaccompanied by severe extra-abdominal trauma the mortality was 43·9%, whereas in cases in which the small bowel as well as colon had been perforated the mortality rose to 58·6%. In small-bowel plus rectal injuries the mortality was 71·4%.

1. *Small bowel.* In this series, 12 patients had combined small-bowel and large-bowel injuries. Of these patients 3 died but analysis of these cases does not indicate that the addition of small-bowel perforations had any direct bearing on the fatal outcome (cases 24, 25 and 26).

2. *Mesentery or omentum.* In the majority of penetrating abdominal wounds, perforations of the bowel wall seldom cause severe haemorrhage. Exsanguinating haemorrhage almost always comes from vessels in the mesentery or the retro-peritoneal space. In 7 cases there was severe mesenteric or retro-peritoneal bleeding, and 3 were fatal (mortality 43%). In 3 of the 4 fatal cases in the whole series exsanguinating haemorrhage was the direct cause of death (cases 25, 26 and 27).

3. *Spleen.* The spleen was lacerated in case 13. Splenectomy was performed and the patient made a good recovery.

4. *Kidney.* The kidney was injured in 3 cases (20, 22 and 27). The third patient died, and at autopsy a large peri-renal haematoma was found.

5. *Liver.* The liver was lacerated in only 1 case (22), in association with wounds of the transverse colon and kidney. The patient made a rapid and uninterrupted recovery.

Extra-abdominal Injuries

1. *Chest.* Six cases had penetrating wounds of the chest as well as of the abdomen. One (case 27) was fatal, and the chest injury—a penetrating wound of the lung with 300 ml. of blood in the pleural cavity—probably contributed to his death. In case 2 the traumatic haemothorax became infected—a very rare complication in this hospital of an extremely common injury—and the resulting empyema required rib resection. He was well on discharge after 4 months. In the remaining cases, the haemothoraces cleared up rapidly on the conservative treatment (non-aspiration) employed in this hospital.

The other extra-abdominal injuries were minor in character, and do not warrant detailed description. On the whole, therefore, extra-abdominal injuries in this series were not very serious. This is one reason why the civilian mortality tends to be less than the military mortality. Ogilvie[4] found that severe extra-abdominal trauma raised the mortality of colonic injuries from 43·9% to 51·5%.

DISCUSSION

In contradistinction to the accepted method of exteriorizing penetrating injuries of the colon during World War II, 25 of the 27 cases reviewed here were treated by simple suture in 2 layers without proximal faecal diversion or exteriorization. The 5 gunshot wounds were treated in the same way as the stab wounds. In no case was there any evidence of faecal leakage from the colonic wounds. In the only case of faecal fistula (case 1), the leakage was found on subsequent laparotomy to originate from the small bowel, which had been perforated in 13 places by a bullet. Of the fatal cases 3 (12%) died as the result of massive haemorrhage from severed mesenteric vessels.

Only 1 case was treated by proximal faecal diversion; he had a wound of the rectum below the peritoneal reflexion as a result of a stab in the buttock area. This seems to be the only reasonable form of treatment for wounds in this particular locality.

One case (24) was treated by exteriorizing a through-and-through wound of the caecum after suturing 3 further perforations in the transverse colon. The unfortunate complication which caused his death is described in detail above.

While Gordon-Taylor[2] and other authors are emphatic about the desirability of exteriorizing the majority of colonic injuries, they do recognize circumstances in which alternative procedures may be used, as follows:

1. *Suture alone.* According to Gordon-Taylor,[2] this is only indicated in minor wounds. His low mortality (20%) resulted from his use of this method in only highly selected cases, generally of a minor character. Imes[5] found the same 'apparent paradox' in his mortality figures: 24% in 168 selected cases where the colon was sutured, and 35% in 945 cases where the colon was exteriorized. He used the same criteria for selection as Gordon-Taylor. In the present series, many of the injuries could not be described as minor, and in case 12 the descending colon was almost completely severed.

2. *Suture with proximal faecal diversion* is also of limited value according to Gordon-Taylor.[2] He feels that it may be used in minor wounds of the right colon and rectum. The colostomy should be made as close as possible to the perforation, and opened at once. He states that this procedure is only justified when exteriorization is difficult or impossible for mechanical reasons. The average mortality with this method he found to be 33%.

3. *Resection and anastomosis* should be avoided in war surgery whenever possible according to both Gordon-Taylor[2] and Imes.[5] This procedure carries a consistently high mortality, in the region of 65%. It may be indicated, however, in massive wounds in the caecal area. In this area, exteriorization carries the real disadvantages of skin excoriation and trouble with fluid balance. Gordon-Taylor[2] feels that if exteriorization is needed here, an accompanying ileo-transverse anastomosis is probably indicated, for this diverts some $\frac{2}{3}$rds of the faecal stream from the skin.

In conclusion we may therefore say that exteriorization is the procedure of choice in the treatment of extensively damaged colonic segments, especially if the blood supply is questionable. Resection and anastomosis has a special place in the management of massive wounds in the caecal area. These conditions apply in many war injuries. On the other hand, in the vast majority of civilian cases with large-bowl injuries, where the injury is less extensive, where there is less delay in definitive treatment, and where sepsis is consequently a less potent factor, simple suture has proved itself eminently satisfactory and associated with far less morbidity.

SUMMARY

1. A review of 27 cases of penetrating abdominal wounds involving the large bowel is given. The patients were all civilians. The regime of treatment is described. Simple suture was performed in all but 2 cases.

2. Four patients died, giving a mortality of 14·8%. This compares favourably with the mortality of this type of injury in war time. The reasons for the difference are discussed.

3. Whereas, owing to the more extensive nature of the lesion and frequent delays before operation, exteriorization of the injured colon is frequently the procedure of choice under conditions of battle, simple suture is a safe procedure with little morbidity in the vast majority of civilian injuries. Here the lesion is frequently not so extensive, and early operation is usually possible.

4. The most important single factor, which contributed to the fatal outcome in 4 cases, was massive haemorrhage from mesenteric or retro-peritoneal vessels. Infection was not a serious complication, and there were no cases of leakage from the colonic wounds.

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