5. Every wound of the abdominal wall, however slight, should be explored, whether signs of internal injury are present or not. If it is found to be penetrating, the abdomen should be opened.

6. The necessity for deciding between the claims of abdominal and other cases can be best avoided by good theatre organization, the provision of two tables for each surgeon, and by not allowing slow operators to do abdominal work. If these measures are insufficient the decision should be left in the hands of the surgeon in charge of the pre-operation ward.

REFERENCES.

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ABDOMINAL OPERATIONS AT AN ADVANCED OPERATING CENTRE.

FIFTY CONSECUTIVE CASES OF PENETRATING WOUNDS OF ABDOMEN, IN SIXTEEN OF WHICH THE CHEST WAS ALSO INVOLVED.

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The Operating Centre.

The centre was situated in a village in advance of the corresponding group of casualty clearing stations. The roads between them at the time presented a very rough surface, and were heavily charged with transport, so that at least one hour's very bad journey was saved.

The accommodation comprised part of a building, without any special heating or lighting arrangements, and marquees. The heating was done by oil stoves, the lighting by an acetylene plant. In the building were the operating theatre, sterilizing room, and a post-operative room of twelve beds, while outside were the reception marquee and thirty-eight extra beds, partially distributed in a long ward of four contiguous marquees and in two separate.

The operating theatre was large enough for two tables, had a tiled floor, and large windows looking both east and south. The walls were distempered white. The sterilizing room adjoined the theatre, and was fitted with a large metal-lined washing-up trough. The post-operative ward of twelve beds was a large, light, airy room, with distempered walls and a parquet floor. The marquees were conveniently arranged adjacent to the building. The reception marquee was fitted with four pairs of trestles for stretchers, and served also as pre-operation and resuscitation departments. The big ward of four marquees joined together had accommodation for twenty-six patients, and two other single marquees were each fitted with six beds, one for officers and one for badly infected cases.

The Staff.

With the exception of the first few days, when a second team was attached (Captain Stevenson, R.A.M.C.), the operative work was done by one surgical team, consisting of surgeon, anaesthetist, sister, and theatre orderly, while the general administration was carried on most of the time by a section of the field ambulance to which the centre was attached. Four extra sisters were attached to superintend the nursing in the wards, the staff of orderlies being supplied by the field ambulance. At a later period, with an increase in the military activities, three extra surgical teams were attached to the centre, and the beds increased to 75. A special marquee was set apart for resuscitation, and a second for those cases considered as hopeless on admission, the reception marquee being utilized only for the reception of cases and the preparation of those to be operated on at once.

PRE-OPERATIVE TREATMENT.

Special efforts were made to evacuate the abdominal cases as quickly as possible from the line, and all concerned displayed the greatest keenness in achieving this. How far it succeeded will be seen in the study of the time intervals between wounding and arrival at the centre.

The reception marquee was always kept very warm, and on arrival the patient was taken to it, examined, and judged fit or unfit for operation.

If considered fit for operation he was washed and put in pyjamas, and morphine and atropine administered hypodermically if necessary. It was not uncommon for the patient to arrive already deeply under morphine; this was found to be especially dangerous in those cases with chest wounds, as great difficulty was sometimes experienced with the respiration after the operation. Rinsing of the mouth with water was allowed, but no drinks. The urine was always examined before operating, but if the patient failed to pass it himself catheterization was deferred till he came into the operating theatre. The operation was commenced one hour after his arrival. At the suggestion of Captain Stevenson a special stretcher was used for these cases to avoid any excessive amount of lifting about. A coarse palliasse was stitched down the sides so as to leave two tunnels through which the stretcher poles could pass, and two iron bars with rings at the ends were slipped over the pole handles to keep them apart. Over this was placed a ground sheet and then an ordinary sheet. The advantage of this was that the patient remained on the palliasse until he arrived in the ward, the poles being slipped out when he was placed on the operating table.

If the patient was considered unfit for operation the usual resuscitation procedures were carried out. He was made as comfortable as possible, morphine was administered if necessary and heating up was done by a Beatrice stove in a kerosene tin with a chimney leading under a cradle over the stretcher. Stimulants were given hypodermically as required, and saline, preferably by the intravenous method. In a few cases blood transfusion was performed, but only one of these was an intraperitoneal lesion. The method used was vein to vein by means of an improvised tube—an ordinary 6 in. glass testing pipette with $\frac{1}{8}$ in. lumen; it was bent into a U-shape, the limbs of the U being 1 in. long. A small flange was made at the ends to prevent the tube slipping out of the veins. The tube was sterilized and washed through with liquid paraffin before use (soft paraffin is undoubtedly better). The median basilic veins were used, an injection of $\frac{1}{2}$ per cent. novocain being given to produce anaesthesia. In one case, where the blood refused to flow into the vein of the recipient, a second incision was made in the neck and transfusion made into the external jugular vein, which was seen to empty with each inspiration. The veins were connected for twenty minutes. The tube can easily be modified for an artery to vein transfusion, and may be made of metal. The method is not so good as Crile's No. 17 transfusion tube, but in an emergency is easily carried out, especially if none of the usual means is at hand. In the abdominal case so treated the pulse-rate came down from 142 to 108 in twenty minutes and remained so for about half an hour, when the patient quite suddenly collapsed again and died in another hour. The time for operation was settled by the progress of the case.

If the interval between wounding and admission was more than eighteen to twenty-four hours expectant treatment was adopted. The patient was put on a Fowler frame, the wound dressed, and fomentations applied to the abdomen, if necessary. Morphine was given, and fluid by the mouth gradually commenced.

When the case was judged hopeless the patient was made as comfortable as possible, morphine was not withheld, and fluids were allowed by the mouth.

A chamber for heating the pyjamas was made of a box the bottom of which was knocked out and replaced by wire netting. It was placed on a stand with a Beatrice stove underneath. By this means a stock of warm clothing was always ready for use.

OPERATIVE TREATMENT.

The patient was taken to the operating room, which was kept at a temperature of 65° to 70° Fahr. The anaesthetic administered was chiefly ether, reinforced at times by chloroform, and given by the Shipway apparatus. In the worst cases continuous oxygen was given simultaneously by attaching a cylinder. If the patient had been unable to micturate, a catheter was now passed and the urine examined.

The skin was prepared under the anaesthetic; it was shaved with spirit soap for preference, followed by the

application of turpentine, if it could be obtained, then more spirit soap and methylated spirit, and finally 5 per cent. picric acid solution in spirit.

Dry sterile towels were placed next to the patient, and covered by hot towels wrung out of 1 in 40 carbolic. Sterilized mops were used wet out of 1 in 10,000 biniodide lotion, and abdominal swabs out of hot saline. Instruments were boiled and kept in 1 in 40 carbolic acid, knives, etc., in spirit, after cresol. Masks were worn by surgeon and assistant, and gowns with long sleeves for preference. The lotion for the hands was 1 in 10,000 biniodide.

The principles observed in operating were: (1) Good exposure; (2) minimum retraction; (3) gentle manipulation; (4) speed, consistent with care and thoroughness.

The operation was begun by excising the wound; subsequently the incision was planned to obtain the best exposure of the affected area, as indicated by the position of the wound and the direction of the track. Hence in some cases it commenced at the excised wound, whilst in others it was entirely a separate opening. When separate a mid-line or transverse or oblique lateral incision was preferably employed, with a view to causing as little damage as possible to the belly wall. When the incision was completed wound gauzes were put on. The extent of the exploration was determined in great measure by the direction of the track, especially with regard to the solid viscera and to the more or less fixed hollow viscera.

When the small gut area was involved, the first loop that presented was taken, and, commencing at this point, examination of the entire length of it was carried out by passing up and down. The exploration was completed as quickly and gently as possible, any exposed viscera being covered with swabs out of hot saline, bleeding was controlled at once, clamps were fixed over the holes in the hollow viscera to stop leakage and serve as guides, and other injuries were noted. Treatment was as conservative as possible, no resection being done unless the affected viscus appeared damaged beyond repair, or the risk of haemorrhage seemed too great, that is, in the solid viscera.

In the case of the hollow viscera silk was used as suture material, and a transverse line of sutures was preferred to a purse-string in holes in the gut. While a single layer only was commonly used for the small gut, in the stomach and colon an additional layer of Lembert sutures was introduced, frequently reinforced by tags of omentum or appendices epiploicae. After resection of gut end-to-end anastomosis was employed, the suture line being strengthened by a few Lembert sutures. Paul's tubes were only used if the patient was so ill that it would have been fatal to prolong the operation; both patients in whom they were employed died within a few hours of operation. Intraperitoneal bladder wounds were closed with or without drainage of the extraperitoneal track, and no suprapubic cystostomy was done. In injuries of the solid viscera, it was routine to bipp all tracks in them, with the object of controlling sepsis, and, if bleeding resulted, it was controlled by deep catgut sutures. Catgut was always used for suturing, but silk was employed for ligaturing spleen and kidney pedicles.

The cleaning of the peritoneum varied with the class of case. When solid viscera alone were injured blood clot was removed and excessive fluid mopped up, and only in a very large extravasation was a saline irrigation used. In injuries of the hollow viscera, if the extravasation of contents were quite small and limited, all that was done was local cleansing and mopping out with flavine solution 1 in 1,000. If, on the other hand, the extravasation was widely diffused, as occurred chiefly in injury to the full stomach, the upper jejunum, the colon and bladder, the peritoneum was irrigated with flavine 1 in 10,000 or saline, at a temperature of 106° F., and a pelvic drain left in for forty-eight hours, either projecting from the lower end of the incision or from a separate superpubic stab. There was no hesitation in leaving a smearing of bipp in any area which appeared rather soiled, and similarly all extraperitoneal tracks were bipped. If the foreign body was not encountered in the course of the general operation no prolonged search was made for it.

As a routine the incision was bipped and sutured in layers, the deeper layers with catgut, the skin with silk-

worm, including the superficial aponeurosis or muscle fibres. If the patient was very ill through-and-through sutures of thick silk only were employed.

When both the chest and abdomen were involved the essential feature of the operation was that the abdomen was dealt with through the diaphragm from above, and that the diaphragm itself was repaired from the thoracic aspect. The wound was excised and the injured rib removed for four or five inches. The incision was then carried on, if necessary, along the rib or intercostal space to the abdomen, reaching the edge of the rectus; in other words, it took the direction of the intercostal nerves. The wound in the diaphragm was enlarged if required, the excision extending in some cases right to its costal attachment. By this proceeding the splenic and liver regions were freely exposed by a minimum amount of retraction or none at all, and operations which by the abdominal route had often given rise to much difficulty became relatively easy as the injured viscera presented in the aperture. Indeed, in two cases the spleen was found prolapsed through the wound in the diaphragm, and in one of them a considerable portion of the fundus of the stomach was also present as well as the splenic flexure of the colon. The abdominal lesion having been dealt with, the aperture in the diaphragm was bipped and sutured with strong catgut and the abdomen closed. The chest condition was then investigated. Extravasated blood was removed, any lung track bipped and sutured, and the pleural cavity irrigated with 1 in 10,000 flavine and mopped dry. Finally the parietal incision was bipped and sutured up completely in layers, no drainage of the chest being employed. The anaesthetic for these cases was chloroform and oxygen given by the Shipway method. No detrimental effects were noticed as a result of this method of procedure.

Before leaving the theatre, if the patients were much shocked, an intravenous infusion of 1 to 1½ pints of saline was given. The injection which proved most satisfactory was composed of 3 per cent. gum acacia, 1 per cent. glucose, and 0.9 per cent. sodium chloride. With the injection, a hypodermic of camphor gr. ij in ether ʒ ss was usually given.

POST-OPERATIVE TREATMENT.

On coming round from the anaesthetic the patients were propped up either with pillows or on a Fowler's bed, and everything possible was done to stimulate them. If the stomach was injured, a pint of saline with 1 oz. of brandy was given every four hours by the rectum and liquids by the mouth after twenty-four hours, sips at first, gradually increasing the amount. In injury to the small gut, especially if low down, small quantities of liquid were given by the mouth from the beginning and rectal saline with brandy as above described. In injuries of the colon as much fluid and stimulant as possible was given by the mouth. When an extraperitoneal injury of the bladder and rectum was present in addition to intra-abdominal lesions, the bowels were confined, if possible, for seven days with pil. opii gr. j, given two or three times daily as required.

When the chest was involved, respiratory difficulty was combated by position and the administration of oxygen, and hypodermic injections of camphor gr. j in ether m xv were freely given, in some cases every half-hour for a few hours. Morphine was given at first if much pain was complained of, but subsequently omopon was preferred as a soporific.

In all cases the patients were kept at the advanced operating centre until they were quite fit, the average being about a fortnight, and when they were evacuated they were usually on full diet.

Of the 50 cases, 33, or 66 per cent., recovered, and 17, or 34 per cent., died.

The average time of all cases before operation was 8½ hours. Excluding Case No. 11, which was 42 hours, the average was 7.6 hours. Case No. 11 was operated on because of abscess and cellulitis in the right groin and iliac fossa; there was a fracture of the ilium, extraperitoneal and intraperitoneal holes in the caecum, and several large holes in the small gut, with widely diffused extravasation and advanced peritonitis. The average time among the recoveries was 7.3 hours, and that among the deaths, omitting Case No. 11, was 8.3 hours.

TABLE I.—Thirty-three Recoveries.

No. of Case.	Time in Hours.	Small Gut.	Large Gut.	Liver.	Spleen.	Kidney.	Omentum and Mesentery.	Chest.	Other Complications.
1	12	1	—	—	—	—	—	—	—
3	4	—	1	—	1	—	1	—	Fractured transverse processes of vertebrae. Flesh wound of thigh.
4	4	—	1	—	—	—	1	—	—
6	9	1	1	—	—	—	1	—	—
7	—	1	—	—	—	—	—	—	—
9	14	1	—	—	—	—	1	—	—
12	8½	—	—	—	1	—	1	1	—
14	12	—	—	1	—	—	—	—	Fractured sternum.
16	6	1	H.	—	—	—	—	—	—
17	6	H.	—	—	—	—	1	—	—
18	8	—	—	—	—	—	1	—	—
19	17	—	—	—	—	—	D.	1	Perforation into splenic pouch.
20	5½	1	—	—	—	—	1	—	Gut divided; anastomosis; no resection. Fractured ribs.
22	7	—	—	—	—	—	—	—	Through-and-through loin-intraperitoneal.
24	4	—	—	1	—	—	—	1	—
25	3	—	—	—	—	1	—	—	Fractured spinous and transverse processes of vertebrae.
27	5½	—	—	1	—	—	—	1	Piece of liver lying free in chest, 2½ in. × 1½ in. × 1 in.
29	3½	—	—	—	1	—	1	1	—
30	4	1	1	—	—	—	1	—	—
31	7	—	—	—	1	—	—	1	—
32	—	—	—	—	1	—	—	1	—
33	4½	—	—	1	—	—	—	1	Compound fracture of tibia and fibula.
34	18	—	—	—	1	1	1	—	—
35	5	—	—	1	—	—	—	1	—
36	—	—	—	—	1	—	1	1	—
37	12	1	—	—	—	—	1	—	—
38	5½	1	—	—	—	—	1	—	—
41	6½	1	—	—	—	—	—	—	Fractured ilium.
43	2½	—	—	1	—	—	—	1	Fractured radius, etc. (multiple).
44	8	—	—	—	1	—	—	1	—
48	7	1	—	—	—	—	1	—	—
49	5	R.	—	—	—	—	R.	—	—
50	5	—	—	1	—	1	—	—	Fractured rib and transverse process of vertebra.

H., Haematoma. R., Hernia. D., Hernia through diaphragm.

All the cases were shell wounds except No. 20 (gun recoil) and No. 30 (bomb). The stomach was wounded in one case only, No. 36 (part of wall); the pancreas also was wounded in one case only, No. 31. The spleen was excised in Cases 31 and 32, and the kidney in Cases 25 and 50. The bladder was involved in Cases 7 and 30. Resection was performed in Cases 7 and 41.

In the 50 operations—

The stomach was injured in	...	...	5 cases
The small gut in...	...	...	22 "
The large gut in...	...	...	14 "
The liver in	...	...	12 "
The spleen in	...	...	10 "
The kidney in	...	...	6 "
The pancreas in	...	...	1 case
The omentum and mesentery in...	...	...	21 cases
The bladder in	...	...	4 "
The chest was perforated in	...	...	16 "
Associated fractures, apart from the fractured ribs in thoracico-abdominal wounds, in	...	...	18 "
Resection was performed in	...	...	6 "
Anastomosis was performed without resection, one of the jejunum and one of both small and large gut, in...	...	...	2 "

TABLE II.—Seventeen Deaths.

No. of Case.	Time in Hours.	Stomach.	Small Gut.	Large Gut.	Liver.	Spleen.	Omentum and Mesentery.	Chest.	Other Complications.
2	9	—	—	1	—	—	—	—	Multiple wounds; toes and fingers amputated.
5	8	—	1	1	—	—	—	—	—
8	12	—	1	1	—	—	—	—	Both small gut and colon divided; double anastomosis; fractured ilio-sacral region.
10	17	—	1	f	—	—	1	—	Multiple; knee-joint with fracture and fractured ulna. Fractured ilium.
11	42	—	1	1	—	—	1	—	—
13	—	—	1	—	—	—	—	—	(Two large protrusions of gut.)
15	9	—	1	1	—	—	—	—	—
21	5	—	1	1	—	—	1	—	(Very large protrusion of gut.)
23	2½	1	—	—	1	—	1	—	—
26	2½	—	—	1	1	—	—	—	Fractured ilium.
28	7	—	1	1	—	—	—	—	—
39	10	—	—	—	1	—	—	—	Fractured transverse process of vertebra.
40	11½	1	—	—	—	1	1	1	Compound fracture of skull; penetrating.
42	6	—	1	—	—	—	1	—	Multiple; fractured clavicle, etc.
45	9	—	—	—	—	1	—	1	Multiple wounds; both knees, head, arm, etc.
46	—	—	1	1	—	—	1	—	Fractured body of vertebra.
47	8	1	—	—	1	1	—	1	—

All the wounds were caused by shells with the exception of Cases 23 and 26 (bomb wounds).

The kidney was involved in two cases (Nos. 15 and 39); the bladder also was injured in two cases only (Nos. 5 and 26). Resection was performed in four cases (Nos. 5, 28, 42, and 46). Case 45 had two wounds of lung and one of heart. The spleen was excised in Case 47.

In the 17 deaths there were—

2 cases in which the intra-abdominal injury was limited to solid viscera:

Case 39.—Injury to liver and kidney and fractured transverse process of vertebra. *Post mortem* there was no sepsis, and the liver presented the typical appearances of delayed chloroform poisoning.

Case 45.—In this case there were, in addition to a ruptured spleen, two perforating wounds of the lung, a wound of the left ventricle of the heart, and multiple peripheral wounds, including both knee-joints.

3 cases in which the stomach was perforated (Cases 23, 40, and 47).

2 cases in which the small gut alone was injured (Cases 13 and 42).

2 cases in which the large gut alone was injured (Cases 2 and 26).

8 cases in which both large and small gut were injured (Cases 5, 8, 10, 11, 15, 21, 28, and 46).

8 cases had fractures associated with the intra-abdominal lesions apart from the fractured ribs of the patients with thoracico-abdominal wounds. These included three fractures of the pelvis and one penetrating head wound.

Almost all the deaths occurred within twenty-four hours of the operation. There were—

3 splenectomies with one death (Case 47).

2 nephrectomies with no death.

6 resections with four deaths (Cases, 5, 28, 42, and 46).

2 anastomoses without resection; one of the jejunum (Case 20) recovered, and the second, a double anastomosis of small and large gut (Case 8), died.

16 cases with associated perforation of the chest, with three deaths (Cases 40, 45, and 47).

No untoward results were observed in those cases in which the foreign body was not removed at the operation. No case underwent a second operation, and no chest required reopening. In no case did the wound break down, although there were one or two stitch abscesses, which occurred in the region of the original wound. The sutures were not removed before the seventeenth day.