Penetrating Wounds of the Abdomen:
Analysis of 155 Cases With Problems in Management

RUSH E. NETTERVILLE, M.D., JAMES D. HARDY, M.D.

From the Department of Surgery, University Hospital, University of Mississippi Medical Center, Jackson, Mississippi

PENETRATING wounds of the abdomen are common in both military and civilian practice. Such injuries are frequently serious, but a reduction in the mortality rate in recent years reflects improved therapy. While Dixon, Martin and Ochsner [3] reported a rate of 16 per cent in 1945 and Sperling and Bosher [15] a rate of 14 per cent in 1947, Moss, Schmidt and Creech [7] reported a mortality of only 1.1 per cent in 1962 and Rothschild and Treiman [9] a rate of 1.6 per cent in 1966. This improvement has doubtless been due in part to the more liberal use of blood transfusions and antibiotics and perhaps to a greater number of trained surgeons experienced in the management of such cases.

It has been suggested that a substantial number of patients with penetrating wounds of the abdomen do not have visceral injuries [6, 7, 9, 11, 17] and for this reason a number of surgical centers now recommend non-operative management of such wounds under certain conditions.[6, 9, 11] It is our purpose to review records of 155 patients who sustained penetrating wounds of the abdomen and were admitted to the University Hospital between July 1, 1955 and January 1, 1966, and to evaluate the plan of management. Of these, 139 were Negro and 16 were white. During this same period Negro patients constituted 50.5 per cent of admissions to the University Hospital. There were 126 men and 29 women. The ages ranged from 2 to 73 years (Table 1), but 78 per cent were between 18 and 40 years of age. More than half the wounds were caused by bullets, 59 by knives (Table 2).

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Preoperative Management of Cases

On admission to the emergency room all patients were examined for evidence of abdominal injury, cardiorespiratory dysfunction due to pneumothorax, hemothorax or cardiac tamponade, injuries of other areas, and for hypotension. Thirty-five patients arrived in shock. A large bore needle or a polyethylene catheter was placed in a vein and secured, and if injury to the inferior vena cava were suspected, arm veins were used. Blood was cross-matched, and colloid solutions and vasopressors were infused until the blood was available. In instances of profound shock with active

TABLE 1. *Age Incidence*

Age	Number of Cases
Under 18 years	18
18 to 30 years	81
31 to 40 years	40
41 to 50 years	12
Over 50 years	4

TABLE 2. *Agent of Injury*

Agent	Number of Cases
Bullet	83
Knife	59
Shotgun	9
Broken glass	2
Broken chain link	1
Ice pick	1

bleeding, type O negative blood was used until matched blood was available, and when indicated the central venous pressure was monitored to prevent excessive transfusion. All wounds were protected with a sterile dressing, and intercostal chest tubes with water seal drainage were inserted when hemothorax or pneumothorax was present. Sucking wounds of the chest were closed with vaseline gauze pressure dressings until the patient had been adequately prepared for operation.

A nasogastric tube was passed to decompress the stomach and to examine the aspirate for blood. An indwelling urethral catheter was passed into the bladder to obtain urine for examination and to monitor urinary output as an indication of adequate blood volume replacement. If rectal injury was suspected, a proctoscopic examination was made. If the patient's condition permitted, roentgenograms were made of the chest and abdomen in the upright position and of the abdomen in the supine position. If a retained foreign body was noted, a lateral view of the abdomen was also made. When injury to the urinary tract was suspected, radiopaque contrast media was injected intravenously before the abdominal film was made to permit visualization of the urinary tract. Cystograms were performed when indicated. Antibiotic therapy was initiated and tetanus immunization was given.

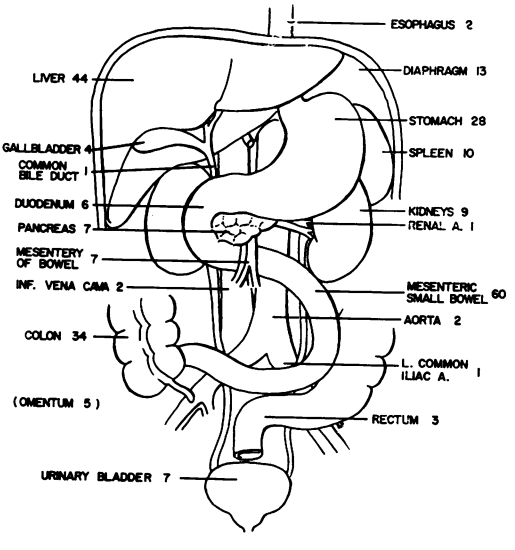

FIG. 1. Organs invaded in 155 cases of penetrating wounds of the abdomen.

In cases in which the arterial hypotension failed to respond to rapid blood replacement, immediate laparotomy was performed to control bleeding. When penetration of the abdominal wall appeared doubtful, a limited exploration was performed through a small adjacent incision. If the peritoneum had been penetrated at injury, the incision was enlarged and exploration carried out; if not, the short incision was closed and such cases were excluded from the present series. While some patients might have been treated successfully by expectant management as suggested by Mason,[6] Rothschild [9] and Shaptan,[12] one or more organs had been injured in 48 of 59 injuries due to knife wounds. All were explored except one who had been shot with birdshot at a considerable distance.[3, 4, 13]

Operative Management

Operation was performed as soon as cardiopulmonary function had been stabilized. However, if rapid blood replacement did not restore a normal blood pressure, indicating massive and continuing hemorrhage, laparotomy was instituted as one of the resuscitation maneuvers. Laparotomy was performed in 148 cases, thoracotomy in three and a thoracoabdominal incision in three. One patient was not explored, as noted above.

The organs injured and the frequency of involvement are indicated in Figure 1. The mesenteric small bowel was most often lacerated (60 cases or 38.7%), with the liver second (44 cases or 28.3%). The colon and stomach were frequently damaged, and major vessels were involved in six instances.

Lacerations and perforations of the mesenteric small bowel were usually closed by a two-layer technic after debridement.

In a few cases multiple perforations involved small segments which were resected with end-to-end anastomoses. Active bleeding in the mesentery was controlled, but small hematomas were left undisturbed unless enlarging or compromising the mesenteric blood supply. Segments of bowel deprived of adequate blood supply were resected. The stomach and duodenum were examined carefully, as perforations of the posterior surface of either organ are easily missed.

Lacerations of the liver were usually sutured and drained. Shaftan *et al.*[12] noted that inadequate drainage was responsible for the majority of intraabdominal complications in their series. Control of hemorrhage from the liver can usually be accomplished with buttressed mattress sutures, and gelfoam or oxidized cellulose packs are seldom indicated.[1, 14] Devitalized tissue, such as is commonly seen in fragmentation injuries, should be removed.[1, 2, 14]

All gallbladder injuries were treated by cholecystectomy, but small lacerations of the gallbladder may also be closed safely with drainage of the area.

The technics of management of the 34 cases of colon injury are listed in Table 3. Fifteen were treated by primary repair without proximal colostomy. Primary repair without defunctionalizing colostomy was commonly used in cases of minimal damage to the colon, with good blood supply to the adjacent colon and without gross soiling of the peritoneal cavity[5, 10]—the so-called "tidy wound" of the colon. In general, patients treated by primary closure without colostomy had fewer complications and shorter terms of hospitalization. However, colostomy may have been performed in more seriously injured patients. Possibly more of these patients could have been treated without colostomy. There were three rectal injuries and all were treated by closure and proximal colostomy.

Only one patient had serious kidney damage. Here the right renal artery had been severed and the left renal vein was lacerated. The right kidney was removed and the left renal vein was sutured. Actually, it was not clear from the record whether the right kidney could have been salvaged by reconstructive arterial surgery. Injuries to the urinary bladder were closed and drainage was provided. In patients with severe lacerations a suprapubic cystotomy was performed, but for small lacerations an indwelling urethral catheter was used.

TABLE 3. *Method of Repair of Colon Injuries*

Method of Repair	Number of Cases
Primary closure	15
Primary closure with proximal colostomy	14
Exteriorization	3
Resection with end to end anastomosis	1
Expired on operating table	1

Since a large retroperitoneal hematoma may mean injury to a major vessel and since profuse bleeding may occur when the hematoma is disturbed, adequate blood for transfusion should be available. In a series of 12 cases of penetrating injuries to the inferior vena cava, Starzl *et al.*[16] reported an average blood loss of 5,200 ml. during operation. In our two cases of injury to the inferior vena cava the blood loss was 2,500 ml. in one and 5,500 ml. in the other. Bleeding from a wound of the inferior vena cava may be controlled immediately by direct pressure, and thereafter a non-crushing clamp or clamps may be placed to exclude the defect while it is being sutured.[8, 16]

Special Problems

Case 1. Multiple Injuries. This 33-year-old man was brought to University Hospital after receiving an 18-inch laceration across the upper abdomen and left thorax. Blood pressure was unobtainable. Part of the liver, stomach, colon and small intestine had eviscerated through the wound and there was a sucking wound of the chest. The chest wound was sealed with vaseline gauze and dextran was administered intravenously.

Blood pressure soon stabilized at 140/80 mm. Hg and at operation the lacerations of the stomach, liver and diaphragm were repaired. The wound was closed, the left pleural cavity was drained, and recovery was uneventful.

Case 2. Successful Ventricular Repair and Cardiac Resuscitation in Emergency Room. This 22-year-old woman entered the emergency room of University Hospital about 30 minutes after receiving three stab wounds. Blood pressure was 120/60 mm. Hg. There were three small stab wounds, one just below the left nipple, a second in the left midclavicular line in the 5th intercostal space, and the third along the lateral border of the right rectus muscle approximately 4.5 cm. below the costal margin. She vomited during examination and the stomach contents smelled strongly of alcohol but there was no blood. Cardiac and breath sounds were normal but a chest x-ray was ordered. While she was being returned by stretcher from the adjacent radiology department, cardiac arrest occurred. An endotracheal tube was quickly passed and left thoracotomy was performed immediately. When the pericardium was opened, liquid blood and clots escaped. The heart responded immediately to massage, and two small lacerations of the left ventricle were closed with 2-0 silk. Following resuscitation the patient was moved to the operating suite where the chest was closed. Exploratory laparotomy was then performed and a laceration of the liver was sutured. She had a smooth postoperative course and was discharged on the 12th postoperative day.

TABLE 4. *Complications*

Complications	Number
Atelectasis	11
Wound infection	7
Abscess, including pelvic and subphrenic	6
Pleural effusion	7
Ileus	7
Wound dehiscence	6
Pneumonia	6
Urinary tract infection	5
Intestinal obstruction due to adhesions	5
Pneumothorax	2
Empyema	2
Hemothorax	1
Osteomyelitis of rib	1
Fecal fistula	1
Phlebitis of axillary vein	1
Peritonitis	1
Pericardial effusion	1
Total	71
Deaths	2

Case 3. Laceration of Inferior Vena Cava. An 18-year-old woman was brought to the University Hospital about 1½ hours after sustaining a bullet wound in the right upper quadrant of the abdomen. On arrival the blood pressure was 130/80 mm. Hg and the pulse rate 84/min. She was given lactated Ringer's solution intravenously and operated upon. The bullet had passed through the inferior aspect of the right lobe of the liver and perforated the gallbladder and the duodenum. The gallbladder was removed, and the duodenum was repaired. However, when the large retroperitoneal hematoma was explored, a gush of blood emerged, and a 1-cm. laceration in the inferior vena cava was discovered. The defect was controlled by direct pressure and then closed with a continuous silk suture. She received 2,500 ml. of blood during operation, and was discharged in good condition on the 10th postoperative day.

Complications

One hundred and three patients had no postoperative complications. The remaining 50 surviving patients developed 71 complications (Table 4). Pulmonary problems (atelectasis 11, pneumonia 6, pleural effusion 7, pneumothorax 2 and hemothorax 1) accounted for 27 of the 71 complications. Wound complications and infection in the peritoneal cavity accounted for 20 more. Osteomyelitis of the rib followed a thoracoabdominal incision in one patient who had a severe laceration of the liver and transverse colon, and bleeding from a phrenic artery. Five patients had urinary tract infections. Of the 33 patients treated for colonic injuries who survived operation, 15 were treated by primary colonic closure alone and 14 by primary closure with proximal colostomy. The injured segment was exteriorized in three patients and resected with end-to-end anastomosis in one. The only fecal fistula occurred in a patient who had had primary colonic closure with proximal colostomy, but he was discharged 15 days after admission.

The average period of hospitalization for 153 surviving patients was 10.5 days. The average period of hospitalization of the patients with colonic injuries treated

by primary closure without proximal colostomy was 9.5 days, and 19 days for those treated by primary closure with proximal colostomy. Most of these patients had to be readmitted at a later date for closure of the colostomy. There were no biliary, duodenal or gastric fistulas.

Deaths

There were two deaths, a mortality rate of 1.3 per cent.

Case 4. Death from Multiple Injuries. J. S., a 31-year-old man, was admitted to the emergency room of the University Hospital about 15 minutes after he bad been shot three times with a 22 caliber pistol. There were wounds of entrance in the 10th intercostal space in the midclavicular line on each side and in the left subcostal region in the midclavicular line. Dextran was given on admission and blood transfusion was started soon thereafter, but mean arterial pressure never rose above 90 mm. Hg. His abdomen was rapidly prepared and opened through a midline incision. Lacerations of the liver, spleen, transverse colon, tail of the pancreas, and a hole in the aorta just above the left renal artery were found. There was severe bleeding from injured mesenteric vessels in the transverse colon and approximately 3,000 ml. of blood had accumulated in the peritoneal cavity. Bleeding from the mesenteric vessels was controlled, the spleen was mobilized, and a Satinsky clamp was placed on the aorta. The spleen was then removed, and the hole in the aorta was repaired; however, bleeding continued from severe stellate lacerations of the liver. Although the patient received eight liters of blood before and during operation, cardiac arrest occurred and cardiac massage was unsuccessful.

Case 5. Late Death Due to Delayed Admission to Hospital. K. C. O., a 26-year-old man, received shotgun wounds about 25 hours before he was transferred to the University Hospital. On admission he was comatose and there was a wound in the suprapubic region. The pulse and blood pressure were initially unobtainable, but intravenous saline, dextran and blood brought the blood pressure to 126/60. At operation he had a large hematoma in the right rectus sheath, about 500 ml. of blood in the peritoneal cavity and multiple perforations of the small bowel. A segment of ileum was resected. Following operation he had renal shut-down and despite peritoneal dialysis, he died on the 13th postoperative day. Such close range shotgun injuries have been reported to be associated with a higher mortality rate than are bullet wounds.[13]

Comment

Nonoperative management of the following wounds is permissible unless there is evidence of deterioration of the patient's condition: 1) ice pick wounds; 2) small wounds due to bird shot from a distance or similar wounds; 3) small wounds that appear to involve only the abdominal wall. Operation is mandatory with the following: 1) all penetrating bullet wounds; 2) wounds with evisceration; 3) evidence of rapid and continuing blood loss; 4) deterioration of the patient's condition as reflected by tachycardia, hypotension, and/or signs of peritoneal irritation (tenderness, rebound tenderness, rigidity and absence of bowel sounds); 5) presence of blood in the urine, gastric contents or rectum.

Steps in Management of Penetrating Wounds of the Abdomen. The plan of management currently employed in our hospital is as follows:

1. Immediate evaluation of the patient: Cardiorespiratory status, wounds of entrance and exit.
2. Insert polyethylene catheter or large bore needle in vein, start available fluids, give blood when indicated and monitor central venous pressure when indicated.
3. Correct cardiorespiratory dysfunction due to cardiac tamponade, hemothorax, pneumothorax or sucking wound.
4. Pass nasogastric tube to decompress stomach and examine contents for presence of blood; pass indwelling urethral catheter to examine urine for blood and to monitor urine output.
5. Cover all wounds with sterile dressings and use tight vaseline gauze dressings on sucking wounds of the chest.
6. Move immediately to the operating suite all patients who have evidence of massive blood loss.

7. Roentgenograms when the patient's condition permits: Upright views of the chest and abdomen, supine view of the abdomen and, when a foreign body is retained, a lateral view of the abdomen. Intravenous urogram and/or cystogram if urinary tract injury is suspected.

8. Administer antibiotics and tetanus immunization.

9. Proctoscopic examination if blood is found in the rectum or if injury to the rectum is suspected.

10. Blood count and urinalysis.

11. Operative intervention in most cases.

Summary

During the last 10½ years 155 patients with penetrating wounds of the abdomen have been treated at the University of Mississippi Hospital. Thirty-five arrived in shock. After resuscitation, laparotomy was performed in 138 instances, thoracotomy in three, and a thoracoabdominal incision in three. One patient who was not explored had sustained a birdshot injury from a distance. One or more organs had been injured in 138 patients. The most common injuries were to the mesenteric small bowel (60), liver (44), colon (34), stomach (28), diaphragm (13), spleen (10), kidney (9), pancreas (7), duodenum (6), and major vessels (6). One hundred and three patients were free of complications following operation, but 50 developed 71 complications. The average period of hospitalization was 10.5 days. There were two deaths, one a patient with multiple vascular injuries who exsanguinated on the operating table and the other a patient admitted after prolonged shock who died 13 days later. Exploratory laparatomy should be performed in most patients with penetrating wounds of the abdomen. However, the increasing tendency in several medical centers to individualize these cases and to treat certain patients without operation should be followed with interest.

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