Part X: Trauma

Chapter 71: Abdominal and Pelvic Injuries

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Abdominal and pelvic injuries are major contributors to morbidity and mortality after trauma. Blunt abdominal injuries account for less than 10% of total injuries, but contribute to about 25% of deaths. The incidence of penetrating abdominal injuries is higher, approaching 25%. Important considerations of abdominal and pelvic injuries are:

1. the severity of associated injuries (ie, to chest and head);

2. potential for severe haemorrhage;

3. difficulties in diagnosing organ damage; and

4. increased risk of post-traumatic sepsis and multi-organ failure.

Mechanisms of Injury

1. Penetrating Wounds

Stab and gunshot wounds account for most penetrating injuries to the abdomen.

(a) *Stab wounds* are immediately life-threatening when vessels are injured. Major vascular injury occurs in about 5% of all abdominal injuries, and is almost entirely due to penetrating injuries. Stab wounds are often multiple. Penetration of the thoracic cavity should be suspected when the wound is situated in the upper abdomen. About 25% of penetrating abdominal wounds involve thoracic structures. Conversely, 15% of stab wounds and 46% of gunshot wounds to the anterior chest involve abdominal structures. In one series of penetrating injuries to the anterior chest, 38% required combined thoracotomy and laparotomy, and 17% required laparotomy alone.

(b) *Gunshot wound* injuries depend on the calibre of the missile, its velocity and trajectory. Modern assault rifles and automatic weapons impart a tumbling action to the fired bullet, which causes extensive injury in its course through the body. On the other hand, small calibre, low velocity bullets from small hand guns result in minimal soft tissue injury, and may not exit the body of the victim.

2. Blunt Trauma

Motor vehicle accidents (MVAs) account for most blunt injuries to the abdomen and pelvis. Injuries may also occur as a result of falls and in industrial accidents. Associated injuries are common, with 50% sustaining one other injury, and 38% two or more injuries. Abdominal injuries accompany blunt chest injuries in 37% of cases. Neurological (brain and spinal cord), skeletal, and faciomaxillary injuries may also be commonly involved

Restraining devices (ie, seatbelts and child seats) in motor vehicles have reduced mortality and severity of head and faciomaxillary injuries in MVAs, but have resulted in a changing pattern of abdominal trauma. Poor seatbelt design and incorrect use are partly responsible. Seatbelt injuries are more severe in lateral impact collisions. Rotation and lateral movement of the belted victim focus impact and deceleration forces over narrow areas defined by the belt. Thus, trauma to the lower thoracic cage, liver, spleen and mesentery is common. Injuries to hollow viscera and retroperitoneal structures have increased markedly with the use of seatbelts. Loosely fitted lap belts may contribute to a higher incidence of pelvic and bladder injuries.

Initial Management

1. Resuscitation

Immediate resuscitation, early triage, diagnosis of severe injuries, and recovery of trauma victims to an area of definitive care are essential priorities. Active fluid resuscitation is essential during retrieval of severely injured patients with evidence of blood loss. On arrival at a trauma centre, resuscitation *should not* delay definitive surgery to control haemorrhage or manage other life-threatening complications.

Use of the pneumatic anti-shock garment (PASG, previously called MAST suit), is controversial, as it has not been shown to improve trauma mortality. Overall systemic arterial pressure is improved, but it may increase haemorrhage in thoracic cavity injuries, and worsen the respiratory status. Moreover, with prolonged use, risk of renal dysfunction may be increased. Nevertheless, the PASG deivce is useful to control haemorrhage in the pelvis and lower limbs, until more definitive therapy is available.

2. Clinical Diagnosis

A full and careful clinical examination by an experienced physician is most important. Eyewitness accounts of the accident may help to focus attention on particular anatomical areas. Areas of contusion and haemorrhage should be noted, and the relationship of superficial injury to underlying viscera observed. All body areas must be examined when penetrating injury is suspected, especially the back.

Penetrating injuries present few diagnostic problems, and the management dilemma relates to whether or not to explore the abdomen. Blunt abdominal trauma is more difficult to diagnose clinically, except when abdominal signs are obvious. When haemorrhage is suspected (eg, increasing abdominal distension) immediate surgery is warranted. However, usual features of intra-abdominal pathology, such as abdominal pain, tenderness, and guarding, may be absent or difficult to assess in multiple trauma. Patients with accompanying chest, head and skeletal injuries, may have more obvious symptoms and signs which mask an intra-abdominal condition. Life support therapy instituted for life-threatening injuries add to diagnostic difficulties. In these less obvious situations, diagnosis of (blunt) intra-abdominal injuries can be aided by screening procedures.

3. Diagnostic Procedures

(a) *Peritoneal lavage* is superior to abdominal paracentes and 4 quadrant taps. It has an accuracy over 95% in detecting intra-abdominal blood, with a low false-positive rate. However, if used in every case as the sole diagnostic criterion, it can lead to a "false laparotomy" rate of up to 14%, because of detection of bleeding from pelvic fracgtures and minor retroperitoneal injuries. Using the red blood cell count of lavage fluid increases diagnostic accuracy (Table 1), as gross inspection of the effluent alone may not be adequate. The general indications for peritoneal lavage are shown in Table 2.

Table 1. *Red Blood Cell Count for Positive Peritoneal Lavage in Abdominal Trauma*

Penetrating Injury	Red Blood Cells/mm^3	
Blunt Trauma	> 100.000	= positive findings
	50-100.000	= equivocal
Penetrating Injury		
Stab wound		
abdomen	> 100.000	= positive finding
	50-100.000	= equivocal
lower chest	> 5.000	= positive finding
Gunshot wound	> 5.000	= positive finding.

Table 2. *Indications for Peritoneal Lavage in Abdominal Trauma*

Blunt Abdominal Trauma
- Suspected trauma in unreliable examination, eg, coma
- Unexplained hypotension
- Multiple truma requiring general anaesthesia

Penetrating Injury
- Stab wounds known or suspected to infiltrate peritoneum
  - abdominal wounds
  - lower chest wounds
- Gunshot wounds suspected to infiltrate peritoneum.

(b) *Computerized tomography (CT)* is less sensitive than peritoneal lavage in detecting intraperitoneal blood. However, it is particularly useful when retroperitoneal injury and pelvic fractures are suspected, and may disclose the sourcwe of intra-abdominal bleeding or injury. Abdominal CT may also be useful to detect severe renal injury in patients with haematuria, and may be more sensitive than intravenous pyelography in this regard. Nevertheless, interpretation of CT scans in trauma patients requires considerable experience, and the scan is unsatisfactory in 20-30% for technical reasons. Moreover, the use of CT should be restricted to stable patients as it is time-consuming, uses considerable staff resources, and removed the patient from areas of definitive care.

(c) *Scintigraphy and ultrasonography* are also operator dependent and time-consuming, and are only useful in the stable patient.

(d) *Selective angiography* may be useful to detect the source of haemorrhage from pelvic fractures or retroperitoneal structures, and is obligatory when vascular injuries are suspected.

In most situations, peritoneal lavage can be used alone as the primary diagnostic modality. It can be performed easily in the emergency room without interrupting resuscitative measures. If the lavage findings are unhelpful or inconsistent with the clinical examination, CT scanning should follow. A CT scan may guide subsequent treatment (ie, surgery versus conservative management). However, CT detection of intraperitoneal blood may be spurious, if the examination follows peritoneal lavage and residual fluid is present.

Specific Injuries

Injury to the Spleen

The spleen is the organ most frequently injured by blunt abdominal trauma. The presentation of splenic injury varies according to the severity of injury, and diagnosis may be delayed in cases of mild trauma. When associated chest or neurological injuries are severe, minor splenic injury may not initially be detected. Fractures of the lower left ribs are found in about 40% of patients with splenic rupture. Minor trauma may cause splenic injury when the spleen is enlarged, eg, from malaria, lymphomas, and haemolytic anaemias. Peritoneal lavage is useful to detect splenic injury when diagnosis is unclear.

Splenic injury may be managed by:

1. splenectomy
2. laparotomy and preservation of splenic tissue, and
3. close observation.

The risks of overwhelming sepsis in infants and young adults who have undergone splenectomy (see Chapter 63, Severe Sepsis), have led to a more conservative approach. However, non-operative management has a high failure rate (approaching 70%). Hospital stay is prolonged, and subsequent operative splenic salvage is much more difficult. For these reasons, laparotomy and a splenic preservation procedure is the preferred management.

Operative procedures to conserve splenic tissue have included partial resection, use of local clotting substances (eg, gelfoam and ativine), mesh wrapping of the spleen, and splenic artery ligation. Splenectomy with autotransplantation of splenic tissue has also been advocated, but its efficacy in preventing overwhelming post-splenectomy infection (OPSI) is as yet unproven.

Splenectomy is reserved for patients with severe and uncontrolled haemorrhage, pulverized spleens, or severe multiple injuries, where delays due to repairing the spleen may compromise survival. In patients who have undergone splenectomy, polyvalent pneumococcal vaccine (Pneumovax) should be administered. The incidence of OPSI in an adult population is low (1 per 332 patient years of observation). Use of penicillin prophylaxis is primarily recommended for children and young adults, whose risk of OPSI is increased 50 times in later life.

Injury to the Liver

The liver is the second most commonly injured organ after blunt abdominal trauma, and the most common with penetrating abdominal injuries. Blunt injuries of the liver are usually diagnosed by peritoneal lavage, and other diagnostic tests (eg, CT scan) are of little additional value. Anatomical injuries include simple capsular tears and lacerations, multiple or stellate lacerations, avulsion or crush injuries, and hepatic venous injuries. In most cases (about 70%) liver injuries can be managed with little difficulty.

Surgical management may present problems when injury is severe and/or devitalized liver tissue is present, and bleeding is active. When bleeding is excessive, haemostasis can often be achieved by manual compression of the liver with gauze packs. Temporary packing of the liver is often sufficient control. The packs are removed in a repeat laparotomy 48-72 h later. If haemorrhage continues despite packing, occlusion of the porta hepatis (Pringle manoeuvre) may be tried. If this, in turn, is unsuccessful, exploration of the laceration to ligate injured vessels is required. Once bleeding is controlled, the liver edges can be approximated and the injury repaired. Avulsion and crush injuries require debridement to remove devitalized tissue. With liver surgery, adequate drainage is important to avoid accumulation of blood and liver secretions, and thus, secondary infection.

Occasionally, hepatic artery ligation may be necessary to control severe liver haemorrhage. The common right or left hepatic artery can be ligated, depending on the anatomical site of injury. The gall bladder must also be removed with right hepatic artery ligation, otherwise viscus necrosis will result. Hepatic artery ligation may not be helpful when bleeding is from the venous system. Hepatic venous injury with or without vena caval involvement, is a particularly troublesome problem. Early surgery is imperative. Surgery requires adequate exposure of the injured area, which may include a median sternotomy for access to the thoracic inferior vena cava. An intracaval shunt may be inserted to isolate the haemorrhage while repair is performed.

Postoperative care of patients with liver injuries involves continuing blood transfusion, correction of coagulation defects, and respiratory, cardiovascular, and nutritional support. Dilutional coagulopathy is common. Patients must be observed in the immediate postoperative period for hypoglycaemia, thrombocytopenia or hypoalbuminaemia. Early complications of liver injury relate to complications of hypoperfusion or massive blood transfusion. Late complications are usually associated with sepsis.

Injuries to Duodenum, Small Intestine, and Colon

Injuries to hollow viscera are commonly due to penetrating injuries rather than blunt trauma. The incidence of hollow viscus injury in abdominal gunshot wounds is approximately 95%. Viscus injury from abdominal stab wounds may be difficult to diagnose, unless peritonitis or unexplained hypovolaemia is present. A plain erect abdominal X-ray may show free air in the peritoneal cavity, but is not presumptive evidence of hollow viscus injury, as air may have entered through the abdominal wound. Diagnostic peritoneal lavage may reduce the incidence of unnecessary abdominal exploration of stab wounds. Instillation of contrast material into the wound tract has been used as a diagnostic aid, but with poor results.

Blunt abdominal injuries to mesentery, small intestine, and colon are increasing with the use of seatbelts, and are more difficult to evaluate. Colonic injuries usually present with obvious peritoneal signs. However, small bowel and duodenal perforations often have minimal signs on physical examination. Duodenal injuries have a high mortality, primarily due to delay in diagnosis. It is not unusual for the initial clinical examination to be normal, and established peritonitis presents several hours later. Diagnostic peritoneal lavage may be useful to provide an indication for laparotomy. CT is a very sensitive indicator of free intraperitoneal air, and when combined with an upper gastrointestinal contrast study (via a nasogastric tube), may be useful to identify retroperitoneal duodenal injuries or haematomas.

Preoperative antibiotics to cover enteric aerobic and anaerobic organisms should be administered to patients with bowel injury and continued for 48 hours postoperatively. Simple closure of lacerations, or primary repair and anastomosis, combined with bowel decompression are procedures for duodenal, small bowel and colon injuries. However, in extensive injury or intraperitoneal soiling, a faecal diversion procedure with delayed repair is indicated. Adequate abdominal drainage *must* be instituted. Intraperitoneal lavage with antibiotics may be useful to reduce abdominal sepsis. If surgery has been delayed, and established peritonitis, abscess formation or necrosis has occurred, mortality is high. "Open management" of intra-abdominal sepsis is currently being proposed and evaluated. The abdomen is not surgically closed, and repeated lavage and drainage is performed under direct vision - (an abdominal mesh zipper facilitates this). (See Chapter 63, Severe Sepsis.)

Diaphragm and Abdominal Wall Injuries

Diaphragmatic injury (see Chapter 69, Chest Injuries) occurs in less than 5% of cases of blunt injury and is commonly associated with injuries to abdominal organs. Diaphragm and abdominal wall injuries are more common with penetrating injuries. Herniation of abdominal viscera into the pleural cavity may result in respiratory difficulties and evisceration may occur with abdominal wounds. Injuries should be repaired to avoid postoperative herniation of abdominal contents. In many cases of blunt rupture of the diaphragm, repair is more readily performed via a thoracotomy incision. Blast injuries to the abdominal wall require debridement and a synthetic mesh implant may be required to close the defect.

Retroperitoneal Haematomas

Retroperitoneal haematomas can be classified into:

1. Pelvic haematomas, which are usually associated with pelvic and/or bladder injuries.

2. Flank haematomas, located lateral to the psoas muscles and rectus sheath, above the iliac crests, and which are usually associated with parenchymal renal injury, and occasionally, injuries of the vessels of the colon or lateral or posterior abdominal wall.

3. Central haematomas, primarily located in the central retroperitoneal area above the pelvic brim, which have 2 subgroups:

(a) The retroperitoneal haematom arises from injuries to major arteries or vein.

(b) The haematoma is associated with injuries to the pancreas, duodenum and local structures.

Retroperitoneal injury may also be of a combined type involving several of the above mentioned structures. There is a high incidence of associated injuries, including liver (22%), spleen (12%), and hollow viscera (20%). Pancreatic injuries mostly involve the capsule and a limited amount of pancreatic parenchyma, and need only drainage and possible debridement. When the pancreatic duct is involved, distal pancreatectomy is required to avoid fistula formation. Pancreaticoduodenectomy is only rarely required.

Management of retroperitoneal haematomas depends on the severity of injury and evidence of persistent bleeding. A patient with haemodynamic stability is managed by observation and simple measures, eg, fixation of pelvic fractures. When haemorrhage is persistent, diagnostic angiography and embolization may be the treatment of choice. If haemorrhage persists then laparotomy may be required. Management is similar, if retroperitoneal haematoma is an incidental finding at laparotomy, ie, if bleeding is not active, exploration of the haematoma is not indicated. Continuing bleeding associated with pelvic injuries cause more serious management problems.

Pelvic Injuries

Injuries to the pelvis can present difficult problems in trauma management. Immediate haemorrhage may be uncontrollable (see below). There is also potential long term disability due to damage of pelvic nerves controlling bladder, anorectal area and sexual function. Furthermore, the important structural role of the pelvis in transmitting weight from the body to the lower extremities may lead to permanent physical disability. Damage to the urethra also gives rise to significant long term disability.

Pelvic fractures can be classified into 3 types.

1. *Type I fractures* are comminuted (crush) injuries which involve 3 or more major components of the pelvis, and are often unstable.

2. *Type II fractures* are unstable injuries which are often associated with haemorrhage and fracture displacement. They can be classified into 4 subgroups:

(a) diametric fractures with cranial displacement of the hemipelvis (Malgaigne fracture),

(b) undisplaced diameteric fractures,

(c) open book (sprung pelvis), and

(d) acetabular fractures.

3. *Type III fractures* are stable injuries of 2 types:

(a) an isolated fracture, or

(b) a fracture of the pubic ramus.

Type III fractures are sgtable and may require no further treatment other than immobilization and symptomatic pain relief.

The majority of pelvic injuries (approximately 75%) become haemodynamically stable after initial resuscitation. Simple measures such as immobilization or internal/external fixation of fracture diastasis may be required to assist haemodynamic control, nursing, and early mobilization. Surgery is also indicated when genitourinary injury is suspected. Ruptured bladder or torn urethra occurs in approximately 30% of pelvic fractures. Suprapubic cystostomy and bladder repair or exploration of the lower genitourinary tract should be performed. About 5% of pelvic fractures are associated with a urethral injury, usually at the prostatomembranous junction. Patients with complete urethral disruption invariably develop stricture at the site of disruption. Elective repair can be attempted 2-3 months after injury. This approach reduces impotence to about 20%, which may be the lowest, unavoidable incidence. Secondary stricture formation occurs in 15-20%, and often can be managed by endoscopic urethrotomy and urethral dilatations.

Severe haemorrhage occurs in approximately 25% of pelvic fractures and requires immediate attention. Haemorrhage is primarily due to lacerations of veins in the posterior pelvis, and to small arterioles associated with fractures in cancellous bone. A PASG may be used initially during resuscitation. It is imperative to reduce fractures, and external fixation may help to control bleeding. If haemorrhage is severe, arteriography and embolization of identified bleeding vessels is warranted. Major bleeding from the common iliac, external iliac or hypogastric arteries can be treated by operative repair. In some cases ligation of the artery may be required. When the bleeding involves superior gluteal or pudendal arteries, embolization at the time of arteriography is more effective.

Compound fractures of the pelvis involving the rectum, intestines or vagina present particular problems in management. There is a high incidence of faecal contamination, even if the rectum is not injured. Diversion of the faecal stream is mandatory if severe pelvic sepsis is to be prevented. The mortality of patients treated with a faecal diversion procedure is halved at 25%. In addition, devitalized tissue should be excised and adequate drainage instituted.

Injury to the Kidney

Kidney injuries may result from blunt or penetrating injuries. Microscopic or gross haematuria is the first indication of kidney injury on initial assessment. Such patients should undergo peritoneal lavage, as there is a high incidence of associated injuries to other abdominal organs. Haematuria also requires investigation of the genitourinary tract. An excretory examination, intravenous pyelogram (IVP) is the primary diagnostic tool. CT scan is useful in defining anatomical renal injury. In severe kidney damage, IVP may not detect the extent of damage, and CT is strongly indicated.

Bed rest and observation successfully manages 95% isolated blunt injuries to the kidney. Once haematuria has cleared, ambulation is allowed. All renal injuries due to penetrating injuries should undergo surgical exploration, unless the injury is regarded as

minor. Excessive or persistent retroperitoneal bleeding, or the presence of pulsatile retroperitoneal haematomas, urinary extravasation, or vascular injury requires immediate surgery. Surgical repair of the injured kidney is successful in about 90% of cases. Total nephrectomy is seldom necessary, and should only be performed when the kidney is non-viable.

Complications

1. Coagulopathies

Abdominal and pelvic injuries are often associated with significant blood loss and blood transfusion replacement, with resultant dilutional coagulopathy. Disseminated intravascular coagulopathy (DIC) may also develop. (See Chapter 88, Haemostatic Failure.) Management is standard, including haemological/clotting studies and replacement of blood components.

2. Nutrition

Patients with abdominal and pelvic injuries often have delayed recovery of gastric and bowel function. Parenteral nutrition is instituted when acute fluid, blood, and blood component replacement is completed. A feeding jejunostomy feeding tube can be placed during laparotomy.

Patients with absent bowel activity should also receive some form of stress ulceration prophylaxis (eg, H_2 antagonists, Sulcralfate, oral antacids).

3. Infection

Abdominal and pelvic injuries may be more susceptible to infection for the following reasons:

(a) Contamination of peritoneal cavity from penetrating wounds.

(b) Depressed immune function mediated through neurohumoral mechanisms activated by trauma, pain and haemorrhage.

(c) Nosocomial infection from invasive procedures.

(d) Post-splenectomy sepsis (see above).

(e) Delayed diagnosis of hollow viscus injuries.

Intra-abdominal sepsis remains an important preventable cause of death after trauma. Early diagnosis and institution of effective lavage and drainage procedures may reduce the incidence of intra-abdominal sepsis. Prophylactic antibiotics for 48 hours are warranted in penetrating injuries. The development of unexplained fever and/or neutrophil leucocytosis, or multiple organ failure point to intra-abdominal sepsis. (See Chapter 63, Severe Sepsis.) Prompt and definitive treatment of associated injuries may lessen the risk of infection.

4. Acalculous Cholecystitis

Acute post-traumatic acalculous cholecystitis is a serious and life-threatening complication, and mortality may approach 66%. Acalculous cholecystitis usually occurs 3-4 weeks after injury, and is associated with severe shock on admission, multiple transfusions, use of high doses of narcotics, sepsis, respiratory failure requiring mechanical ventilation, acute renal failure, and parenteral nutrition. Patients present with fever, leucocytosis, right upper quadrant pain and tenderness, with or without a mass. Liver function tests indicate hyperbilirubinaemia in about 60%, and increased alkaline phosphatase is detected in 22%. Untreated, the condition may lead to necrosis or gangrene of the gall bladder, and perforation with generalized peritonitis follows. Early surgery may reduce mortality, and consists of cholecystectomy and/or cholecystotomy. About half the patients have positive bile cultures at operation, due to aerobic and anaerobic enteric organisms. Prophylactic antibiotics should be given for the immediate operative and postoperative periods. Right upper quadrant tenderness is difficult to assess in abdominal and pelvic injuries. Therefore, any case of unexplained fever, leucocytosis or sepsis should be investigated by ultrasonography or abdominal CT scan.

5. Jaundice

Jaundice is a not uncommon complication of abdominal and pelvic injuries. Its aetiology is usually multifactorial. Factors implicated include massive blood transfusion, resorption of soft tissue haematomas, cholestasis, and hepatocellular injury from hypoperfusion, hypoxaemia and/or septicaemia. Improved screening procedures have lessened the risk of viral hepatitis from blood transfusion, but high-risk groups (eg, intravenous drug users or homosexuals) should be observed for concomitant viral infections. Precautions should be taken with the handling of blood and body fluids from such patients.

6. Acute Respiratory Failure

Acute respiratory failure may occur as an immediate or delayed complication of abdominal or pelvic injury. In the acute phase, respiratory failure is usually due to massive blood and fluid replacement. Laparotomy and surgical procedures in the upper abdomen may contribute. Abdominal pain, tenderness and distension splint the abdomen to limit deep inspiratory efforts and inhibit effective coughing. Respiratory failure in the later phase is usually due to sepsis (intrabdominal or nosocomial pneumonia), and will persist unless infection can be controlled.

7. Acute Renal Failure

Acute renal failure shows a similar pattern of disease as acute respiratory failure. The early phase of injury may be complicated by severe hypovolaemia and prolonged hypotension, which may lead to acute tubular necrosis. Effective pre-hospital retrieval and resuscitation have contributed to a decline in the incidence of acute renal failure from these causes. When renal failure develops as a late complication, its cause is invariably intra-abdominal sepsis. Recovery cannot be expected unless the sepsis is adequately controlled.