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Blunt Abdominal Injury

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Abstract

Road traffic accidents are one of the leading causes of mortality. Blunt injury to the abdomen contributes to mortality second to head injury. The mechanism of injury in road traffic accidents is due to blunt force created by collision between the patient and the external forces and acceleration and deceleration forces acting on the person's internal forces. The common solid organs involved in blunt abdominal trauma are the spleen, liver, and kidney. Mesenteric tears and isolated small bowel injuries can also occur. A high degree of suspicion and watchfulness, regular examination, imaging, and investigations are needed to diagnose blunt abdominal injury. The eFAST exam is an emergency screening tool used to diagnose intra-abdominal injuries in emergency departments. Treatment for these injuries depends on hemodynamic status, whether stable or unstable. Hemodynamically unstable patients with a positive eFAST exam will be taken up for emergency exploration, while stable patients will undergo further imaging and investigation to plan management. This chapter discusses the grades of injuries in the spleen, liver, mesentery, and retroperitoneum. It also discusses the various diagnostic and treatment modalities available and when and where to use them. This chapter is useful for surgical postgraduates, aspiring surgeons, and trauma surgeons.

Keywords: blunt abdominal injury, AAST grading, splenic injury, liver injury, retroperitoneal hematoma

1. Introduction

Abdominal blunt injury is a common emergency in emergency departments that regularly results from road traffic accidents, assaults, or accidental falls. Since the occurrence of road traffic accidents is increasing, they are now the leading cause of global disease burdens. According to the 2013 Global Status Report on Road Safety, more than 1.3 lakh people died on Indian roads, giving India the dubious honour of topping the global risk of fatalities from road crashes. Head injury, fractures, and blunt abdominal injury are the common causes of death in road traffic accident injuries.

2. Mechanism of blunt abdominal injury

Intra-abdominal injuries secondary to blunt force are due to collisions between the injured person and external forces and the acceleration and deceleration forces acting on the person's internal organs.

2.1 Deceleration

Rapid deceleration causes differentiating movement among adjacent structures. As a result, shear forces are created and cause injury to hollow, solid visceral organs and vascular pedicles at relatively fixed points of attachment, for example, a hepatic tear along the ligamentum teres. As bowel loops travel from their mesenteric attachments, mesenteric tears with resultant splanchnic vessel injuries can result.

2.2 Crushing

Intra-abdominal contents can be crushed between the anterior abdominal and vertebral columns. Solid viscera such as the spleen, liver, and kidneys are more vulnerable to crush injuries.

2.3 External compression

External compressive forces such as direct blows or external compression against a fixed object result in a sudden and dramatic rise in intra-abdominal pressure, which can cause a rupture of the hollow viscus, in accordance with the principles of Boyle's law. The liver, spleen, small intestine, and large intestine are the most frequently injured organs in increasing order of frequency.

3. Clinical examination

Abdominal blunt injury is associated with other injuries, such as head injuries or fractures, thus the presenting symptom will vary. For blunt injury alone, the patient will present with abdominal distension, abdominal pain, or hemodynamic instability.

Once the patient enters the emergency room, a primary survey is performed. Primary survey consists of:

- Airway
- Breathing—oxygen saturation
- Circulation—pulse rate, volume, and blood pressure
- Glasgow coma scale

Abdominal examination follows the primary survey and includes:

- Inspection—pattern contusions, abrasion, abdominal distension
- Palpation—tenderness, guarding, rigidity, rib fracture, pelvic fracture
- Percussion—for free fluid and liver dullness obliteration
- Auscultation—bowel sounds

After primary examinations, clear the airway, resuscitate for breathing (if necessary), and insert a wide-bore IV needle for infusion or insert a central venous catheter. According to the Advanced Trauma Life Support (ATLS) definition, a patient is “unstable” with blood pressure < 90 mmHg and heart rate > 120 bpm,

evidence of skin vasoconstriction (cool, clammy, decreased capillary refill), altered level of consciousness, and/or shortness of breath.

If the patient is hemodynamically unstable, stabilize first with crystalloids, colloids, or blood transfusion (whichever is applicable) and perform an eFAST exam. If there is any evidence of free fluid, the patient is shifted directly to emergency operation theatre (EOT). If the patient is hemodynamically stable and the primary survey is negative, the patient can be shifted to CT scan and review. A strong suspicion is needed to diagnose blunt injury in the abdomen.

4. Splenic injury

Splenic injury is the most common visceral injury from violence. The likelihood of severe injury is increased in a diseased spleen.

Splenic injury is commonly associated with the left hemothorax, fracture of the left lower ribs, and injuries to the tail of the pancreas, left lobe of the liver, left kidney, or left colon. Direct compression of the spleen causes parenchymal injury. Rapid deceleration causes tears to splenic parenchyma. Direct blows to the abdomen (domestic violence or leisure and play activities) can also cause splenic rupture.

4.1 Clinical presentation

- Hilar injury: rapid development of shock and rapid deterioration (even death can occur).
- Other injuries: features of shock (pallor, tachycardia, restlessness, tachypnea, anxiety, hypotension, decreased capillary refill, and decreased pulse pressure).
- Abdominal pain, distension, tenderness, and abdominal rigidity in the left upper quadrant (LUQ); positive Kehr's sign (a clot or blood collected under the left diaphragm that irritates it and the phrenic nerve (C3, C4) causing referred pain in left shoulder 15 min after foot end elevation).
- Delayed splenic rupture (DSR): latent period of Baudet in which the patient has no signs or symptoms for hours to days and presents later. DSR tends to occur 4–8 days after trauma. This may be due to expanding subcapsular hematoma, clot disruption, pseudocyst rupture, or pseudoaneurysm/AV fistula rupture (Table 1).

4.2 Management of splenic injury

Management of splenic injury depends on the hemodynamic stability of the patient and associated injuries. It can be managed nonoperatively, operatively, or via splenic artery angioembolization.

Patients who have diffuse peritonitis or who are hemodynamically unstable (a positive FAST examination or positive diagnostic peritoneal lavage (DPL)) following blunt abdominal trauma should be taken urgently for exploratory laparotomy. A routine laparotomy is not indicated in hemodynamically stable patients without peritonitis presenting with isolated splenic injury. Factors such as patient age, grade of injury, and presence of hypotension need to be considered in the clinical management of these patients. For patients undergoing nonoperative management (NOM), an abdominal CT scan with IV contrast should be performed to identify and assess the severity of injury to the spleen. Angiography should be considered for patients with AAST grade

Grade	Type of injury	Description
I	Laceration Hematoma	Capsular tear, <1 cm depth Involving <10% TSA of spleen
II	Laceration Hematoma	1–3 cm parenchymal depth which does not involve a trabecular vessel Subcapsular, Involving 10–50% TSA of spleen, Intra parenchymal, <5 cm in depth
III	Laceration Hematoma	>3 cm parenchymal depth or involving trabecular vessels Subcapsular involving >50% of TSA of spleen or expanding; ruptured subcapsular or parenchymal hematoma
IV	Laceration	Segmental or hilar (>25% devascularization)
V	Laceration Vascular	Shattered spleen Hilar vascular injury which devascularizes the spleen

Table 1.
American Association for the Surgery of Trauma (AAST) splenic injury scale.

III injuries. The presence of a contrast blush, moderate hemoperitoneum, or evidence of ongoing splenic bleeding is an indication for splenectomy. Nonoperative management of splenic injuries should only be considered in an environment that provides capabilities for continuous monitoring, such as serial clinical evaluations, serial HB estimation, serial radiological screening, and availability of an emergency operating room at any given time [1]. If vital signs or hematocrit values decrease, or if there is evidence of expanding hematoma or ongoing bleeding, the patient should be shifted for emergency laparotomy.

5. Liver injury

The liver is the most common organ injured in blunt and penetrating injuries. Its anterior location in the abdomen and fragile parenchyma makes it susceptible to injury from blunt forces. Its fixed location under the diaphragm also makes it susceptible to shear forces from deceleration injuries. The vasculature in the liver is made up of large but thin-walled vessels with high blood flow (**Table 2**).

5.1 Nonoperative management (NOM) of traumatic liver injury

Blunt trauma patients with hemodynamic stability and absence of other internal injuries requiring surgery can be treated nonoperatively. Patients can undergo NOM irrespective of the grade of liver injury. NOM should not be used for patients with hemodynamic instability and peritonitis. NOM should be adopted in centers with facilities for intensive care monitoring, angiography, immediate availability of an operating room, and immediate access to blood products [2, 3]. CT angiogram should be performed in patients considered for NOM. If there is any blush in the CT angiogram, angioembolization should be considered. NOM patients should be continuously monitored for vitals, hematocrit, abdominal girth, and the development of peritonitis.

Complications of NOM include:

- bleeding
- abdominal compartment syndrome
- infections (abscesses and other infections)
- biliary complications (bile leak, hemobilia, bilioma, biliary peritonitis, biliary fistula) [2, 3]
- liver necrosis
- rebleeding or secondary hemorrhage (rupture of a subcapsular hematoma or a pseudoaneurysm)

Grade	Type of injury	Description
I	Laceration Hematoma	<1 cm depth, nonbleeding Subcapsular, Nonexpanding, Involving <10% TSA of liver
II	Laceration Hematoma	1–3 cm depth, <10 cm in length Subcapsular, Involving 10–50% TSA, nonexpanding
III	Laceration Hematoma	>3 cm depth Subcapsular—involving >50% of TSA, intraparenchymal >2 cm, expanding
IV	Hematoma Laceration	Bleeding intraparenchymal rupture Involving 25–50% of the lobe
V	Laceration Vascular	Involving more than 50% of the lobe Juxta hepatic veins, main hepatic veins or retro hepatic area
VI	Vascular	Hepatic avulsion

Table 2.
American Association for the Surgery of Trauma (AAST) liver injury scale.

If there is a decrease in blood pressure or hematocrit values or the development of any signs of peritonitis, the patient should be immediately taken up for laparotomy.

NOM can be used for penetrating liver trauma in hemodynamically stable patients without peritonitis, significant free air, localized thickened bowel wall, evisceration, and impalement [2, 3].

5.2 Operative management (OM) of traumatic liver injury

Patients should undergo operative management (OM) for liver trauma (blunt and penetrating) in case of hemodynamic instability and concomitant internal organ injury. The primary intention is to control hemorrhage and bile leakage. Major hepatic resections should be avoided in emergency situations and should be considered in subsequent management. Intraoperative management [2, 4] includes:

- hepatic manual compression and hepatic packing
- usage of energy sources such as bipolar cautery, argon laser beams, and so on
- ligation of vessels in the wound
- hepatic debridement
- balloon tamponade
- shunting procedures
- hepatic vascular isolation

For patients undergoing hepatic packing, temporary abdominal closure can be performed to prevent abdominal compartment syndrome. Selective hepatic artery ligation can be considered for patients with massive hemorrhage. Associated portal vein injuries should be repaired because portal vein ligation can lead to hepatic necrosis and bowel edema. Hepatic resections can be performed for severe injuries with uncontrolled bleeding that is not controlled by any of the aforementioned means.

6. Pancreatic injury

Most pancreatic injuries are associated with spinal fracture at the level of the first and second lumbar vertebrae. Isolated injuries of the pancreas after blunt abdominal trauma were noted in 20% of pancreatic injuries. Pancreatic head injuries may be associated with injuries to the stomach, duodenum, and transverse colon. Injuries of the body and tail of the pancreas may be associated with injuries to the stomach, transverse colon, splenic flexure of the colon, splenic vessels, and spleen.

6.1 Clinical presentation

Direct blowing with compression of the upper abdomen against the spine is the most common cause of pancreatic injury. Many patients have minimal clinical symptoms and signs when evaluated after trauma. Pancreatic injuries will be

missed if not properly looked for because of minimal symptoms and signs. When symptoms present, the most common is deep epigastric pain associated with nausea and vomiting. Hyperamylasemia is not a precise marker for pancreatic injury. Hyperamylasemia is present in 30–40% of patients admitted with trauma, and the progressive rise in the amylase level over the first 24–48 h of hospitalization is strongly suggestive of pancreatic injury. CECT using 128 slice scanners is the diagnostic modality of choice. Endoscopic retrograde cholangiopancreatography (ERCP) can be used to rule out injury to the main pancreatic duct.

6.2 CT findings

In patients with suspicious pancreatic injuries, CT findings may include:

- fluid in the lesser sac
- fluid between pancreas and splenic vein
- hematoma of transverse mesocolon
- thickening of left anterior renal fascia
- duodenal hematoma or laceration injury to spleen, left kidney, or left adrenal gland
- chance fracture of lumbar spine

CT findings that are diagnostic of pancreatic injuries include:

- parenchymal hematoma or laceration
- obvious transection of the parenchyma
- disruption of head of pancreas
- diffuse swelling characteristics of posttraumatic pancreatitis (**Table 3**) [5]

6.3 Management of isolated pancreatic injuries

In hemodynamically stable patients, pancreatic contusions (AAST grade I), minor capsular injuries, and traumatic pancreatitis can be treated without drainage [6]. Most other injuries require some sort of drainage.

Grade	Type of injury	Description
I	Hematoma	Minor contusion without duct injury
	Laceration	Superficial laceration without duct injury
II	Hematoma	Major contusion without duct injury or tissue loss
	Laceration	Major laceration without duct or injury or tissue loss
III	Laceration	Distal transection or parenchymal injury with duct injury
IV	Laceration	Proximal transection or parenchymal injury involving ampulla
V	Laceration	Massive disruption of pancreatic head

Table 3.
American Association for the Surgery of Trauma (AAST) pancreas injury scale.

AAST grade I injuries are managed with observation and omental pancreatorrhaphy with simple external drainage. Grade II injuries are managed with simple external drainage or omental pancreatorrhaphy and drainage. Grade III injuries are managed with distal pancreatectomy with or without splenectomy, and Roux-en-Y distal pancreaticojejunostomy. Grade IV injuries are managed with pancreaticoduodenectomy, Roux-en-Y distal pancreaticojejunostomy, anterior Roux-en-Y pancreaticojejunostomy, and endoscopically placed stent and simple drainage in damage control situations. Grades V and VI injuries are managed with pancreaticoduodenectomy.

Complication rates after operative treatment of pancreatic injuries range from 26% to 86%. The most common postoperative infectious complication and the leading cause of morbidity in patients with pancreatic injuries is an intra-abdominal abscess. A pancreatic fistula is the most common pancreatic complication after operative repair of a major injury [5, 6].

7. Renal injury

The most common mechanisms that cause renal injury are motor vehicle collisions, falls, vehicle-associated pedestrian accidents, sports, and assault. Frontal impact caused by acceleration of the occupants into the seat belt or steering wheel, or side impact injuries, occur when the vehicle side panel intrudes into the compartment and hits the occupant, causing renal injury. Frontal and side airbags reduce the risk of renal injury by 45.3% and 52.8%, respectively. Sudden deceleration or a crush injury may result in contusion and laceration of the renal parenchyma. Penetrating renal injuries can occur as a result of gunshot or stab wounds. The incidence of urological tract injury following abdominal trauma is approximately 10%. Renal trauma comprises of 1–5% of all traumas.

7.1 Clinical presentation

Patients may present with localized pain, tenderness, or diffuse tenderness. Retroperitoneal bleeding may lead to abdominal distention, ileus, nausea, and vomiting. Features of hypovolemic shock may be present. Ecchymosis may be present over the flank on the affected side. Lower rib fractures or pelvic fractures may be frequently associated with renal injury. A palpable mass may represent a large retroperitoneal hematoma or perhaps urinary extravasation. If the retroperitoneum has been torn, free blood may be noted in the peritoneal cavity, but no palpable mass will be evident. Hematuria may be present [7].

7.2 Investigations

Contrast-enhanced CT is the gold standard for the evaluation of stable patients with renal trauma. The absence of enhancement on contrast administration or the presence of para hilar hematoma suggests renal pedicle injury and makes it difficult to directly visualize renal vein injury. Standard CECT scans may miss collecting system injury, which is best detected by repeating the scan 10–15 min after contrast injection. CT imaging is both sensitive and specific for demonstrating parenchymal lacerations and urinary extravasations, delineating segmental parenchymal infarcts, and determining the size and location of the surrounding retroperitoneal hematoma and/or associated intra-abdominal injury (spleen, liver, pancreas, and bowel). Renal artery occlusion and global renal infarct are noted on CT scans by lack of parenchymal enhancement or a persistent cortical rim sign.

Grade	Description of injury
I	Contusion or non-expanding subcapsular hematoma No laceration
II	Non-expanding peri renal hematoma Cortical laceration <1 cm deep without extravasation
III	Cortical laceration >1 cm deep with extravasation
IV	Laceration through cortico medullary into collecting system Vascular-segmental renal artery or vein injury with contained hematoma or partial vessel laceration or vessel thrombosis
V	Laceration shattered kidney Vascular: renal pedicle or avulsion

Table 4.
American Association for the Surgery of Trauma (AAST) renal injury scale.

The most common indication for arteriography is nonvisualization of a kidney on intra venous pyelogram (IVP) after major blunt renal trauma when CT is not available. It is the test of choice for evaluating renal vein injury (**Table 4**) [8].

7.3 Nonoperative management (NOM) of traumatic renal injury

Stable patients with blunt renal trauma grades I–IV should be managed conservatively with bed rest, prophylactic antibiotics, and continuous monitoring of vital signs until hematuria resolves. Persistent bleeding represents the main indication for renal exploration and reconstruction.

7.4 Operative management (OM) of traumatic renal injury

Indications for operative renal exploration include:

- hemodynamic instability due to renal hemorrhage
- grade V renal injuries in a stable patient
- expanding or pulsatile perirenal hematoma seen at laparotomy for associated injuries [7].

The goal of renal exploration following renal trauma is the control of hemorrhage and renal salvage. Renorrhaphy or partial nephrectomy is used to manage parenchymal laceration. Attempts should be made for watertight closure of the collecting system. Raw areas should be minimized by using renal capsule, omentum, or fibrin glue. Repair of grade V renal injury is rarely successful, and nephrectomy is usually the best option, except in the case of a solitary kidney. The retroperitoneum should be drained following renal exploration.

7.5 Complications

Early complications occur within the first month of injury and can include bleeding, infection, perinephric abscess, sepsis, urinary fistula, hypertension, urinary extravasation, and urinoma. Delayed complications include calculus formation, chronic pyelonephritis, hypertension, arteriovenous fistula, hydronephrosis, and pseudoaneurysms. Peri-nephric abscesses are best managed by percutaneous

drainage. Delayed bleeding and arteriovenous fistula are managed by angiographic embolization. Treatment of hypertension is required if it persists and could include medical management, excision of the ischemic parenchymal segment and vascular reconstruction, or total nephrectomy. Urinary extravasation after renal reconstruction often subsides without intervention if ureteral obstruction and infection are not present. Persistent urinary extravasation responds to stent placement or percutaneous drainage.

8. Mesenteric injury

Isolated mesenteric injury is rare. Mesenteric tears occur because of deceleration injuries. The tear in the mesentery may be longitudinal or transverse. Longitudinal tears are more common than transverse tears. Longitudinal tears can occur from the base of the mesentery to the margin of the gut. The tear may be single or multiple. Longitudinal tears can be suture ligated without bowel resection if they do not extend up to the margin of the gut. Longitudinal tears can involve the root of mesentery and superior mesenteric vessels. Transverse tears are dangerous, as they will cause gangrene of the segment of the bowel. Clinically isolated mesenteric injuries present as follows:

- Immediate—due to bleeding. Signs of continuous bleeding, shock, and peritoneal irritation are present, requiring early laparotomy.
- Delayed—due to bowel infarction. Delayed diagnosis of patients leads to intestinal infarction and requires bowel resection. The patient may present between 12 h and 5 days after injury.
- Due to bowel stenosis or adhesion formation. Mesenteric vascular injury may induce chronic ischemia of the corresponding segment of the small bowel, inducing secondary thickening of the bowel wall and intestinal occlusion and may present between 5 and 8 weeks after injury [9].

9. Traumatic retroperitoneal hematoma

Retroperitoneal injury can be due to blunt or penetrating trauma. Blunt trauma is caused by direct energy transfer. A penetrating injury is an injury that directly violates tissue planes.

The retroperitoneum is divided into three zones.

Zone 1 is the central retroperitoneum from the diaphragm superiorly to the bifurcation of the aorta inferiorly. It contains the inferior vena cava, origins of the major renal and visceral vessels, duodenum, and pancreas. Blunt trauma to this region affects the duodenum and the pancreas to a greater extent, with vascular lesions being less frequent. Pancreatic injuries have an incidence that ranges between 1% and 12% of penetrating trauma and 5% of blunt trauma. The most frequent complication is duodenal fistula.

Zone 2 includes both lateral perinephric areas of the upper retroperitoneum from the renal vessels medially to the lateral reflection of the posterior parietal peritoneum of the abdomen (from the diaphragm superiorly to the level of aortic bifurcation inferiorly). Organs contained include adrenal glands, kidneys, renal vessels, ureter, and ascending and descending colon. Renal and adrenal injuries are common in this region.

Zone 3 is inferior to the aortic bifurcation and includes the right and left internal and external iliac arteries and veins, distal ureter, and distal sigmoid colon and rectum. Mostly vascular injuries occur in this region. Iliac vessel injury occurs in this region [10].

9.1 Management of traumatic mesenteric injury

9.1.1 Penetrating injury

- Zone 1—Major vessel injury can occur. Exploration must be done.
- Zone 2—Selectively explore the kidney for active hemorrhage or an expanding hematoma. The colon is mobilized to rule out retroperitoneal colon injury and the ureters are explored if in proximity to the wound.
- Zone 3—Explore as this is likely a major vascular injury.

9.1.2 Blunt injury

- Zone 1—Explore, as this is likely a major vascular injury. The most frequent aortic injuries are infrarenal, while vena cava injuries are predominantly adrenal in origin. In the presence of hemodynamic stability and absence of contraindications, conservative management, including angioembolization, should initially be considered.
- Zone 2—Conservative treatment is the most widely accepted. Exploration will be done for an expanding hematoma or one that has failed alternative methods of hemorrhage control, such as angioembolization, for the presence of associated injuries or when there is suspicion of ureteral injuries. Do not explore a contained, nonexpanding hematoma [10].
- Zone 3—Do not explore and utilize a method for hemorrhage control, such as intraoperative preperitoneal packing or angioembolization. Iliac vessel injuries prevail in importance due to their associated high mortality. Angiography and venous ligation can be done. The management of bone injury is based on a multidisciplinary approach.

10. Conclusion

Blunt injury of the abdomen is a common abdominal emergency. A high degree of suspicion and watchful screening and examination are needed to diagnose blunt abdominal injury.

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