INTRODUCTION

Trauma continues to be an enormous public health problem worldwide and it is associated with high morbidity and mortality both in developed and developing countries. [1] Blunt abdominal trauma (BAT) refers to injuries due to direct impact or countercoup (An injury in which the damage is located on the opposite side of the primary impact site) without wounds entering the peritoneal cavity. [2] Identification of serious intra-abdominal pathology is often challenging. Many injuries may not manifest during the initial assessment and treatment period. [3] Delay in diagnosis and treatment is a major contributing factor to mortality, which is often due to hemorrhage, sepsis, and multiple organ failure. [4] Retroperitoneum is a wide space at the back of the peritoneum. [5] Blunt abdominal trauma can cause significant and sometimes life-threatening injuries to retroperitoneal structures.[6] Retroperitoneal traumatic lesions are among the most challenging and serious emergencies, and necessitate a maximum of attention and expertise by the surgical team involved. [7, 8]

Incidence and epidemiology of retroperitoneal trauma:

BAT is more frequently encountered in the emergency department (ED) than penetrating abdominal trauma. [9] The prevalence of intra-abdominal injury among patients presenting to the emergency department with blunt abdominal trauma is approximately 13 percent. [10] Retroperitoneal injuries (RPI) are known to occur in a significant minority of abdominal trauma cases. [6] The incidence of abdominal trauma increases each year. [11]

Causes and mechanism of retroperitoneal trauma:

RPI most often results from a motor vehicle crash (MVC) and such incidents account for over 75 percent of cases. Blows to the abdomen and falls are responsible for 15 and 6 to 9 percent, respectively. Occult trauma may occur with child abuse and domestic violence. [12, 13] the kidneys are vulnerable to blows or kicks to the sides of the abdomen. [14] Motorcyclists that have been ejected from their bike frequently sustain pelvic fractures and intraabdominal trauma. The lap portion of the seat belts frequently causes injury to hollow organs particularly small colon and abdominal wall. [15] Since abdominal trauma is usually caused by road accident, it is almost always found in patients with severe trauma, and associated with orthopedic, thoracic, or central nervous system (CNS) injuries. [2]

The mechanism of RPI structures can be classified into 2 primary mechanisms:

1. Compression or concussive forces may result from direct blows or external compression against a fixed object (e.g., lap belt, spinal column). These forces may deform hollow organs and transiently increase intraluminal pressure, resulting in rupture.
2. Deceleration forces cause stretching and linear shearing between relatively fixed and free objects. These longitudinal shearing forces tend to rupture supporting structures at the junction between free and fixed segments. [13, 16]

Sex and age incidence of RPI:

There is a male preponderance; studies have shown that men tend to be affected slightly more than women. [17] Male to female ratio is 3:2, according to the international data. [18] Retroperitoneal trauma is a leading cause of morbidity and mortality among all age groups. It affected mainly young patients who constitute an active and productive segment of the society with greater mobility with increased risk of accident. [19]

Morbidity and mortality of RPI:

There is high mortality rate associated with multiple abdominal organ injuries than with single organ injuries. [15] The presence of lesions on the retroperitoneum generally worsens the prognosis in traumatic pathology; it implies more attention and skills from both the medical and surgical aspect. Mortality is high, compared to abdominal traumatic lesions confined within the peritoneal sac. Lesions of great vessels are immediately life-threatening. The involvement of duodenum or pancreas determines instead a poorer prognosis at a distance. [8]

In developed countries, morbidity and mortality rates have been reduced as a result of improved safety standards, advances in diagnostic imaging techniques, patient monitoring devices, prompt intervention often in specialized trauma centers among other factors. [20] Speedy and accurate diagnosis and treatment can play an important part in determining the fate of these patients, after initial resuscitation and primary evaluation, secondary measures for diagnosing damage to each organ should be under taken immediately.[14]

Organ injuries:

The retroperitoneum is that portion of the abdomen posterior to the peritoneal cavity from the diaphragm to the pelvic inlet. It is separated from the peritoneum anteriorly by the posterior peritoneal fascia and is bounded posteriorly by the transversalis fascia. [6]

The retroperitoneum has traditionally been divided into the posterior pararenal space, containing only fat; the perirenal spaces, containing the kidneys, renal pelvis, proximal ureters, adrenal glands, and perirenal fat; and the anterior pararenal space, containing the retroperitoneal segments of the colon and duodenum, the pancreas, and the root of the small bowel mesentery. [21] Major retroperitoneal vascular structures include the abdominal aorta, inferior vena cava (IVC), renal vessels, proximal celiac axis and superior mesenteric arteries, superior mesenteric vein, lumbar arteries and veins, and iliac vessels within the pelvis. [22]

Table (1): Anatomic spaces of the retroperitoneum. [21]

Space	Boundaries	Contents
Anterior pararenal	Peritoneum, anterior perirenal fascia, latero-conal fascia	Pancreas, duodenum, ascending colon, descending colon
Perirenal	Anterior and posterior renal fasciae	Kidneys, adrenal glands, proximal renal collecting systems, renal hilar vessels
Posterior pararenal	Posterior renal fascia, transversalis fascia, fascia over the psoas muscle continuous with the transversalis fascia	Fat

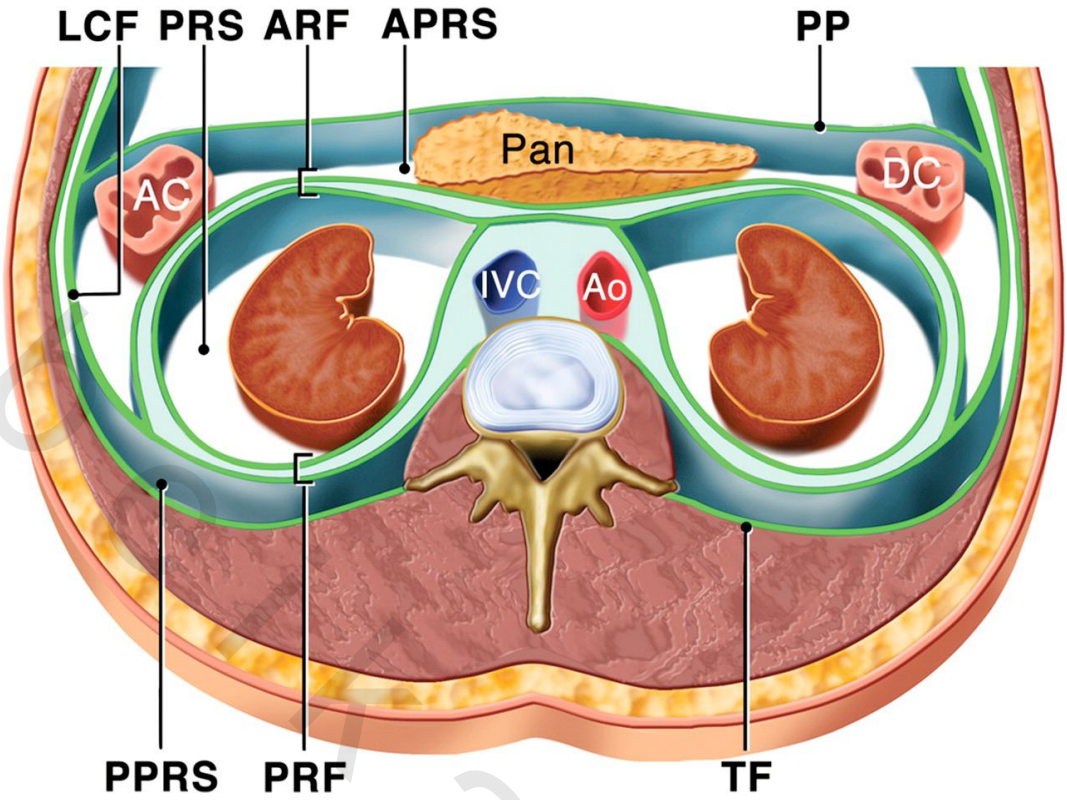


Figure (1): An illustration of fascial planes and spaces of the retroperitoneum:
The above illustration shows the traditional tricompartment model of the retroperitoneum, which is accordingly divided into the anterior pararenal space (APRS), perirenal space (PRS), and posterior pararenal space (PPRS). The anterior renal fascia (ARF), posterior renal fascia (PRF), and lateroconal fascia (LCF) divide the spaces. Posterior peritoneum (PP) and transversalis fascia (TF). [9]

Clinical picture:

Abdominal examination is often affected by different factors including fractures of lower chest ribs, contusion and abrasions of the abdominal wall, presence of fractured lumbar vertebrae with retroperitoneal hematoma, and reduced level of consciousness. Rapid assessment and appropriate treatment of potentially life-threatening conditions is therefore essential. [23] Early symptoms include nausea, vomiting and fever. [9] The injury may present with abdominal pain, tenderness, distension, or rigidity to the touch, and bowel sounds may be diminished or absent. Abdominal guarding is a tensing of the abdominal wall muscles to guard inflamed organs within the abdomen. Pneumoperitoneum, air or gas in the abdominal cavity, may be an indication of rupture of a hollow organ. [12] Blood in the urine is another sign. [24] People injured in motor vehicle collisions may present with a "seat belt sign," bruising on the abdomen along the site of the lap portion of the safety belt, this sign is associated with a high rate of injury to the abdominal organs.[16] Attention should be paid to palpating the lumbar spine in the patient with abdominal wall ecchymosis. Patients with a lap-belt sign may have sustained a coincident burst fracture of the upper lumbar vertebra (chance fracture). Drugs, alcohol, head and spinal cord injuries frequently complicate physical examination. It may also be impractical in patients who require general anesthesia for the treatment of other injuries. [25]

A pelvic fracture can be a significant source of blood loss. The clinical criteria are:

- Unstable vital signs
- Significantly altered mental status
- Ecchymosis and laceration to the pelvis and surrounding structures
- Blood at uretheral meatus, gross hematuria
- Tender pelvis, sacrum, or lower lumber spine
- Neurologic deficit in lower extremities

- Abnormal rectal examination(lax tone, bloody stools)
- Pain upon hip movement. [26]

Diagnostic tests:

A variety of tests are used to identify RPI after BAT patients including: clinical examination, plain radiologic studies, focused assessment with sonography for trauma (FAST), diagnostic peritoneal lavage (DPL) and computed tomography (CT). [27]

The clinical history and physical examination alone are usually unreliable, as nearly half the patients may have no complaints or external signs of abdominal injury on admission to hospital. [23]

Chest and pelvic radiography continue to be important adjuncts to the primary survey. The results may suggest haemorrhage in adjacent cavities, but they cannot rule out intra-abdominal bleeding or visceral injury. [28] The chest x-ray can help distinguish pneumothorax, hemothorax, diaphragmatic rupture, and rib fractures and other signs of potential aortic disruption. [26] Pelvic films on the other hand are standard in evaluation processes. Patients with pelvic fractures have a high energy mechanism .This mandates rapid abdominal evaluation to avoid confusing retroperitoneal bleeding common with pelvic fracture with intra abdominal blood loss. In addition patients with thoraco-lumbar spine fracture must have abdominal evaluation. [29]

Bedside tests such as DPL and FAST can yield negative findings or fail to help detect signs of retroperitoneal injury, even in the presence of significant retroperitoneal injury. [30, 31]

Imaging, particularly CT, plays a central role in the assessment of retroperitoneal structures following blunt trauma. [31] The appropriate management of blunt abdominal trauma depends on a careful initial evaluation; the timely use of diagnostic procedures; and vigorous therapy directed at immediate life threatening problems. [32]

Computed tomography:

CT can allow the accurate assessment of trauma patients, including the detection of traumatic retroperitoneal injuries, many of which are clinically occult. Accurate characterization of injury with CT can affect clinical management and can help minimize unnecessary laparotomies. Equivocal findings at initial abdominal CT should prompt close clinical follow-up with possible imaging follow-up, particularly for suspected occult duodenal and pancreatic injuries**.** [6]

CT scanning's benefits include:

- Can provide a rapid and accurate appraisal to detect intraperitoneal fluid and free air in the abdomen, as well as to assess the solid organs, hollow viscus, retroperitoneum, vasculature, diaphragm and abdominal wall. [15] [26] [33]
- It is very useful in predicting the grade of injury in order to select the appropriate management of trauma patients. [34]
- In addition, an abdominal CT scan can assist in the evaluation of coexisting abdominal injuries such as thoracic injuries and unsuspected pelvic and spinal fractures. [35]
- It carries asensitivity of 85–98%. With muti-slice helical scanners, abdominal CT has improved sensitivity and specificity in diagnosing solid and hollow viscus injury, making CT the diagnostic modality of choice in the stable patient. [26]
- In addition, CT can be used to detect smaller volumes of hemoperitoneum that are not sonographically evident; CT plus serial abdominal examinations increase the ability to detect hollow viscus injury. [15]

CT scanning's disadvantages include:

- CT is reader-dependent, requires transfer of the patient from the trauma bay, exposes the patient to ionizing radiation, and is not available in some hospitals. [15]
- Intravenus (IV) contrast is needed. [36]

- Relatively high cost can be unobtainable. [37]
- Suboptimal sensitivity for pancreatic, diaphragmatic, bowel and mesenteric injury. Pancreatic injuries may not be identified on initial CT scans but generally are found on follow-up examinations performed on high-risk patients. [37]

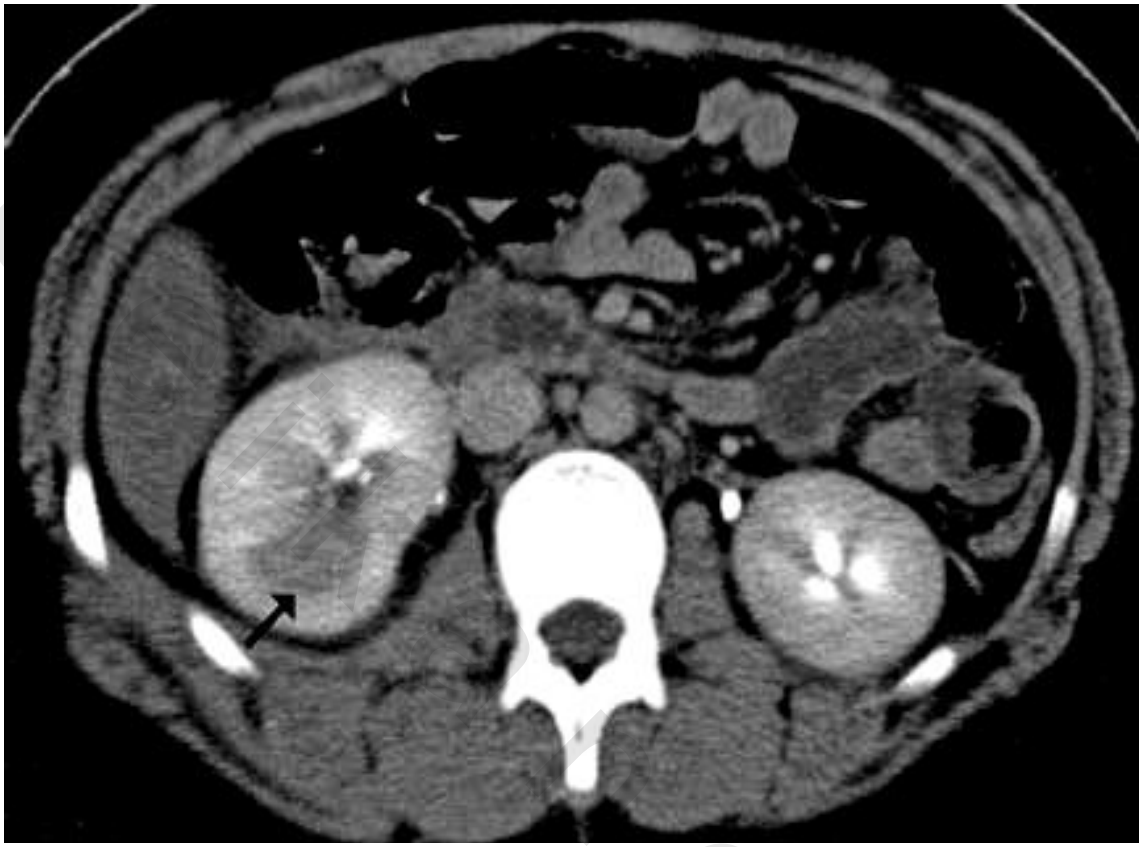


Figure (2): Right renal contusion (grade I renal injury).
Axial enhanced CT image shows a focal area of decreased enhancement (arrow) in the right kidney. [38]

Management:

The decision for operative or non operative management depended on the outcome of the clinical examination and results of diagnostic tests. [39] The choice between the two modalities of management should be guided by hemodynamic considerations rather than the severity of organ injury. [40]

Non-operative management of RPI after BAT:

Schwab CW stated that over the past two decades, there has been a major shift from operative to selective nonoperative management of traumatic injuries. [41] Physicians are becoming increasingly comfortable in managing such injuries nonoperatively. [39] The nonoperative approach relies heavily on the availability of trauma trained surgeons, modern radiographic imaging (particularly computed tomography), accurate interpretation of such high quality radiographic images, as well as the presence of appropriate supporting services. [42]

Protocol :[16, 37, 43, 44, 45]

1- The patient should be admitted to an intensive care unit or other closely monitored environment for 24 to 72 hours with careful serial abdominal examination, repeat hemoglobin and hematocrit checkup.
2- Serial clinical examination and monitor vital signs hourly.
3- Patients selected for non operable management were placed on strict bed rest.
4- Nothing per orum.

5- Appropriate diagnostic tests especially ultrasound of abdomen was repeated as and when required. Draw serial hematocrit and hemoglobin every 6hours until stable.
6- Repeated examination of abdomen and other systems.

If the patient is stable and there have been no adverse hemodynamic events:

1. The patient can be transferred to a regular ward bed with less intensive monitoring
2. Repeat FAST and CT prior to discharge from the emergency department.
3. Serial imaging studies have been recommended if needed.
4. Estimation of hematocrit and hemoglobin daily.
5. Mobilize when stable, physical examination and hematocrit.
6. If the patient stable and tolerating diet he could be discharged.

Indications for Laparotomy in RPI after BAT: (46)

1. Patient with hemodynamic instability
2. Patient with active extravasation from a major abdominal vessel or a contained hematoma adjacent to a major vessel suggesting injury.
3. Patient with solid organ injury with active extravasation.
4. Patient with pancreatic injury with major ductal injury.
5. Patient with hollow viscus injury.
6. Patient with solid organ injury being managed non-operatively developing hemodynamic instability or requiring > 2 units of packed cell transfusion related to the solid organ injury.
7. Persistent urinary leakage or persistent hematuria from a fragmented kidney.
8. Patient with negative initial evaluation but not improving or showing clinical deterioration, with no other explanation.

Laparotomy carries a different set of risks that are related to the surgeon, the anesthesia, the nature of operation and potential complications, and patient-related risk factors. (40)

Injuries to retroperitoneal structures

Pancreas:

Incidence:

Pancreatic trauma is uncommon and most trauma surgeons have little experience in managing the condition. (47, 48) Blunt pancreatic injury is more common in children and young adults because they have a thinner or absent mantle of protective fat, which surrounds the pancreas in older adults. (6)

Mechanism of injury:

The retroperitoneal location of the pancreas protects it in most instances of blunt abdominal trauma. Blunt injuries usually result from direct impact or deceleration injury, often in conjunction with other visceral injuries. Pancreatic injury typically results from severe anterior-to-posterior force vectors compressing the pancreas against the spine, with the injury commonly occurring just to the left of the mesenteric vessels. (6)

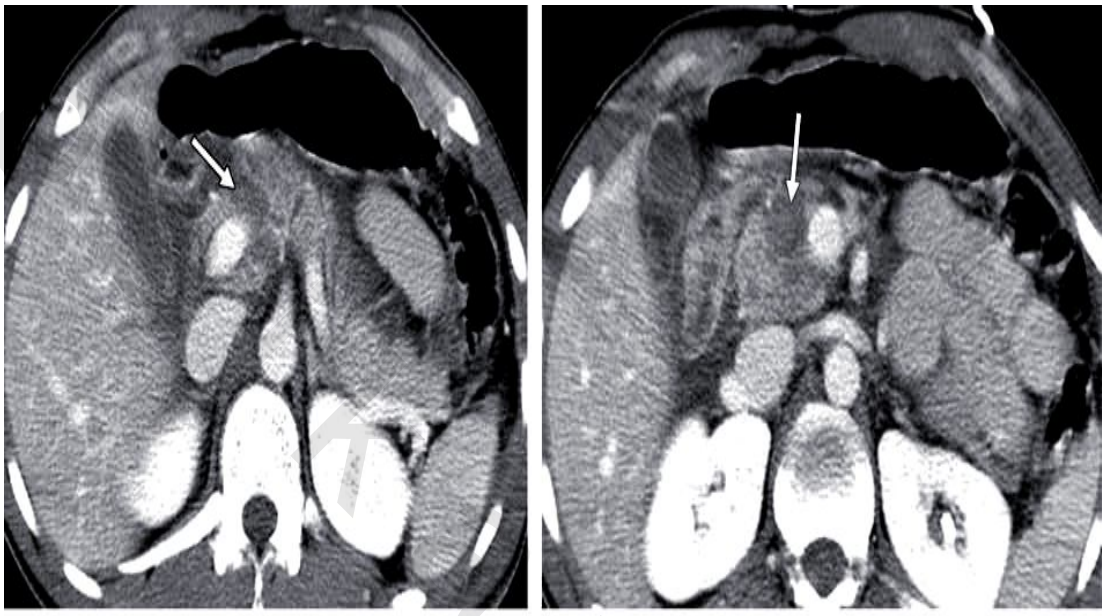
Steering wheel impact in a motor vehicle collision is a common mechanism in adults, whereas bicycle handlebar impact is a common cause in children. (49)

Two-thirds of blunt pancreatic injuries occur in the pancreatic body, with the remainder occurring with equal frequency in the head, neck, and tail.(6) Mortality rates for pancreatic injuries range from 10% to 30% and have been reported as high as 60% when treatment is delayed. (50)

Diagnostic tests:

Laboratory findings are often nonspecific (in particular, initial serum amylase levels may be normal in about 25% of patients), and underestimation of the severity of pancreatic injury on the initial computed tomogram is possible during first 48-72 hours. Lastly, it is possible for low severity blunt abdominal trauma to be associated with isolated pancreatic injury. (40)

The pancreas is deeply seated in the retroperitoneum and there are difficulties using physical examination, sonography and diagnostic peritoneal lavage to investigate this area. [47, 51] Many pancreatic injuries are not apparent at initial clinical examination and may become apparent only when complications arise.[52] If the patient is stable enough to undergo imaging, the initial test of choice is a high- definition CT scan performed with intravenous contrast.[53, 54]



a. b.

Figure (3): Abdominal CT scan with IV contrast (pancreatic transaction). (a) At the level of the pancreas shows a full-thickness linear low-attenuation laceration of the pancreatic neck (arrow) just anterior to the proximal portal vein. (b) Inferior level of the pancreas to shows a focal hematoma at the transection site that extends into the pancreatic head (arrow). [55]

Classification of pancreatic injuries: [56]

Table (2): American Association for the Surgery of Trauma Pancreatic Organ Injury Scale (OIS):

Grade*	Type of injury	Description of injury	AIS
I	Hematoma	Minor contusion without duct injury	2
	Laceration	Superficial laceration without duct injury	2
II	Hematoma	Major contusion without duct injury or tissue loss	2
	Laceration	Major laceration without duct injury or tissue loss	3
III	Laceration	Distal transection or parenchymal injury with duct injury	3
IV	Laceration	Proximal transection or parenchymal injury involving ampulla†	4
V	Laceration	Massive disruption of pancreatic head	5

* Advance one grade for multiple injuries up to grade III.
†Proximal pancreas is to the patient's right of the superior mesenteric vein.
AIS, Abbreviated Injury Score.

Management:

The majority of cases of pancreatic trauma had associated organ injuries. Patients with superficial pancreatic injuries were candidates for non-operative therapy while deep pancreatic lesions revealed on CT required surgery. Delayed operation resulted in complications and was associated with prolonged hospital stays.[57]

The integrity or disruption of the pancreatic duct is the principal determinant in the management of pancreatic injuries. Delay in diagnosis of a pancreatic ductal injury most commonly occurs in patients with BAT isolated to the pancreas. [58]

The role for early ductal injury detection with endoscopic retrograde cholangio-pancreatogram (ERCP) or magnetic retrograde cholangio-pancreatogram (MRCP) should be incorporated to better analyze the most appropriate treatment. Non operative management of low grade pancreatic injury diagnosed by CT was successful in the majority of hemodynamically stable patients, with low morbidity and mortality. [59]

The duodenal injuries:

Incidence:

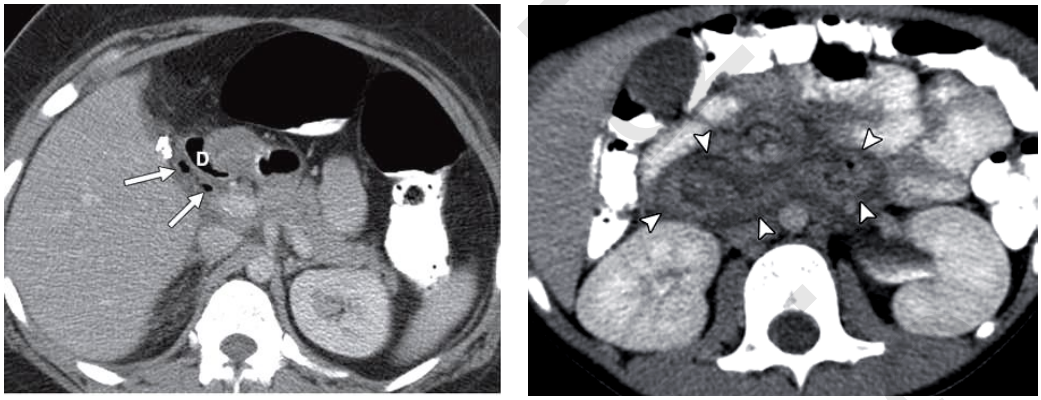
Although the deep, central, retroperitoneal location of most of the duodenum protects it against frequent injury, morbidity and mortality rates for traumatic duodenal injuries remain high.[52] Fortunately, duodenal injuries are relatively uncommon.[6]

Mechanism of injury:

A force that impacts the duodenum against the vertebral column would produce a type of crushing injury.[52]

Diagnostic tests:

The high complication rate is due to diagnostic delays and missed injuries.[52] CT is sensitive for the diagnosis of bowel rupture from blunt trauma. Patients with duodenal injuries who had undergone CT at the time of admission, extraluminal air, extraluminal oral contrast material, or both were specific signs of duodenal perforation and were useful in differentiating duodenal perforation from hematoma.Traumatic duodenal perforation requires emergent surgical intervention, whereas duodenal hematoma is frequently managed conservatively. [6]



a. **b.**

Figure (4): Abdominal CT scan obtained with IV and oral contrast.
(a) extra luminal air (arrows) adjacent to the duodenum (D) (Duodenal perforation). (b) The third portion of the duodenum is thickened and edematous; no extraluminal air could be identified (arrowheads) (Duodenal hematoma). [60]

Classification of duodenal injuries: [56]

Table (3): American Association for the Surgery of Trauma duodenal OIS:

Grade*	Type of injury	Description of injury	AIS
I	Hematoma	Involving single portion of duodenum	2
	Laceration	Partial thickness, no perforation	3
II	Hematoma	Involving more than one portion	2
	Laceration	Disruption <50% of circumference	4
III	Laceration	Disruption 50% to 75% of circumference of D2	4
		Disruption 50% to 100% of circumference of D1, D3, D4	4
IV	Laceration	Disruption >75% of circumference of D2	5
		Involving ampulla or distal common bile duct	5
V	Laceration	Massive disruption of duodenopancreatic complex	5
	Vascular	Devascularization of duodenum	5

*Advance one grade for multiple injuries up to grade III. D1, first position of duodenum; D2, second portion of duodenum; D3, third portion of duodenum; D4, fourth portion of duodenum.

Management:

Since surgical repair becomes more difficult if the injury is recognized late. If recognized early, up to 80% of duodenal injuries can be safely repaired primarily. [31]

Grade I or II hematoma: If hematoma is detected at laparotomy treat with evacuation, If hematoma is detected by non operative means observe the patient.
Grade I or II laceration and advanced grades revealed on CT required surgery. [61]

Adrenal Injuries:

Incidence:

Adrenal injuries are seen in up to 2% of patients with blunt abdominal trauma. They are frequently associated with more significant abdominal and thoracic injuries. Liver injuries are the most common associated injury. [62]

Mechanisms of injury:

Mechanisms of adrenal injury include direct crush injury (ie, between the spine and the liver or spleen), injury due to acutely increased adrenal venous pressure transmitted from a compressed IVC, IVC–adrenal vein thrombosis, and shear injury to small adrenal vessels due to rotational or deceleration forces.[62,63] Isolated adrenal injuries are uncommon and can be relatively benign and self limited, Adrenal injuries are thought to occur more frequently on the right side due to the location of the right adrenal gland (making it more susceptible to compression between the liver and the spine) Although bilateral adrenal hemorrhage is uncommon, it can result in life-threatening adrenal insufficiency in rare cases. [62]

Diagnostic tests:

Typical CT findings include a round or oval hematoma expanding the adrenal gland, irregular hemorrhage obliterating the normal margin of the gland, glandular swelling, an adrenal mass and periadrenal hemorrhage. [62]

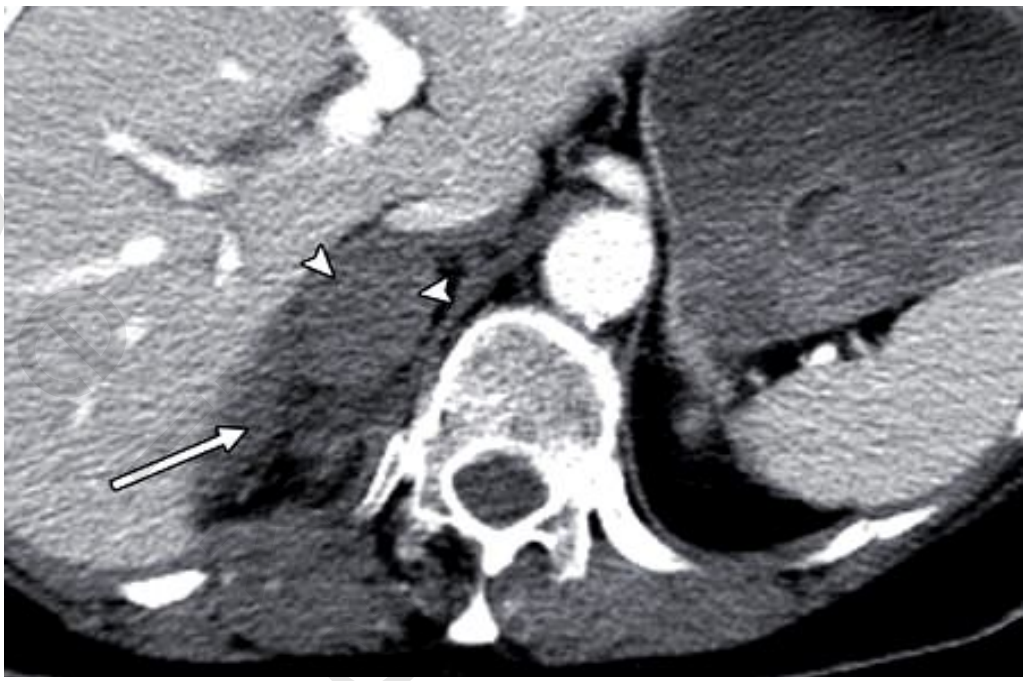


Figure (5): abdominal CT scan obtained with IV contrast (Traumatic adrenal hemorrhage) shows a right adrenal hemorrhage (arrowheads) with periadrenal hemorrhage (arrow). [62]

Classification of adrenal injuries: [56]

Table(4): American Association for the Surgery of Trauma Adrenal OIS:

Grade*	Description of injury	AIS
I	Contusion	1
II	Laceration involving only cortex (<2 cm)	1
III	Laceration extending into medulla (≥2 cm)	2
IV	Parenchymal destruction (>50%)	2
V	Total parenchymal destruction (including massive intraparenchymal hemorrhage)	3
	Avulsion from blood supply	3

* Advance one grade for bilateral lesion up to grade V.

Management:

Depending on the extent of the injury and the patient's hemodynamically stability, adrenal haemorrhage is addressed surgically or conservatively and a few adult patients with isolated adrenal haemorrhage have been treated with embolization. [64]

Kidneys:

Incidence:

Traumatic injuries to the kidneys account for approximately 3% (1 to 5%) of all trauma admissions and as many as 10% of patients who sustain BAT. The kidney is the most common injured genitourinary (GU) organ.(65) Adopt a high level of suspicion for renal injuries in patients with major BAT, patients complaining of gross hematuria. (66) MVC being the most common cause; less common causes include: a direct blow to the flank or abdomen during an assault, a fight or sports activity (e.g., bicycling, horseback riding, and a fall from a height). Children and young adults are victims of blunt force traumatic injuries more often than the older person, with the incidence in males being approximately ten times as high as it is in females. These differences are because young males are more active and tend to engage in activities which have a greater chance to lead to renal injury. (65)

Mechanism of injury:

Thus, due to its somewhat protected position by the surrounding ribs, muscles (psoas and quadratus lumborum), perinephric fat, and peritoneum, the kidneys are rarely damaged by frontal blunt force trauma, but may be injured by impact laterally or posteriorly in the region of the loin either due to crushing or deceleration. Impacts to the flank can compress the kidney against the lumbar vertebrae.(65)

Diagnostic tests:

Hematuria is the hallmark of GU injury. Renal injury should be suspected and evaluated in patients with hematuria. Hematuria can result from injury anywhere along the GU tract and multiple urologic injuries can coexist. The mechanism, location and severity of injuries play an important role in determining the need and type of further diagnostic evaluation and/or therapeutic intervention. (56)

Classification of kidney injuries:(56)

Table (5): American Association for the Surgery of Trauma Kidney OIS:

Grade*	Type of injury	Description of injury	AIS
I	Contusion	Microscopic or gross hematuria, urologic studies normal	2
	Hematoma	Subcapsular, nonexpanding without parenchymal laceration	2
II	Hematoma	Nonexpanding perirenal hematoma confined to renal retroperitoneum	2
	Laceration	Parenchymal depth of renal cortex (<1.0 cm) without urinary extravasation	2
III	Laceration	Parenchymal depth of renal cortex (>1.0 cm) without collecting system rupture or urinary extravasation	3
IV	Laceration	Parenchymal laceration extending through the renal cortex, medulla, and collecting system	4
	Vascular	Main renal artery or vein injury with contained hemorrhage	4
V	Laceration	Completely shattered kidney	5
	Vascular	Avulsion of renal hilum which devascularizes kidney	5

*Advance one grade for bilateral injuries up to grade III.

Approximately 82% of injuries may be classified as grade 1, minor parenchymal lacerations (grade 2) accounted for 6% and major lacerations (grades 3 & 4) accounted for 7% of injuries. Vascular injuries (grades 4 & 5) accounted for only 5.5% of cases.(65)

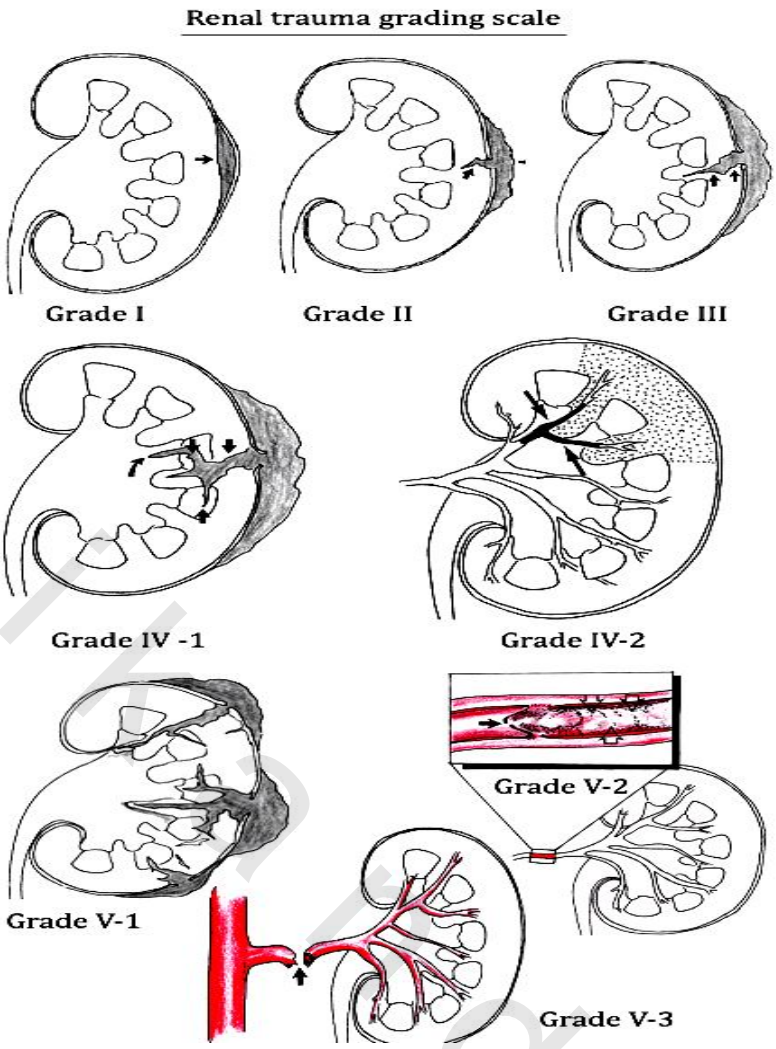


Figure (6): An illustration of the various grades in severity of injury to the kidney, extending from Grade 1, which is a subcapsular hematoma to a Grade 5, which includes a completely shattered kidney.(65)

Management:

Renal management has three goals:(65)

(1) Minimize hemorrhage.
(2) Maintain urinary flow without obstruction to preserve renal function.
(3) Prevent extravasation of urine outside the urinary tract, thereby decreasing the risk of local and systemic infection.

95 to 98% of isolated renal injuries are considered minor injuries and are managed nonsurgically because they usually heal spontaneously and without complications.(65) The majority of renal injuries can be managed non operatively, with few absolute indications for surgical intervention. (67)

Non operative management is the standard of care for hemodynamically stable patients with grade I to III and nonvascular grade IV renal injuries. (56) The non operative management involves a period of bed rest, monitoring of vital signs and serial hematocrit measurements, with either selective or routine use of early follow-up imaging. (68,69)

Laparotomy and repair is indicated if there is:

1. Persistent bleeding or blush on CT scan, hemodynamic instability. (44)
2. Urinary extravasation that is persistent over 48–72 hours. In most patients presenting with gross hematuria, the hematuria usually resolves. In cases where the hematuria does not resolve and the imaging studies suggest renal fragmentation. (44)
3. It may be required to remove whole or part of the kidney. The warm ischemia time for the kidney is four to six hours, and hence attempts at revascularization after traumatic avulsion or thrombosis of the renal artery are usually futile. (44)
4. Presence of an expanding or pulsatile hematoma, or when a hilar injury is suspected.(37)
5. Moderate severity injuries can be controlled usually by cortical renorrhaphy and drainage; occasionally, a polar nephrectomy may be indicated. A shattered kidney or a vascular hilar injury requires nephrectomy. (37)

Ureter:

Incidence:

The ureteral injuries in adults are more commonly penetrating than blunt.(70) Blunt ureteric injury is rare and usually occurs with other major injuries that require laparotomy. (44) Accounting for less than 1% of all urologic traumatic injuries. The upper third of the ureter is more often injured than the middle and lower thirds.(70)

Associated injuries are frequently present. These injuries can result from high-speed motor vehicular accidents, falls from a substantive height, or a direct blow to the lumber vertebrae L2-L3. There is another type of blunt traumatic lesion, which is referred to as a straddle injury. These are more commonly seen in children than adults These are injuries produced when the person falls, striking the urogenital area with the force of their body weight. Injury is caused by the compression of soft tissues against the bony margins of the pelvic outlet. (65)

Mechanisms of injury:

The rarity of ureteral trauma is due to the fact it is well protected in the retroperitoneal space by the bony pelvis, psoas muscles and vertebrae. Such injuries involve deceleration or acceleration mechanisms, typically, causing a partial or total avulsion at the ureteropelvic or ureterovesical junctions. Undiagnosed ureteral injuries can result in significant morbidity and mortality. (65)

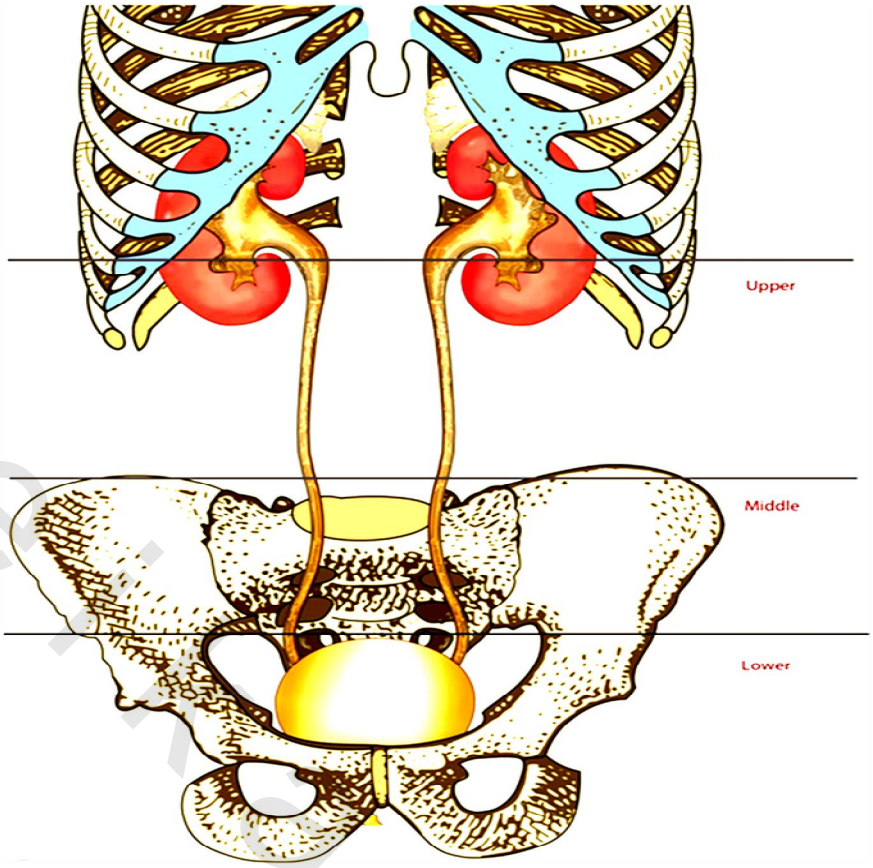


Figure (7): An illustration of anatomic division of the ureter.[70]

Diagnostic tests:

Typically there are no classic signs or symptoms for ureteral injuries, but should be suspected in all cases of blunt deceleration trauma, particularly in children in whom the kidney and renal pelvis can be torn from the ureter, secondary to their hyper-extensible vertebral column. Hematuria is not a sensitive indicator of ureteral trauma and any patient that presents with gross hematuria, flank pain or ecchymosis should undergo more extensive investigation. CT scan and retrograde pyelography accurately identify ureteral injuries when performed together. Delay in diagnosis is correlated with a poor prognosis.[70]

Classification of Ureter injuries: [56]

Table (6): American Association for the Surgery of Trauma Ureter OIS:

Grade*	Type of injury	Description of injury	AIS
I	Hematoma	Contusion or hematoma without devascularization	2
II	Laceration	Transecection <50%	2
III	Laceration	Transection ≥50%	3
IV	Laceration	Complete transection with <2 cm devascularization	3
V	Laceration	Avulsion with >2 cm of devascularization	3

*Advance one grade for bilateral lesions up to grade III.

Management: [70]

The most important factor in the management of these injuries is to maintain drainage of urine from the kidney and to prevent the formation of urinoma and abscess Ureteroureterostomy, with or without indwelling stent, is the surgical procedure of choice of both trauma surgeons and urologists.

Vascular Injuries:

Major retroperitoneal vascular structures include the abdominal aorta, IVC, renal vessels, proximal celiac axis and superior mesenteric arteries, superior mesenteric vein, lumbar arteries and veins, and iliac vessels within the pelvis.[22]

Blunt injury to the abdominal aorta is uncommon, with thoracic aortic injuries occurring 20 times more frequently than abdominal aortic injuries in several autopsy series. The infrequency with which blunt abdominal aortic injury occurs is likely due to the central protected position of the abdominal aorta. Most injuries result in damage to the intima, with creation of an intimal flap. The degree of injury may range from subtle intimal injuries to frank transection. Thrombus formation may occur with partial or total aortic occlusion. A mortality rate of up to 24% has been reported for these injuries. [22]

Injuries involve the infrarenal abdominal aorta in almost all cases (98%). Proposed mechanisms for traumatic rupture of the abdominal aorta include direct forces on the abdominal aorta, such as between a lap belt and the lumbar spine, as well as indirect forces generated by transmission of the pressure of the initiating force through adjacent organs to the aortic wall. Neurologic deficits ranging from sensory loss to paraplegia have also been associated with abdominal aortic injuries. [6] Blunt injuries to the IVC are also rare. These injuries can be difficult to diagnose, since many of the reported cases lack contrast material extravasation as direct evidence of vascular injury. [71]

Abnormal findings within the retroperitoneum following trauma:

- **Retroperitoneal Hematoma (RPH):**

Retroperitoneal hemorrhage may arise from injuries to major vascular structures, hollow viscera, solid organs, or musculoskeletal structures or a combination thereof. [76] From a surgical stand point, the retroperitoneum can be divided into zones because hematoma location has therapeutic implications. [73]

Table (7): Anatomic Zones of the Retroperitoneum. [73]

Zone	Vascular Contents	Visceral Contents
I (midline retroperitoneum)		
Supramesocolic area	Suprarenal abdominal aorta, celiac axis, proximal superior mesenteric artery, superior mesenteric vein, proximal renal arteries	Pancreas, duodenum
Inframesocolic area	Infrarenal abdominal aorta, infrahepatic IVC	. . .
II (upper lateral retroperitoneum)	Renal arteries, renal veins	Kidneys, adrenal glands, renal pelves, proximal ureters
III (pelvic retroperitoneum)	Iliac arteries, iliac veins	. . .

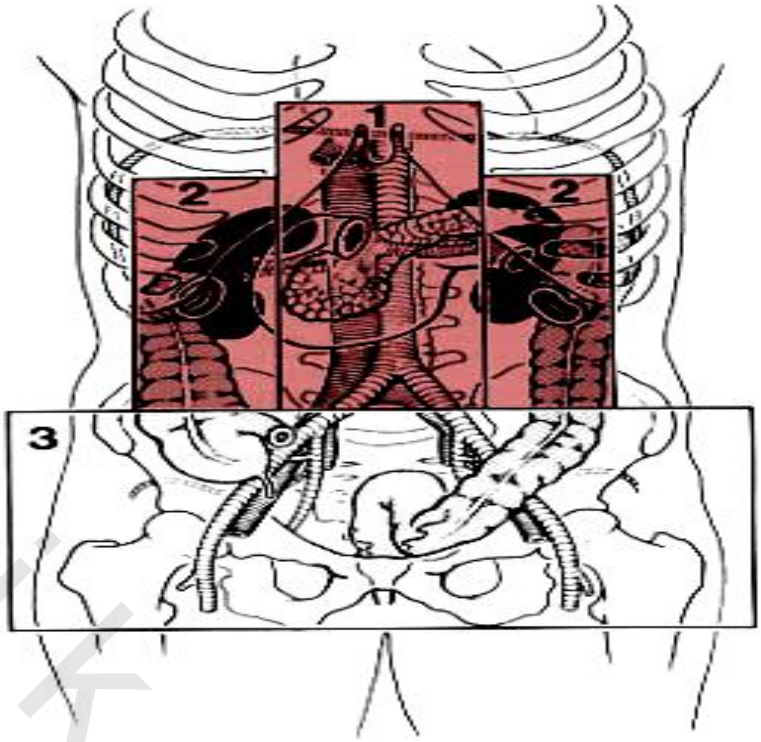


Figure (8): Zones of retroperitoneum. [73]

4- Central-medial retroperitoneal zone.
5- Lateral retroperitoneal zone.
6- Pelvic retroperitoneal zone.

Zone I retroperitoneal hemorrhage includes the midline area between the aortic hiatus and sacral promontory and carries the highest risk of vascular injury because the major abdominal vessels lie in this zone. Unless they are small or stable, many zone I retroperitoneal hemorrhages are investigated with a surgical approach. [73]

Zone II encompasses the flank or lateral retroperitoneum, including the right and left perirenal spaces, and represents the second most common site of retroperitoneal hemorrhage after the pelvis. Renal injuries account for the majority of these hemorrhages. Management depends on the severity of the hemorrhage and may include exploration or angiographic embolization for large or expanding hematomas. [6] Many perirenal and pericolonic hematomas are self limiting, and patients can be treated with observation alone if they remain hemodynamically stable and no extraluminal gas or active extravasation of contrast material is identified at initial imaging. [73] Follow-up imaging can be used to assess the stability of retroperitoneal hemorrhage when observation is chosen. [74]

Zone III encompasses the pelvic retroperitoneum and is the most common location of retroperitoneal hemorrhage, frequently in association with pelvic fractures. [72] Surgical intervention is avoided in most cases of blunt pelvic trauma, with external fixation and angiographic embolization being the preferred methods for addressing large, expanding, or actively bleeding pelvic hematomas. Surgical intervention is generally reserved for major arterial injury, exsanguinating pelvic bleeding, or bleeding into a peritoneal wound. [6]

Incidence:

RPH is frequently due to blunt trauma. Incidence of this complication in adults is high, but in childhood is uncommon. RPH in infancy should be treated conservatively. [75]

Management:

Clinical management depends on the presence of active contrast material extravasation, hematoma size and stability, and the hemodynamic status of the patient. Options include surgical intervention, angiographic embolization, and observation with fluid support.The goals of imaging are to identify the retroperitoneal hemorrhage, its location, and its possible source and to assess its relative stability on the basis of the size and presence (or absence) of active extravasation of IV contrast material. [74]

Although the guidelines for exploration are clear-cut during laparotomy for associated intra-abdominal injuries, this is not the case with isolated RPH. For the traumatized patient with RPH, laparotomy is mandated by persistent hemodynamic instability despite intensive volume replacement.The judgment of whether and when to explore the RPH is guided by the mechanism of injury (blunt or penetrating) and the location of the RPH. [76]

Despite all the advances in the fields of technology and surgical techniques, RPH still remains as a nightmare for the surgeons. There are still many uncertain points in respect to their diagnosis and treatment. Especially decision making for surgical intervention of pelvic RPH is very difficult and risky decision to make for the surgeons. [77] The choice to "open" a patient with RPH has to be taken upon a careful estimation. It could be better in more than a situation leave such hematoma in its place, especially in the iliac region, waiting for the spontaneous resolution of the hemorrhagic source and of the hematoma itself.[8]

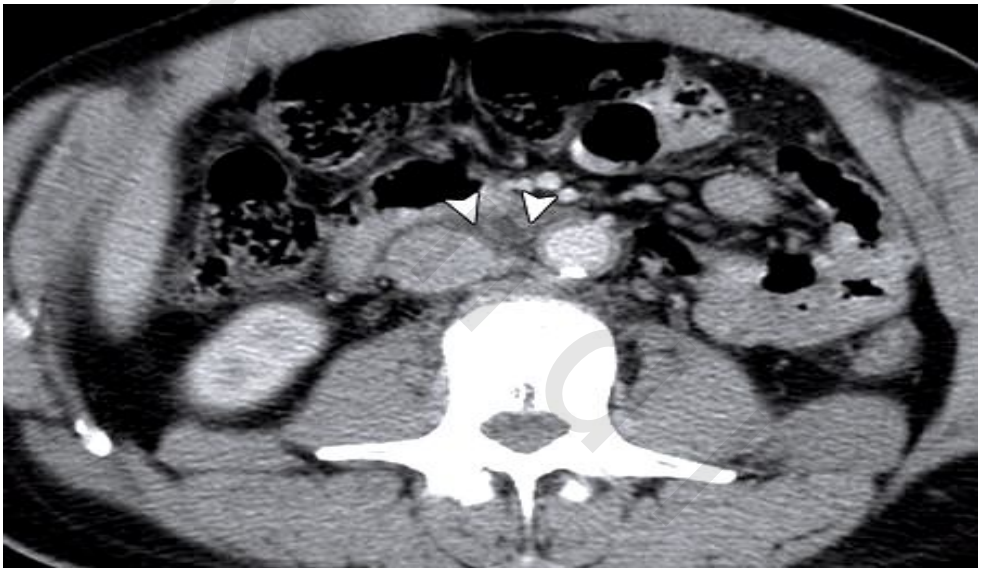
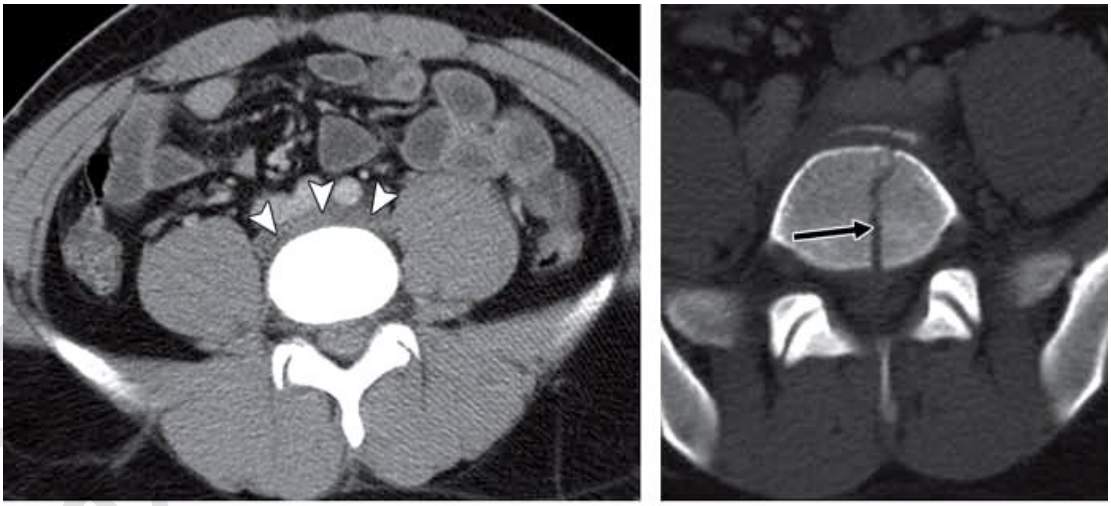


Figure (9): Abdominal CT scan with IV contrast (Small zone I retroperitoneal hematoma) shows a small amount of intermediate-attenuation fluid (arrowheads) between the aorta and IVC, the finding represents venous hemorrhage. [73]

- ## Para spinal or Spinal Injuries:

Thoracolumbar spinal injuries with resultant paraspinal hematoma may account for the appearance of RPH, particularly one that displaces the aorta and IVC anteriorly. [78] The presence of aparaspinal hematoma is an important sign of spinal injury and should prompt careful evaluation of the adjacent spinal elements and paraspinal musculature. [79]



a. b.

Figure (10): Paraspinal hematoma due to a burst fracture.**(a)** Contrast-enhanced CT scan obtained through the upper pelvis shows a paraspinal hematoma (arrowheads)that surrounds the L5 vertebral body.**(b)** CT scan (bone window) shows a burst fracture of L5 (arrow). [79]

- ## Retroperitoneal Air:

The presence of retroperitoneal air should raise suspicion for a perforated retroperitoneal viscus in the setting of both blunt and penetrating abdominal trauma. Isolated pneumoretroperitoneum in the anterior pararenal space adjacent to the duodenum is suggestive of a duodenal perforation. [6] Likewise, localized pericolonic retroperitoneal air is suggestive of colonic perforation. [80]

Pneumoretroperitoneum from communications between the retroperitoneum and the thorax is more commonly seen, particularly in patients with a pneumothorax who are on mechanical ventilation. Airway injury anywhere from the pharynx to the alveolus can produce pneumomediastinum and, in turn, pneumoretroperitoneum. Esophageal perforation producing pneumomediastinum is another potential source of retroperitoneal air. [6]

- ## Retroperitoneal Fluid:

The presence of fluid within the retroperitoneum in the setting of trauma should raise suspicion for pancreatic injury, duodenal injury, renal collecting system injury (with urine leakage), or retroperitoneal hemorrhage. However, retroperitoneal fluid accumulation can be seen in the absence of retroperitoneal injury. [81] [82]

Resuscitation effects alone can result in the appearance of low-attenuation retroperitoneal fluid. [83] The radiologist must exclude underlying injury particularly injury to the pancreas, duodenum, or renal collecting system before concluding that the presence of retroperitoneal fluid is likely the result of resuscitation or shock. Because both pancreatic and duodenal injuries can be subtle at initial CT, close clinical observation with possible imaging follow up should be considered in cases of equivocal CT findings. [84]

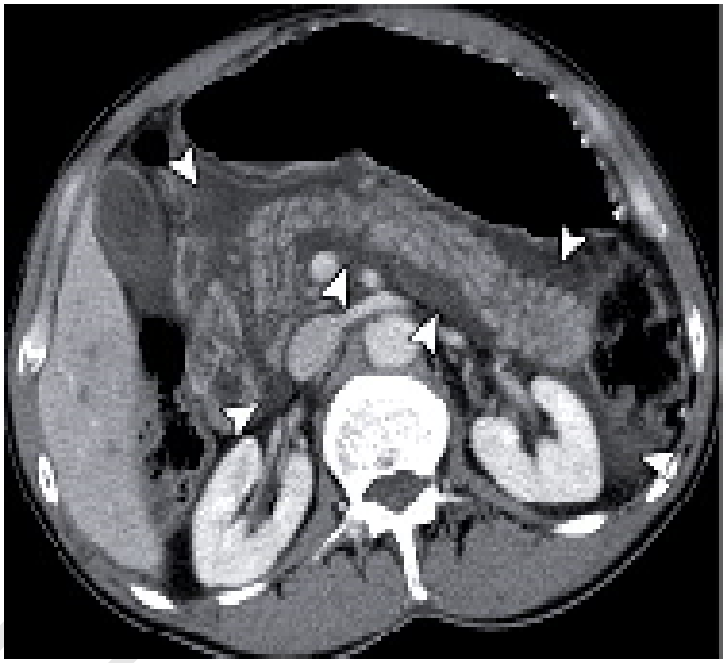


Figure (11): Abdominal CT scan (Retroperitoneal fluid without retroperitoneal organ injury) shows fluid within the anterior pararenal space (arrowheads) diffusely surrounding the pancreas. [81]