Blunt abdominal trauma: CT findings in patients with solid organ, bowel, mesenteric and diaphragmatic injury

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1. Learning objectives

To recognize the CT signs of solid organ, bowel, mesenteric and diaphragmatic injuries from blunt trauma. To differentiate CT findings indicative of significant injury from those indicative of nonsignificant injury.

2. Background

- Blunt abdominal trauma is a common cause of morbidity and mortality among patients admitted to trauma centers after sustaining multiple traumatic injuries.
- Although abdominal injuries are often suspected in this setting, clinical diagnosis can be challenging due to the lack of specific physical findings in many patients.
- In addition, the presence of associated injuries may mask overt clinical manifestations or divert the attention of the admitting physician away from potentially life-threatening intra-abdominal bleeding.
- Blunt trauma mechanisms leading to significant intra-abdominal injuries often include compression and deceleration forces.
- Motor vehicle collisions are the leading cause of injury throughout the world.

Diagnostic Evaluation

- After initial evaluation and resuscitation, subsequent management depends heavily on the hemodynamic stability of the patient.
- Patients who remain hypotensive, with clinically obvious continued intra-abdominal bleeding, may go directly to the operating room.
- - Currently, ultrasonography performed at the bedside by an experienced ultrasonographer, is more often used for this purpose.
- Hemodynamically stable patients and patients who respond to initial resuscitation measures require further diagnostic evaluation.
- With current multidetector technology, CT is a rapid and accurate test for detecting injuries that require immediate therapy or observation in multiple body parts.

CT Protocols

- Although a standard CT protocol is important in the setting of trauma, the examination needs to be tailored to the patient's condition.
- The majority of acute trauma patients is now examined without oral contrast administration. Only in selected cases, and if the pa-tient's condition permits, 250-500 ml of water-soluble oral contrast material (2-5%) are administered via the nasogastric tube in the emergency department and an ad-ditional 250 ml in the CT suite immediately before scan-ning. Additional administration of rectal contrast materi-al is an option in patients with pelvic trauma or a sus-pected colon injury.
- Preliminary scanning before administration of intra-venous contrast material may sometimes facilitate image interpretation but is not recommended routinely as it also increases the radiation dose significantly.
- An automated uniphasic bolus injection of 130-180 ml of intravenous non-ionic iodinated contrast material is given at 2-4 ml/s. A standard scan delay of 70-90 s may be used, but a longer delay may be preferable in patients with significant arterial hypotension in order to avoid artefacts in the early parenchymal phase or to miss extra-vasation of contrast material.
- Repeat, delayed scanning may be necessary for better demonstration of the distri-bution of

extravasated contrast material from the blood vessels, parenchymal organs, gastrointestinal tract or uri-nary system.

- Depending on the questions that need to be answered, additional acquisitions may then be per-formed.
- Regardless of the scanning protocol used, modern 16- and 64-row detector scanners share several definite advantages over earlier generation scanners. The most important of these is their markedly improved temporal resolution. Other benefits include improved quality of multiplanar (MPR) and three-dimensional (3D) reformations and the ability to combine routine protocols with CT angiograms of multiple body parts while still using a single bolus of contrast.

3. Imaging findings OR Procedure details

Liver Trauma

General features

- Liver 2nd most frequent injured solid intra-abdominal organ after spleen
- Location: right lobe (75%), left lobe (25%)

CT findings

- Lacerations: hypoattenuating linear, often branching regions within the parenchyma of the liver.
- Parenchymal and subcapsular hematomas: lenticular conforms to the confines of the liver capsule.
- - Unclotted blood (35-45 HU) soon after injury
  - - NECT: may be hyperdense relative to normal liver
    - CECT: hypodense compared to enhancing normal liver
  - Clotted blood (60-90 HU) - sentinel clot sign
  - - More dense than normal unenhanced liver
- Active hemorrhage or pseudoaneurysm
- - CECT: active hemorrhage
  - - Isodense to enhanced vessels
    - Seen as contrast extravasation (85-350 HU)
  - Pseudoaneurysms, identified as hyperattenuating foci on early phase images and demonstrating washout on delayed phase images, have been described involving arterial as well as hepatic and portal venous branches.
- Hemoperitoneum: perihepatic and peritoneal recess collections of blood
- Areas of infarction: wedge-shaped peripheral areas of low attenuation

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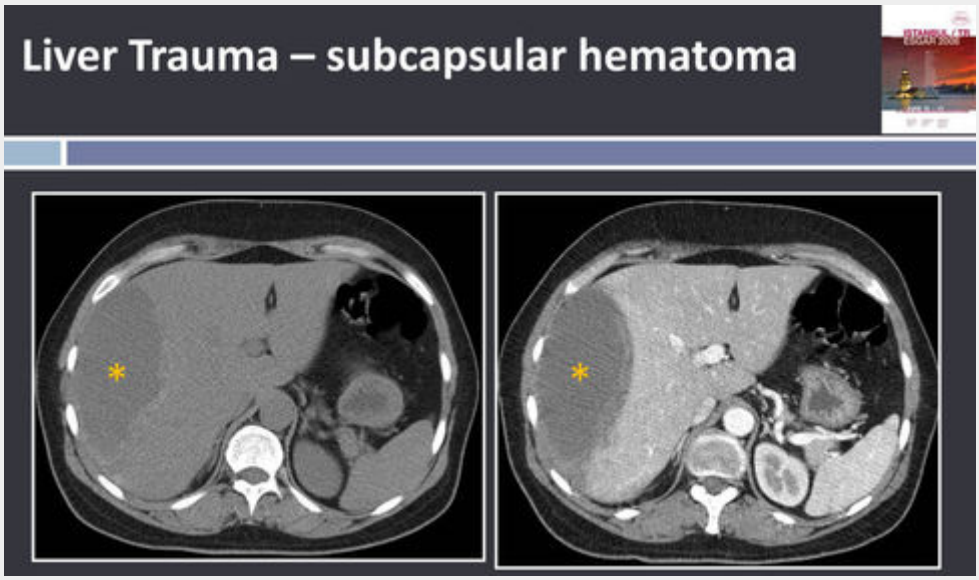

Non-contrast and portal venous phase CT axial images.

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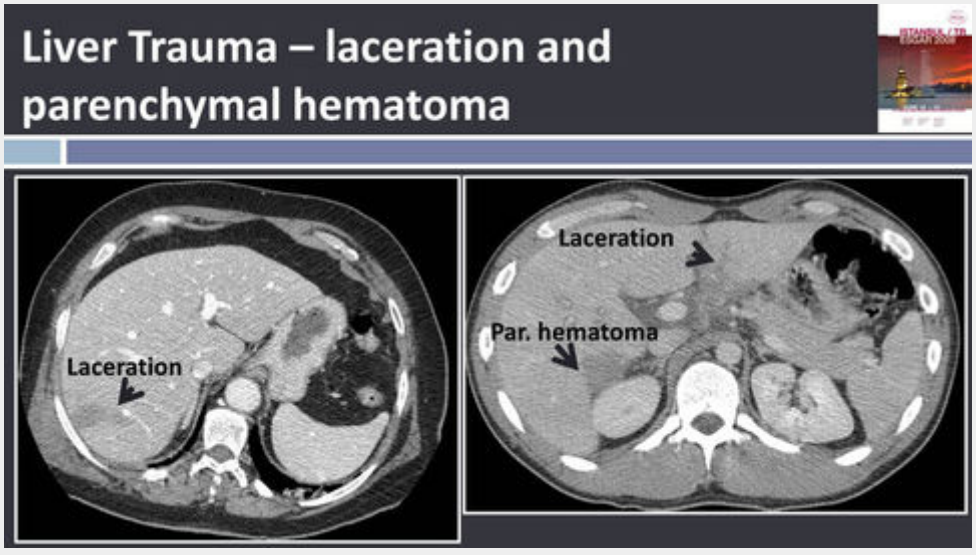

Axial CT images from two different patients. Portal venous phase.

Splenic Trauma

General features

- The spleen is the most commonly injured intraperitoneal organ in blunt trauma
- It is vital to image in the portal venous phase during peak splenic parenchymal enhancement to demonstrate splenic injury optimally. Imaging during the early arterial phase may simulate injury owing to normal transient heterogeneous enhancement of splenic tissue during this

period.

CT findings

- NECT: high attenuation (> 30 HU) hemoperitoneum or perisplenic clot (> 45 HU)
- CECT
- - Subcapsular hematoma: compresses lateral margin of parenchyma
  - Parenchymal laceration: jagged linear area of nonenhancement due to hematoma
  - Splenic fracture: deep laceration extending from outer capsule through splenic hilum
  - Active arterial extravasation: high attenuation focus isodense with aorta; surrounded by lower attenuation clot or hematoma; shows no evidence of washout on delayed imaging
  - Contained vascular injuries (as pseudoaneurysm or arteriovenous fistula) appear more regular, are most commonly within the borders of the spleen, and follow enhancement of adjacent arterial structures, showing washout on delayed images
  - Devascularization appears as a geographic region of nonenhancing parenchyma due to injury of major hilar vascular structures.

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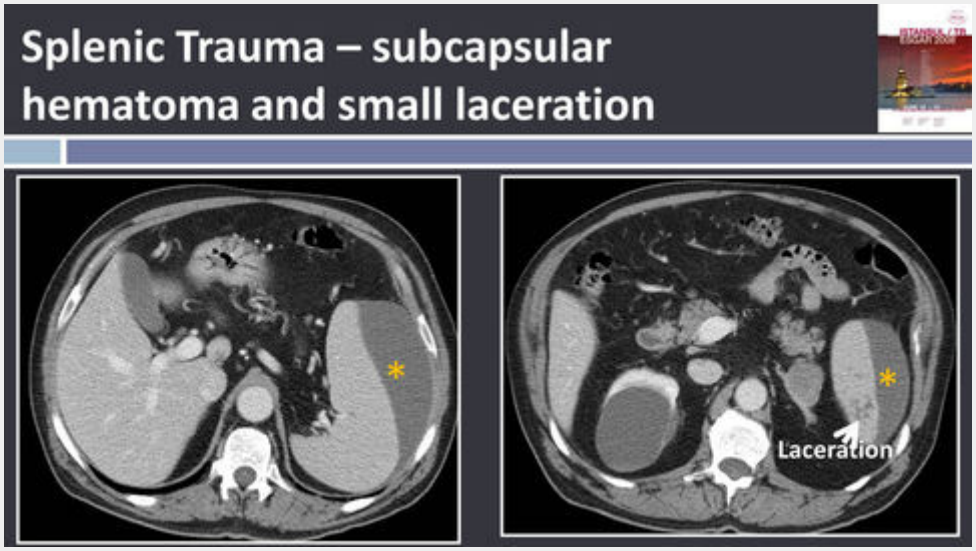

Portal venous phase axial CT images.

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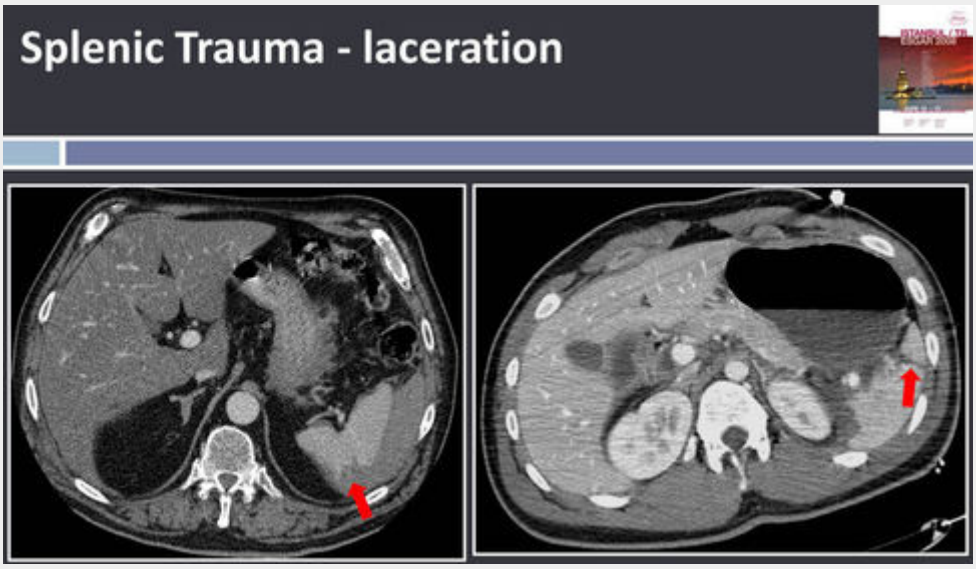

Axial portal venous phase CT images

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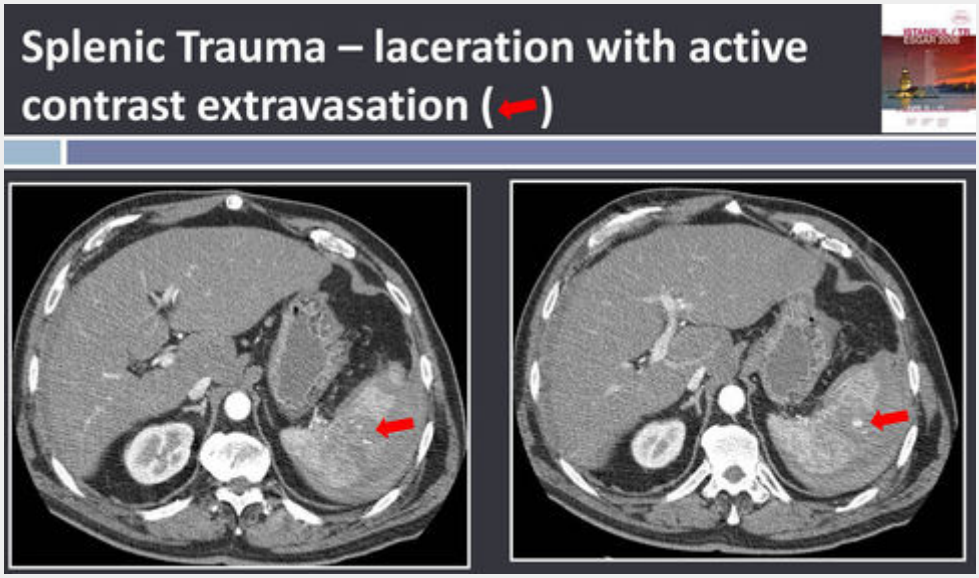

Axial arterial phase CT images.

Biliary trauma

General features

- Intrahepatic biliary ductal injury is often associated with acute liver injury.
- Intrahepatic ductal injury may result in continued bile leak and biloma formation, a cause of significant morbidity.
- The location of the hepatic parenchymal injury may predict those patients more likely to

develop bile leak. Central injuries often carry a higher likelihood of biloma development given the increasing diameter of the bile ducts in this location.
- Percutaneous transhepatic, hepatobiliary scintigraphy or endoscopic retrograde cholangiography: gold standard for diagnosis of bile duct injuries
- Common bile duct / common hepatic duct are most frequently injured
- Injuries of the gallbladder are uncommon in blunt abdominal trauma.

CT findings

- Presence of biliary dilatation, configuration of injured bile duct
- Hemobilia: blood may appear as high-attenuation material (> 50 HU) in ducts / gallbladder
- Gallbladder trauma
-
    - Gallbladder wall thickening, pericholecystic fluid, hyperattenuation within the lumen suggesting hemobilia, or direct evidence of frank mural disruption may be identified
    - Further evaluation of the integrity of the gallbladder may be accomplished by a variety of modalities including ultrasound, hepatobiliary scintigraphy, MRCP, or ERCP.
- Ancillary signs of liver injury

Pancreatic trauma

General features

- Injury of the pancreas, while uncommon, presents a difficult imaging diagnosis.
- An important role of imaging in patients with pancreatic trauma is to assess for injury to the main pancreatic duct, which typically requires intervention in the form of operative management or endoscopic retrograde cholangiopanctreatography (ERCP) with stent placement.
- The application of CT imaging to the diagnosis of acute pancreatic injury has thus far resulted in fairly low diagnostic accuracy.
- The image quality afforded by 64-row MDCT may improve the detection of injury, though the morphology of the pancreas itself, with its many clefts, continues to present a diagnostic challenge.
- Early evidence shows magnetic resonance cholangiopanctreatography (MRCP) may be useful in diagnosing pancreatic injury. MRCP allows for improved visualization of the main pancreatic duct and may be used for assessment of main duct injury. The use of secretin may further increase the diagnostic accuracy of MRCP in pancreatic ductal injury by temporarily increasing ductal caliber and allowing for improved visualization.
- ERCP may be used in both the diagnostic confirmation and treatment of pancreatic ductal injuries.

CT findings

- Focal / diffuse pancreatic enlargement; irregularity of pancreatic contour
- Edema / fluid in peripancreatic fat
- Heterogeneous parenchymal attenuation
- Laceration
-
    - Area of low attenuation
    - Linear cleft, usually oriented anteroposteriorly
- Pancreatic fracture or transaction
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    - Ill-defined low density area
    - Results in clear separation of two ends of gland
    - Nearly always extends through pancreatic neck
- Extrapancreatic fluid collections

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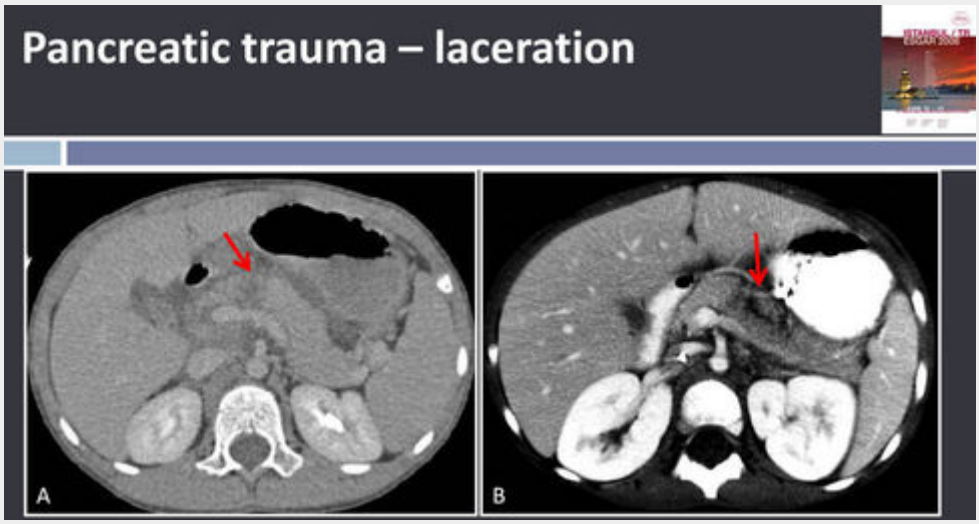

A. 16-year-old boy. Delayed phase axial CT image. Traumatic pancreatic laceration with suspected injury to the pancreatic duct at the junction of the body and the neck. B. 15-year-old boy. Portal venous phase (with oral contrast) axial CT image. Multifocal laceration injury to the pancreatic body

Renal Trauma

General features

- Renal injury is a common occurrence in trauma with incidence of up to 10% in significant blunt abdominal injury.
- Currently, CT is routinely used to diagnose and to characterize traumatic renal injuries. The initial CT scan, typically acquired during the portal venous phase, is used to characterize renal parenchymal injuries including hilar injuries that may devascularize the kidney. The delayed images, typically performed 5 minutes following intravenous contrast injection, are crucial in identifying injury to the collecting system or uretero-pelvic junction as evidenced by extravasation of excreted contrast.

CT findings

- Intrarenal hematoma or contusion
- - Ill-defined round or ovoid lesion; parenchymal phase: reduced enhancement relative to normal kidney
- Subcapsular hematoma
- - Round or elliptic fluid collection (40-70 HU clotted blood)
- Laceration
- - Minor: small linear hypodense areas in periphery
  - Major: extending to medulla; extending into collecting system (contrast extravasation into perinephric space in excretory phase.
  - Shattered kidney
- Infarct
- - Small peripheral wedge-shaped area of low density in nephrographic phase
  - Subacute infarction (larger): cortical rim sign of preserved capsular or subcapsular

enhancement

- Vascular injury
- - Active arterial contrast extravasation
  - Global infarction (nonenhancement) + no perinephric hematoma (renal artery thrombosis)
  - Global infarction (nonenhancement) + perinephric hematoma (renal artery avulsion)
- Uretopelvic junction injury
- - Complete transaction or laceration
  - Perinephric contrast extravasation
  - Urinoma

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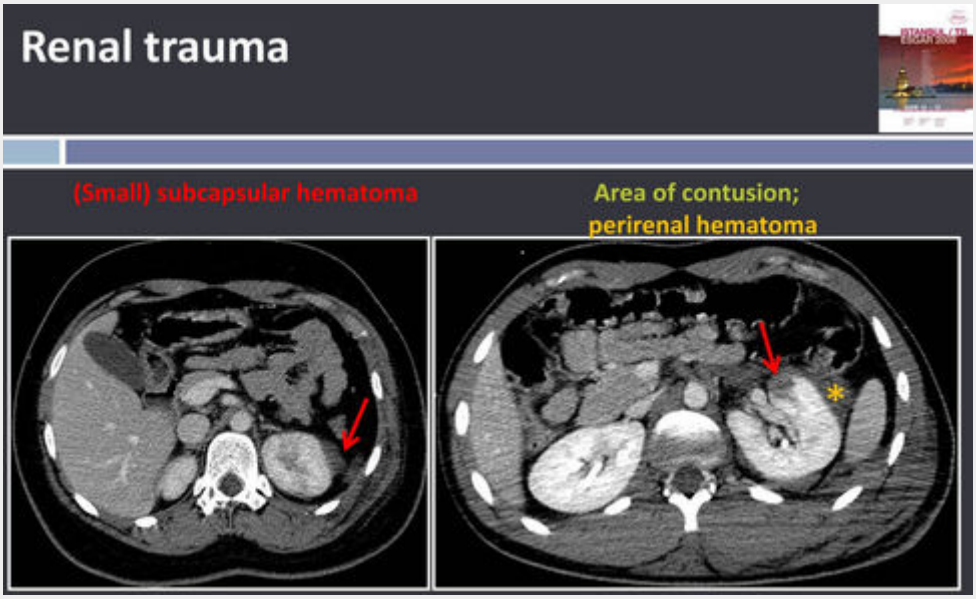

Axial CT images. Portal venous phase.

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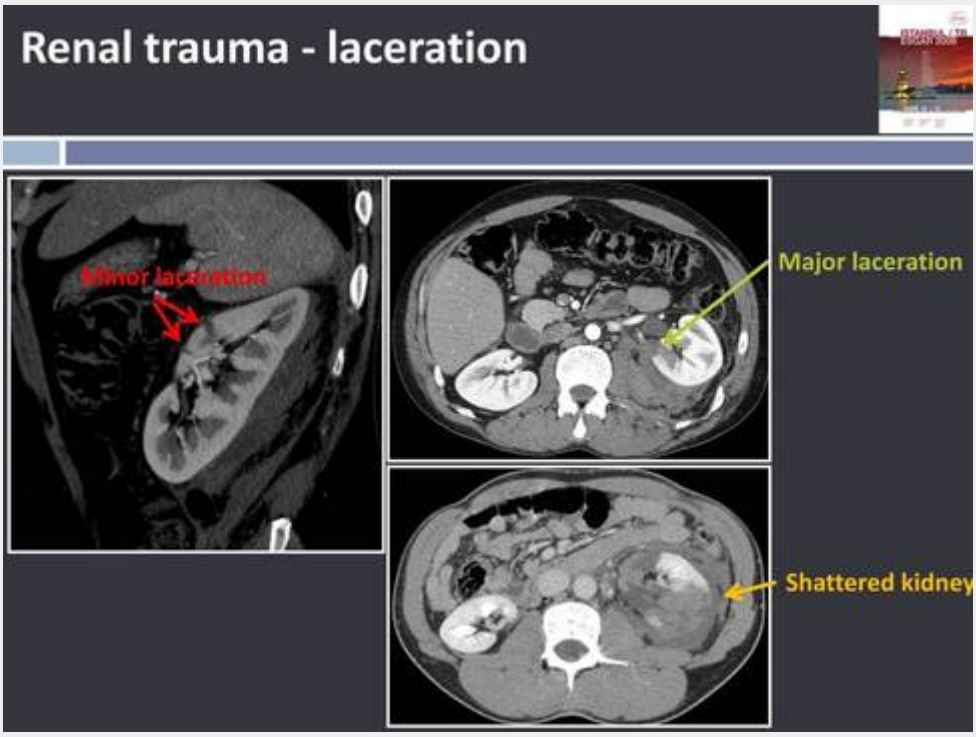

Sagittal reformatted and axial portal venous phase CT images from three different patients with renal trauma.

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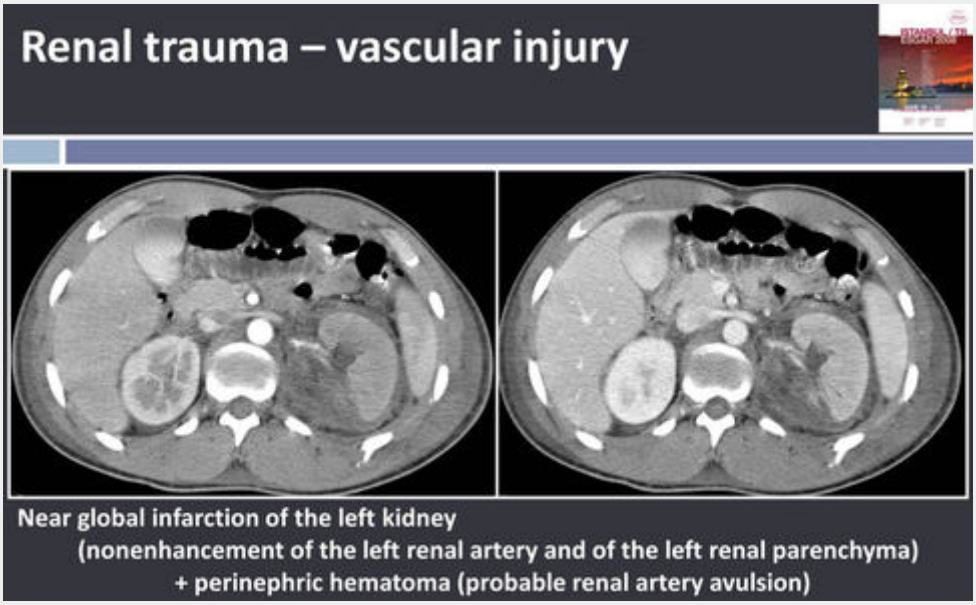

Arterial and portal venous phase axial CT images.

Bladder trauma

General features

- Bladder injury must be a consideration in patients with blunt abdominal injury, especially in patients with pelvic fractures.
- In addition, gross hematuria is a highly sensitive clinical sign for bladder injury.
- Currently, CT cystography, in which the bladder is filled with cystographic contrast (10ml of idodine contrast, 300ml saline) via a Foley catheter, is commonly used in patients with pelvic fractures or clinical suspicion of bladder injury. CT cystography may be integrated into routine trauma imaging of the abdomen and pelvis and has been shown to have a high diagnostic accuracy.

CT findings

- Bladder contusion: normal CT findings
- Intraperitoneal rupture: recognized as contrast within the peritoneal cavity, surrounding segments of bowel or within leaves of the mesentery
- Interstitial injury: intramural extravasation of cystographic contrast
- Extraperitoneal rupture: characterized by the presence of contrast material within the perivesical space or, in more severe injury, dissecting through the multitude of fascial planes in the extraperitoneal space.

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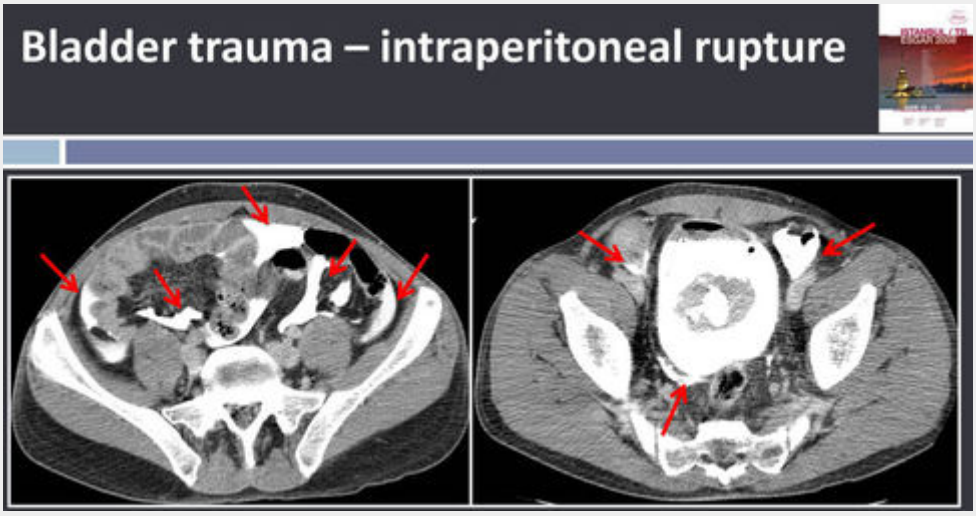

CT cystogram. Axial CT images demonstrates extravasation of contrast from the bladder into the peritoneal cavity.

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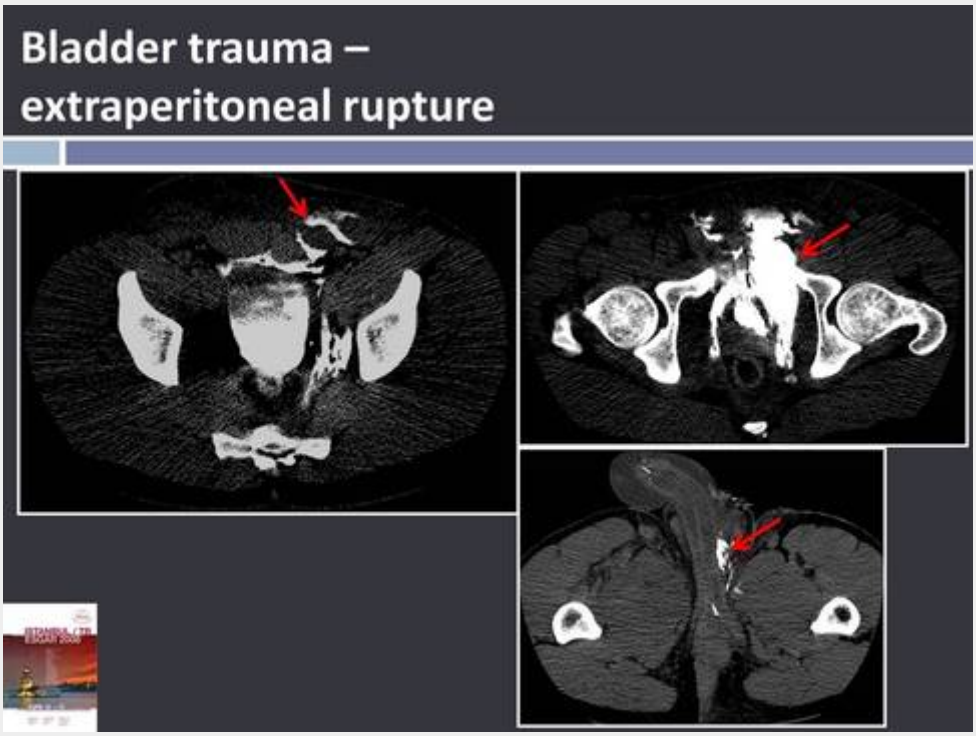

CT cystogram. Axial CT images demonstrates extravasation of contrast dissecting through the multitude of fascial planes in the extraperitoneal space.

Adrenal trauma

General features

- Adrenal injury is not an infrequent complication of major blunt abdominal trauma.
- The right adrenal gland is most commonly injured, reportedly in 85% of cases of adrenal gland injury. This may be as a result of the gland's precarious position interposed between the liver and the spine

CT findings

- CT appearance of adrenal hematoma is of an enlarged or obliterated gland.
- Less commonly, active extravasation of contrast is noted secondary to direct injury to the adrenal artery or vein.
- Complications rarely ensue after unilateral adrenal injury, although inferior vena cava thrombosis secondary to the compressive effects of an adrenal hematoma has been described.
- With bilateral injury, acute adrenal insufficiency may result.
- When seen on follow-up CT, the adrenal hematoma or diffuse gland enlargement typically regresses and calcifications or low attenuation pseudocysts may result as sequelae of acute adrenal injury.

Bowel and Mesenteric Injury

General features

- Bowel and mesenteric injuries are detected in 5% of blunt abdominal trauma patients at laparotomy.
- CT has been shown to be accurate for the diagnosis of bowel and mesenteric injuries and is the diagnostic test of choice in the evaluation of blunt abdominal trauma in hemodynamically stable patients.
- Unlike solid organ injury, it is uncommon to visualize direct evidence of bowel and mesenteric injury by CT. Instead, the interpreting radiologist has to rely on a number of indirect signs.

CT findings in bowel Injury

- Bowel Wall Discontinuity: uncommon finding on CT images
- Extraluminal Contrast Material: uncommon finding on CT images due to a lack of bowel distention during CT or to the transience of extraluminal contrast enhancement.
- Extraluminal Air: highly specific for a diagnosis of bowel perforation, but it also may be observed in the absence of bowel perforation
- - Subtle injuries may allow air to escape into the bowel wall, producing focal pneumatosis.

- Bowel Wall Thickening: isolated, localized, unequivocal bowel wall thickening in the context of trauma usually indicates bowel wall contusion.
- - Diffuse small-bowel wall thickening is atypical for contusion and may represent bowel edema secondary to systemic volume overload or to hypoperfusion complex (shock bowel). Hypoperfusion complex is usually associated with other findings of shock, such as a flat inferior vena cava, increased enhancement of adrenal glands and bowel.
- Abnormal Bowel Wall Enhancement: the area of thickening may appear hyperdense relative to the normal bowel wall due to the presence of blood.
- - On the other hand, areas of decreased or absent contrast enhancement are indicative of ischemic bowel.
- Mesenteric Features: mesenteric foci of fluid, air, or fat stranding may be secondary to bowel injury alone. Retroperitoneal air is seen with duodenal injury or injury to the retroperitoneal aspect of the ascending or descending colon

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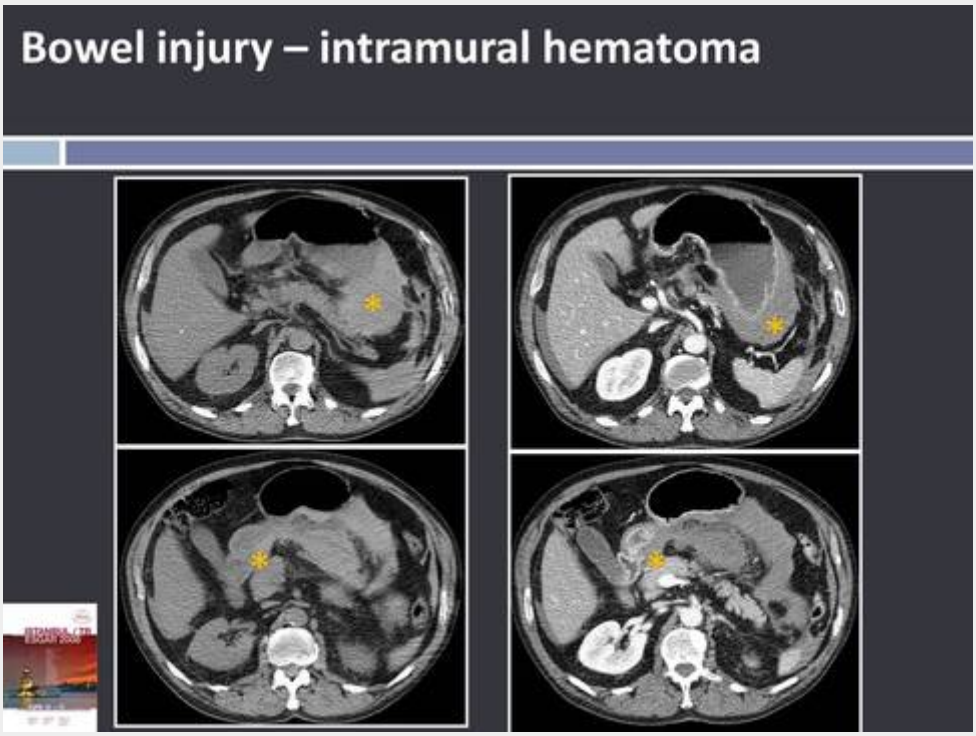

Axial CT image demonstrates the presence of eccentric gastric and duodenal wall thickening (asterisk) due to a focal intramural hematoma (spontaneously hyperdense in NECT, hypodense in CECT).

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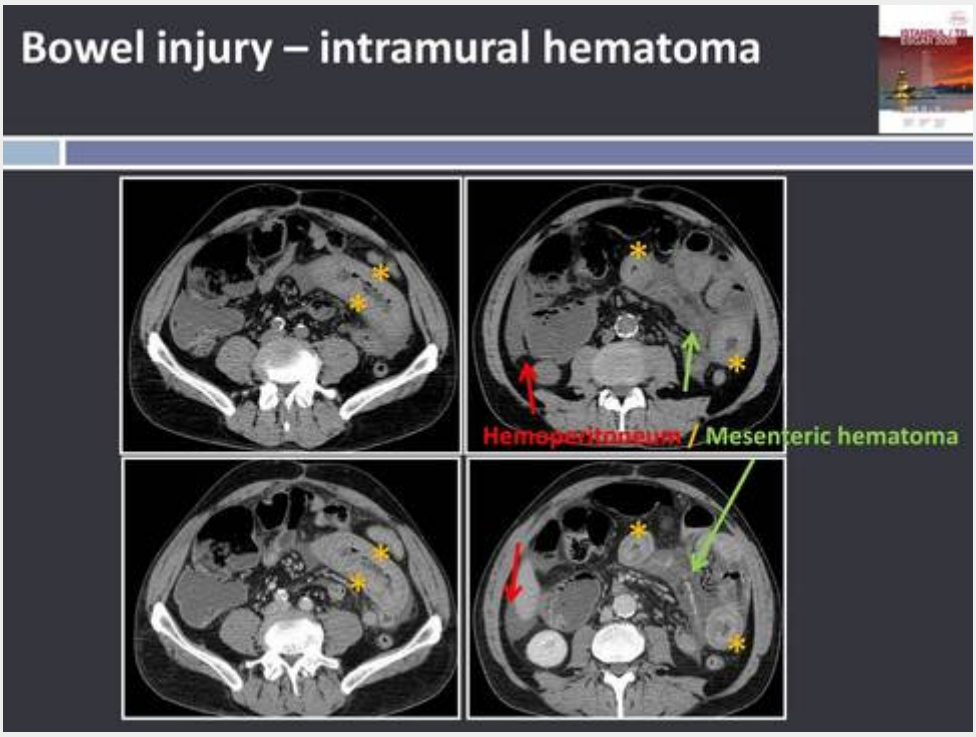

Axial CT image demonstrates the presence of extensive jejunal wall thickening (asterisk) due to a focal intramural hematoma (spontaneously hyperdense in NECT – upper row, hypodense in CECT – lower row).

CT findings in Mesenteric Injury

· Mesenteric Extravasation

· Mesenteric Vascular Beading: irregularity in mesenteric vessels.

· Termination of Mesenteric Vessels: abrupt termination of a mesenteric artery or vein

- Mesenteric Infiltration: haziness and fat stranding in the mesentery may indicate mesenteric injury with or without bowel wall injury. Retractile mesenteritis may simulate mesenteric injury, but it can be differentiated from mesenteric infiltration by the well-defined contour of the abnormally thickened mesentery and the presence of flat mesenteric lymph nodes surrounded by halos of hypoattenuation
- Mesenteric Hematoma: indicative of laceration of a mesenteric vessel

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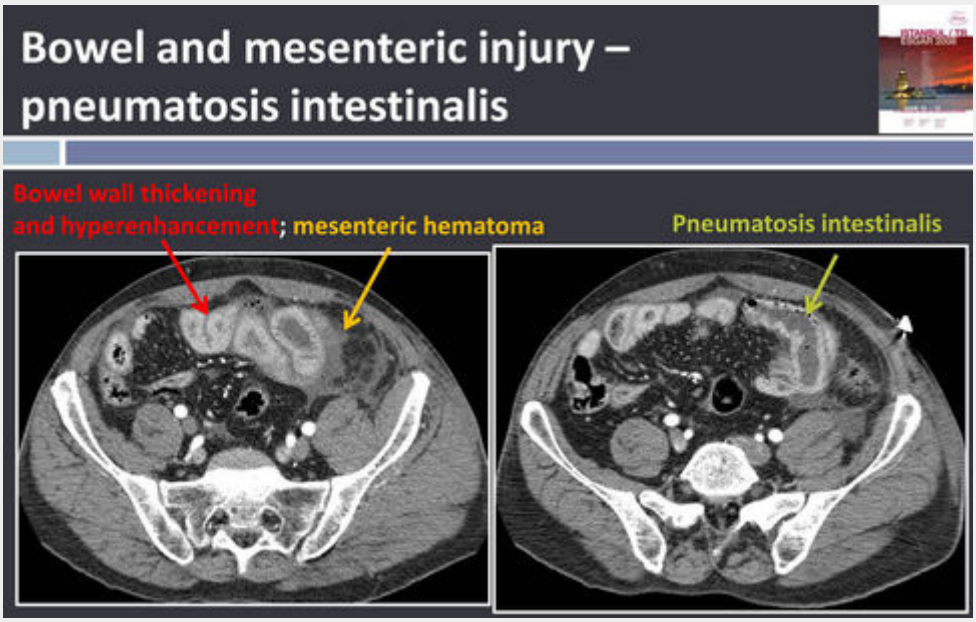

Axial CT image demonstrates the presence of extensive jejunal wall thickening due to intramural hematoma, mesenteric fluid and extraluminal parietal bubbles of gas in small bowel loop.

Common Features in Bowel and Mesenteric Injuries

- Intraperitoneal and Retroperitoneal Fluid: the location of the fluid may indicate the location of injury. Retroperitoneal fluid may indicate injury of a retroperitoneal segment of bowel. Retroperitoneal blood tends to localize at the site of injury. Hemoperitoneum in the absence of solid organ injury should raise the possibility of bowel or mesenteric injury.

Diaphragmatic trauma

General features

- Diaphragmatic rupture as a result of blunt trauma is rare and is found in 4% to 8% of patients who require emergency laparotomy.
- The left hemidiaphragm is involved more often than the right.
- Although most ruptures are diagnosed at the time of the injury, in some cases the acute injury may go unrecognized and cause delayed symptoms and complications such as gastric or colonic obstruction or strangulation.
- With MDCT, multiplanar reformations of thin section images provide a superb delineation of the complete diaphragm. Careful scrutiny of the orthogonal images is usually sufficient to confirm integrity.

CT findings

- Focal diaphragmatic discontinuity or elevation, herniation of abdominal hollow viscera or solid organs into the thorax, focal thickening (retraction) of the diaphragm, and segmental indistinctness of the diaphragm.
- - The stomach and colon are the most common viscera to herniate on the left side, and the liver is the most common viscus to herniate on the right side

- The “collar” sign: a waistlike constriction of the herniating hollow viscus at the site of the diaphragmatic tear
- The “hump” sign: describes a rounded portion of liver herniating through the diaphragm forming a hump-shaped mass
- The “ dependent” viscera sign: when a patient with a ruptured diaphragm lies supine at CT examination, the herniated viscera (bowel or solid organs) are no longer supported posteriorly by the injured diaphragm and fall to a dependent position against the posterior ribs

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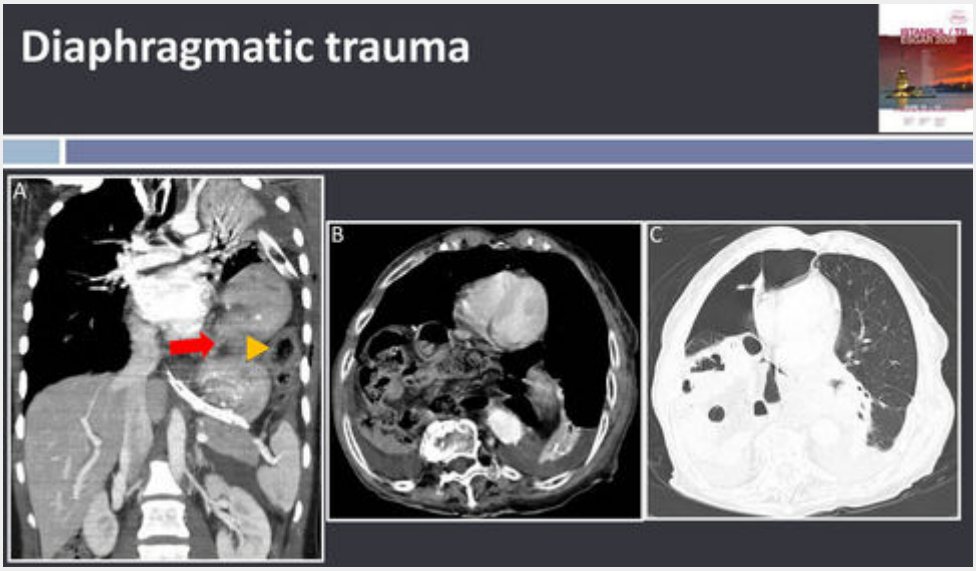

Selected images from two patients with blunt abdominal trauma and diaphragmatic rupture. Coronal MIP shows gastric herniation into the left chest and elevation of the splenic flexture of colon (arrowhead) as well. The stomach shows a collar sign (arrow) due to narrowing of at the level of the diaphragmatic tear. The left upper lobe is atelectatic. B. and C. Axial CT images showing herniation of the hepatic flexure and descending portions of the colon and right pneumothorax.

4. Conclusion

- MDCT is the imaging modality of choice to evaluate the hemodynamically stable patient who has blunt trauma.
- Technical advances have made it possible to scan rapidly during vascular, parenchymal, and excretory phases with optimal contrast enhancement.
- The volumetric data acquired can be used to obtain high-resolution MPR, MIP, and 3D images. These views have not only helped to display complex injuries but have also significantly increased the diagnostic capabilities, accuracy, and confidence of the trauma radiologist.
- MDCT has had a major impact on the number of patients with abdominal injury managed nonoperatively.

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7. Mediafiles

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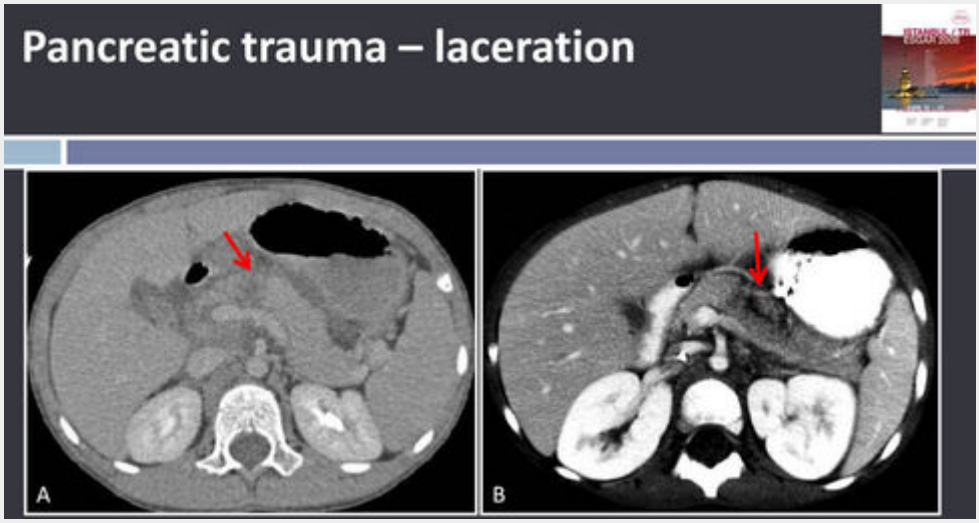

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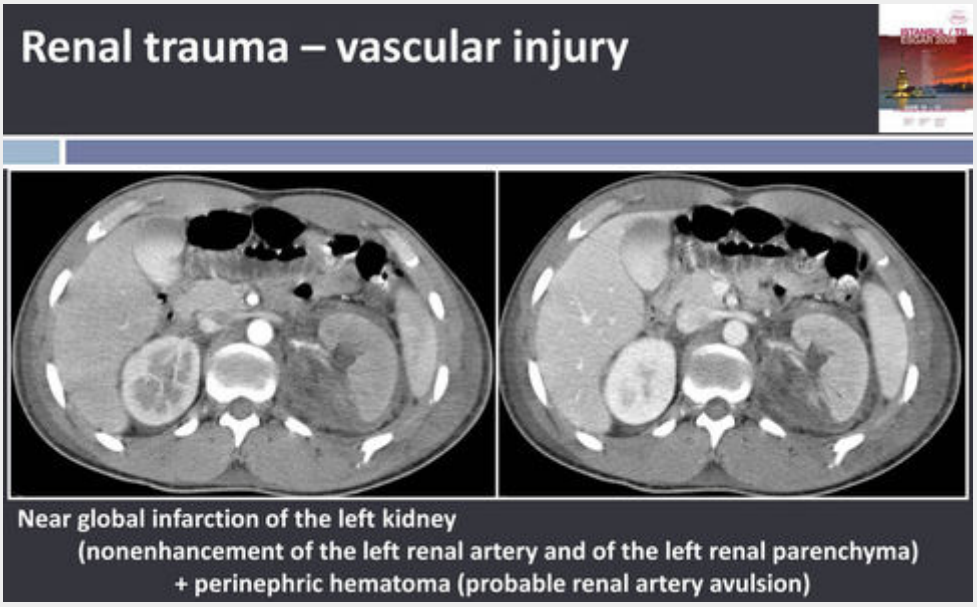

Arterial and portal venous phase axial CT images.

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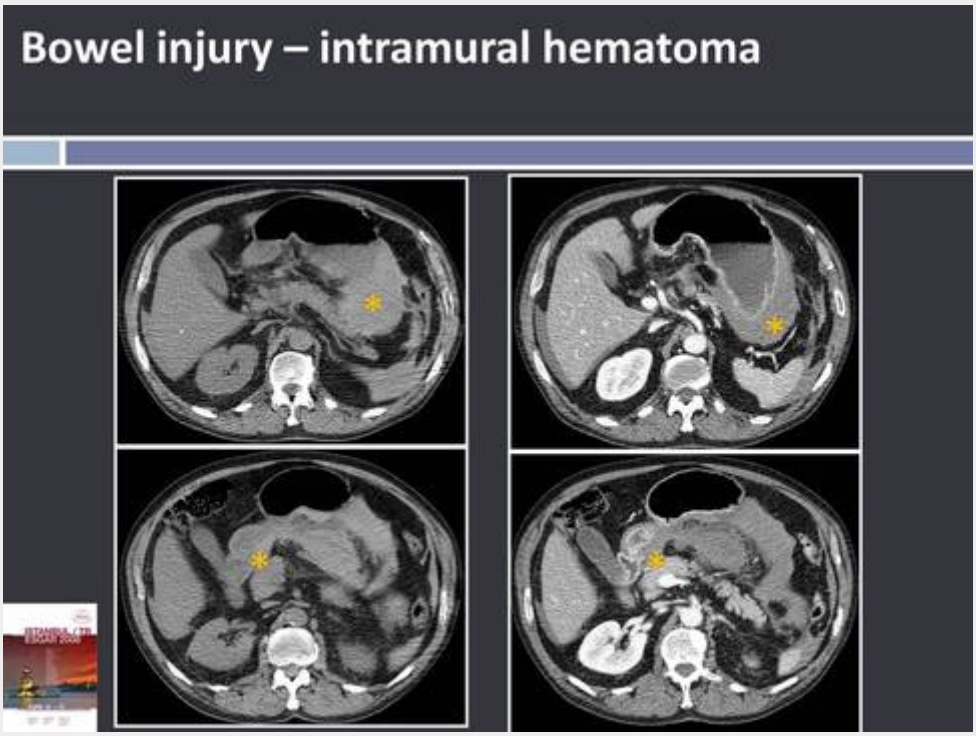

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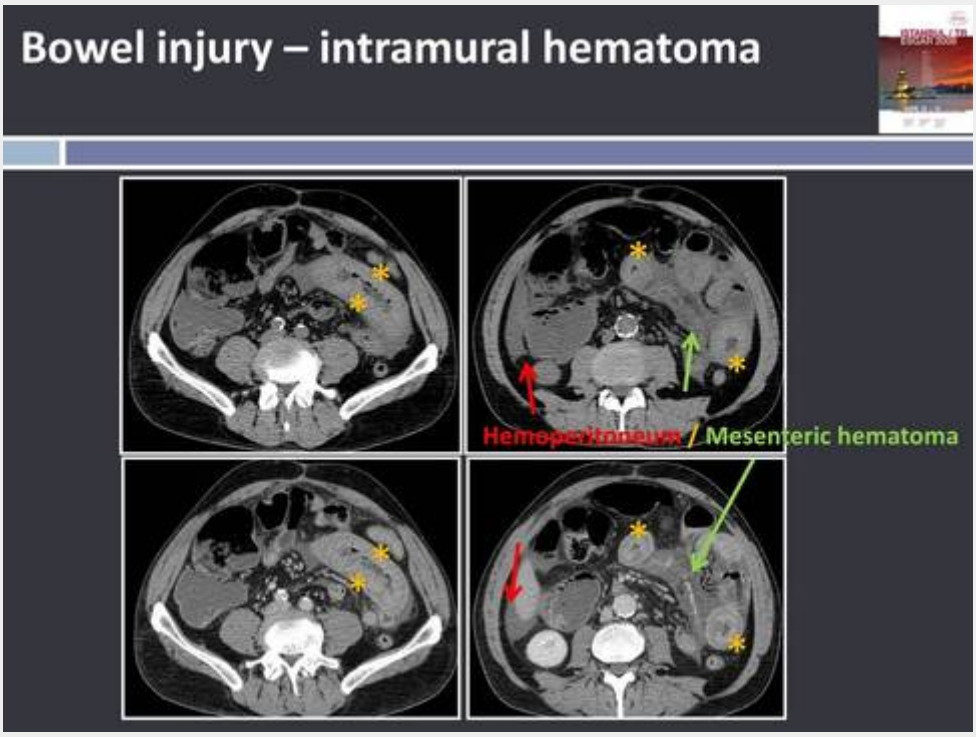

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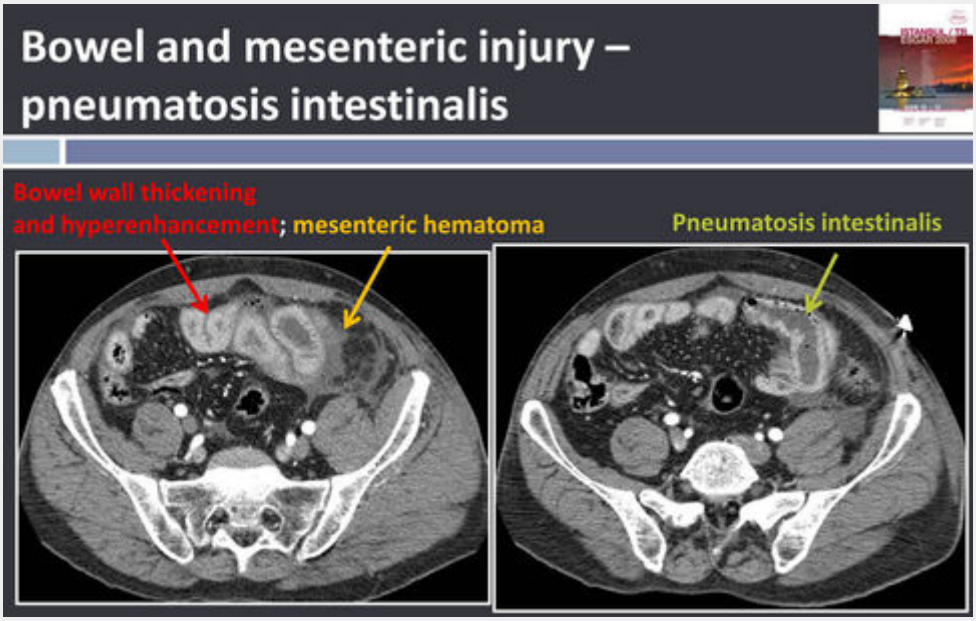
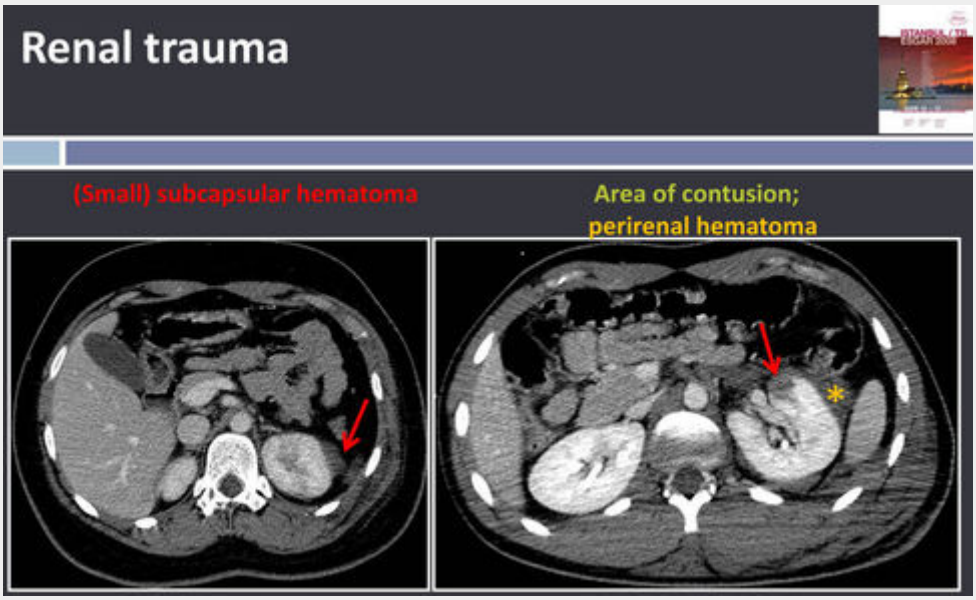


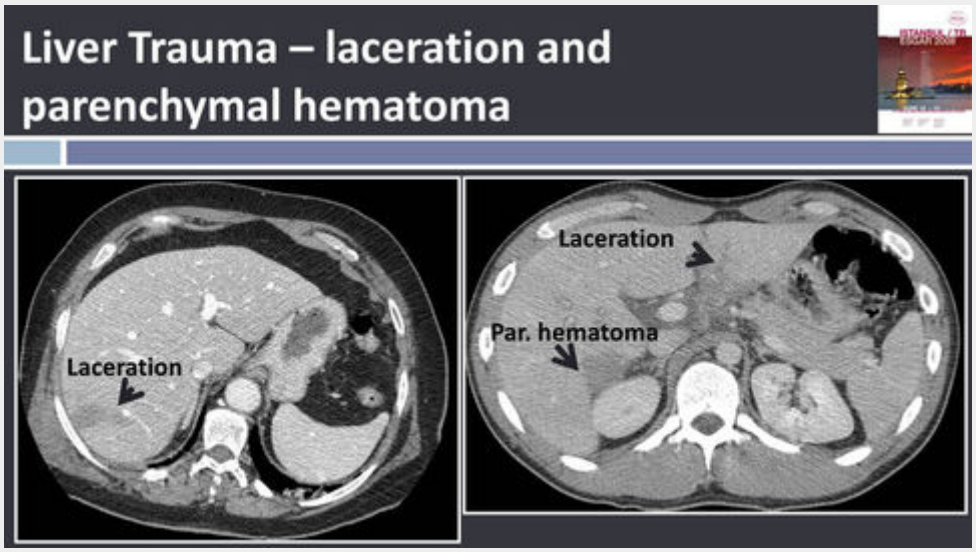
Axial CT image demonstrates the presence of extensive jejunal wall thickening due to intramural hematoma, mesenteric fluid and extraluminal parietal bubbles of gas in small bowel loop.

diapositivo9.jpg



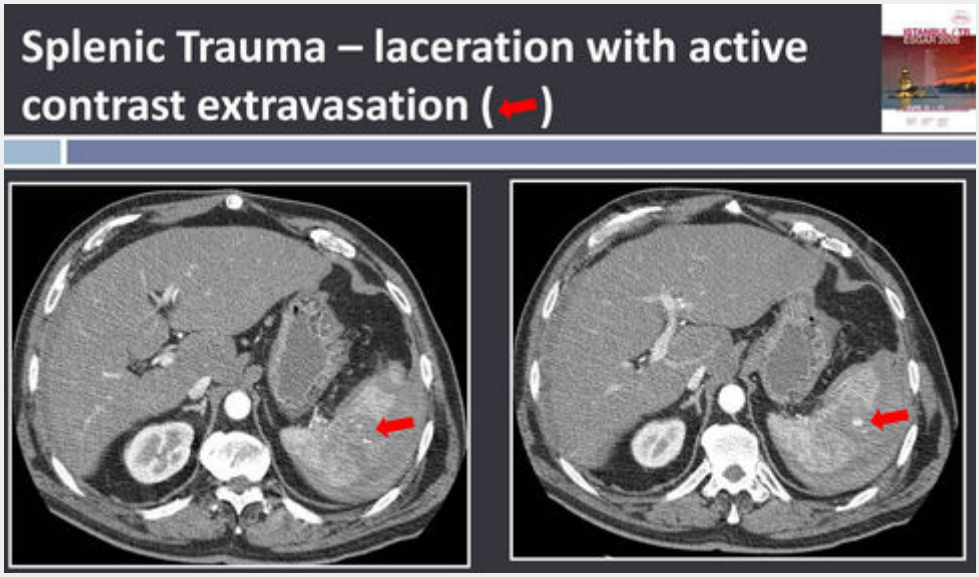
Axial CT images. Portal venous phase.

diapositivo2.jpg



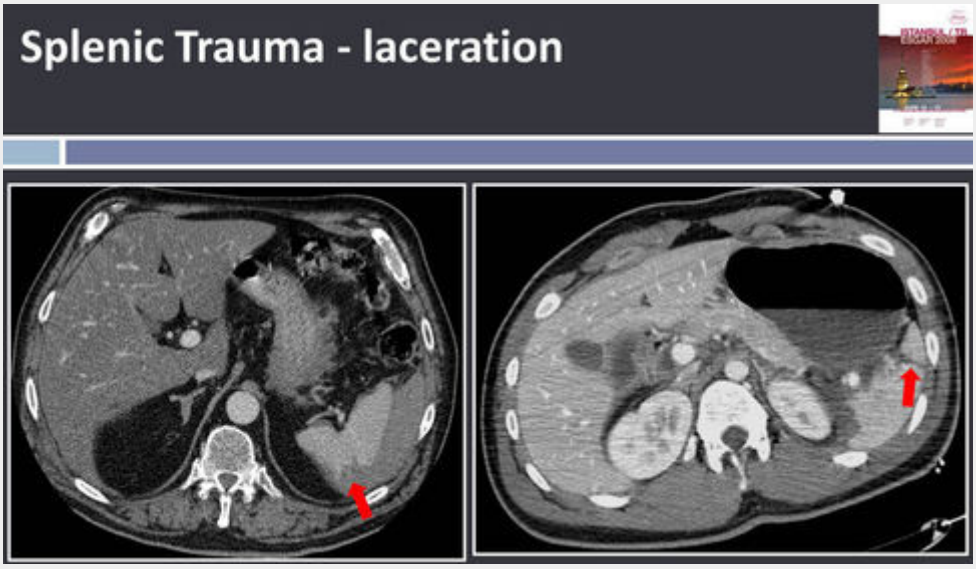
Axial CT images from two different patients. Portal venous phase.

diapositivo5.jpg



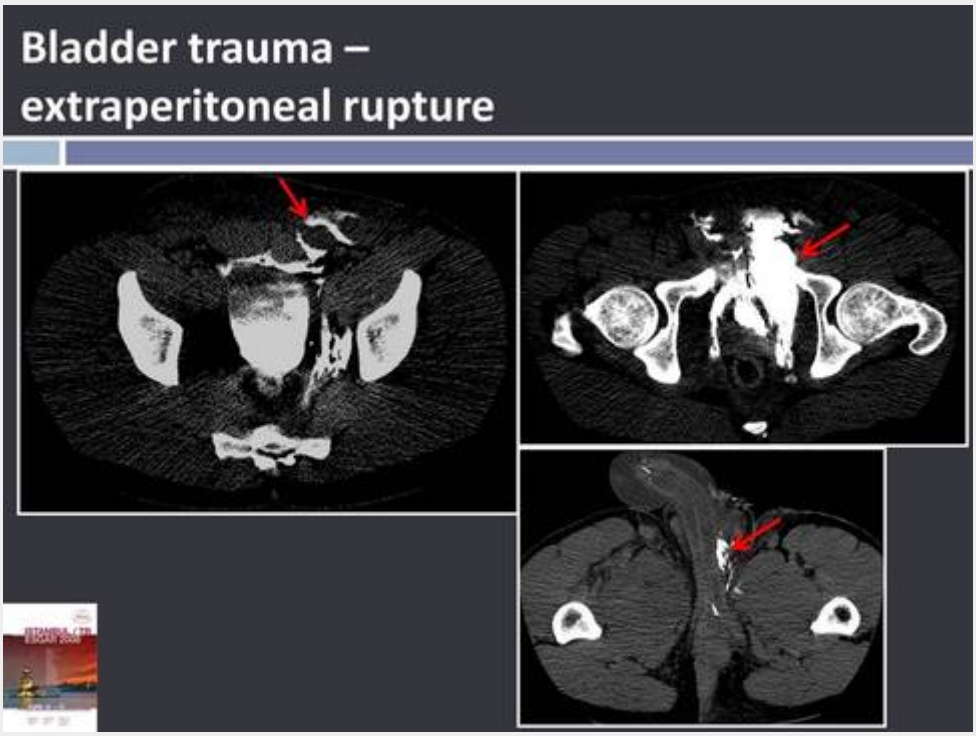
Axial arterial phase CT images.

diapositivo4.jpg



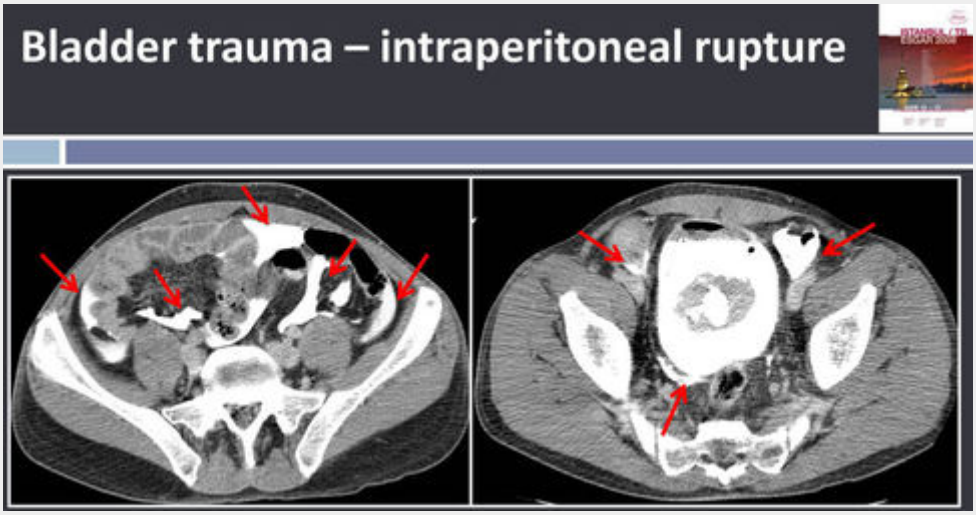
Axial portal venous phase CT images

diapositivo13.jpg



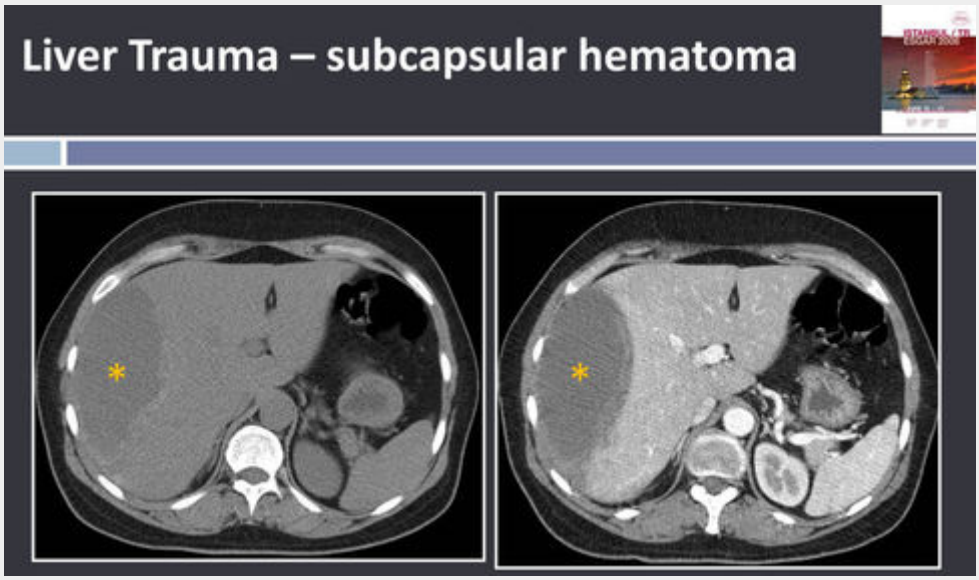
CT cystogram. Axial CT images demonstrates extravasation of contrast dissecting through the multitude of fascial planes in the extraperitoneal space.

diapositivo12.jpg



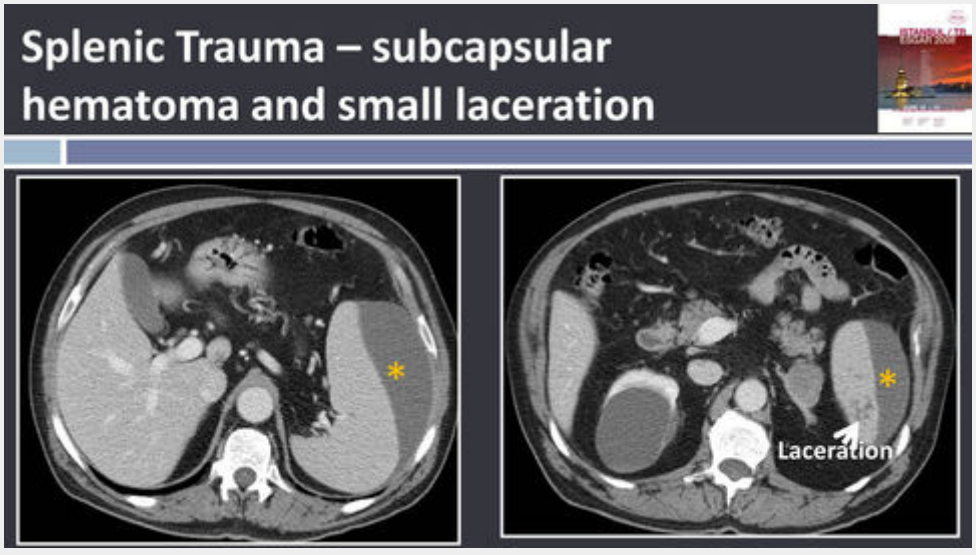
CT cystogram. Axial CT images demonstrates extravasation of contrast from the bladder into the peritoneal cavity.

diapositivo1.jpg



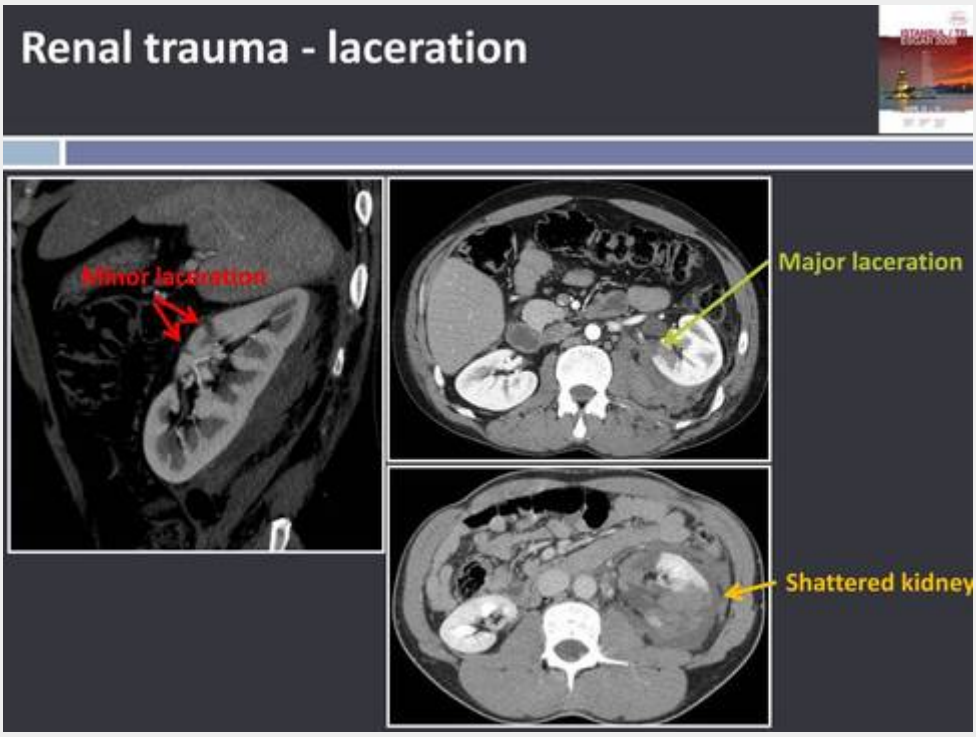
Non-contrast and portal venous phase CT axial images.

diapositivo3.jpg



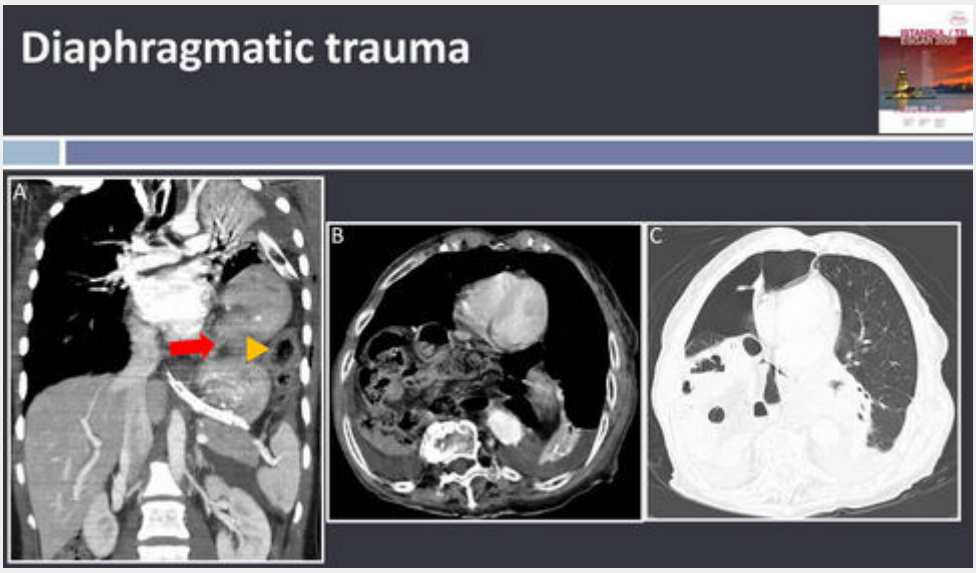
Portal venous phase axial CT images.

diapositivo10.jpg



Sagittal reformatted and axial portal venous phase CT images from three different patients with renal trauma.

diapositivo15.jpg



Selected images from two patients with blunt abdominal trauma and diaphragmatic rupture. Coronal MIP shows gastric herniation into the left chest and elevation of the splenic flexture of colon (arrowhead) as well. The stomach shows a collar sign (arrow) due to narrowing of at the level of the diaphragmatic tear. The left upper lobe is atelectatic. B. and C. Axial CT images showing herniation of the hepatic flexure and descending portions of the colon and right pneumothorax.

autores.jpg