

CT Evaluation of Blunt Abdominal Trauma

🕒 Expires Tuesday, February 28, 2023

📁 Radiology

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Objectives

1. Describe the different types of CT imaging techniques and the usefulness of contrast agents when evaluating a patient with blunt abdominal trauma
2. Explain how CT imaging is useful in diagnosing the various ways hemorrhage can appear in a patient who has suffered abdominal trauma.
3. Describe the major organs of the abdomen and how they might appear on CT imaging after blunt abdominal trauma.

Article

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Clinical Overview

CT is the imaging method of choice to evaluate clinically stable patients sustaining significant abdominal trauma. Sonography has largely replaced peritoneal lavage in the assessment of unstable patients to search for free fluid indicative of hemoperitoneum. This article focuses on the CT diagnosis of a spectrum of abdominal injuries emphasizing CT's unique contribution to the diagnosis of arterial extravasation.

CT Technique

Most trauma centers use helical or multidetector CT to evaluate stable patients with significant injuries. Multidetector CT is gaining wide popularity because its dramatic increase in speed (3 times greater than single slice helical CT) allows for rapid assessment of head, neck, spine, thoracic aorta, abdominal, and pelvic injuries in a manageable timeframe. The increased speed and anatomic coverage afforded by multidetector CT is enhanced by the use of thinner collimation to improve spatial resolution.

Intravenous contrast is essential for evaluating solid parenchymal and vascular injuries. Intravenous contrast is most often administered as a uniphasic bolus at a rate of 2-3 ml/sec. For abdominal imaging, scanning is initiated after a 70 sec. delay for a single slice helical CT and after 80 sec. for multidetector CT. This ensures scanning during the peak arterial opacification in order to visualize parenchymal and vascular injuries.

The role of oral contrast in CT for blunt trauma is controversial. Although proven to be safe, some surgeons feel that it leads to unnecessary delays. Other groups, such as ourselves, feel that it aids substantially in diagnosing bowel injuries.

The Role of Intravenous Contrast

Intravenous contrast enhancement of vascular structures and solid viscera is a key reason for the success of CT in trauma. Intraparenchymal hematomas and lacerations alter the perfusion of contrast and are generally significantly lower in attenuation than normally perfused parenchyma on contrast CT. Primary vascular injuries such as aortic arch lacerations or areas of active arterial extravasation can only be confidently diagnosed with contrast administration.

CT Diagnosis of Hemoperitoneum

Blood is unique as a biologic fluid due to its high protein content and high attenuation of the iron-containing hemoglobin molecule. In patients without anemia, CT attenuation values of blood are substantially greater than other fluid collections commonly encountered in the abdomen. Urine, bile, chyle and ascites fluid typically have attenuation values less than 15 HU. Free lysed blood within the peritoneal cavity only has attenuation values of 30 HU or more. Clotted blood has a higher attenuation and is on the order of 40-60 HU. Active arterial extravasation represents a unique contribution of CT in the diagnosis of abdominal trauma. The ability to visualize active bleeding cannot be demonstrated by any other modality short of arteriography. Areas of active arterial extravasation appear as high attenuation density fluid collections that are iso-dense with adjacent major arterial structures, often on the order of 70-100 HU. There are invariably areas of hematoma formation around sites of active arterial extravasation.

The anatomic location of arterial extravasation is critical for directing patient management. Patients with extraperitoneal arterial extravasation, particularly from a lumbar arterial source, are best treated with immediate angiographic embolization. Surgical dissection in these patients is hazardous, time-consuming and fraught with danger due to the potential for ligating lumbar arteries, which may supply the spinal cord. Intraperitoneal arterial extravasation is most commonly due to splenic injuries. Although some centers treat splenic injuries with arterial embolization, the standard of care in most trauma centers is to perform urgent laparotomy to insure that there are no other associated intraperitoneal injuries.

Important CT Signs in Abdominal Trauma

The sentinel clot sign refers to the fact that the attenuation of blood may be useful to identify the source of visceral injury. The attenuation of blood is highest in close proximity to sites of injury. Therefore clotted blood and active arterial extravasation due to parenchymal and vascular injuries will be of higher attenuation than free lysed blood elsewhere in the peritoneal cavity. Occasionally the sentinel clot sign may be useful to identify occult sources of injury.

The collapsed inferior vena cava sign refers to the fact that patients who have undergone substantial blood loss may have decreased circulating venous return. Because general anesthesia results in vasodilatation, vigorous volume replacement should be initiated prior to surgery in patients with the collapsed inferior vena cava sign. Failure to recognize this fact may result in ischemic injury to the brain or heart during crash induction of anesthesia. Frank shock may be evident on CT due to vasoconstriction of the splanchnic vasculature with marked arterial constriction of the mesenteric arteries. The kidneys may demonstrate telltale signs of shock due to a prolonged appearance of the nephrographic phase and a lack of renal excretion. The spleen may be diminished in size and attenuation due to vasoconstriction of the splenic artery.

CT Findings in Specific Organ Injuries

Splenic Trauma

The spleen is the most commonly injured organ requiring surgical intervention. There is growing awareness of the unique immunologic contribution of the spleen in fighting encapsulated bacteria. This has led to a trend in trauma surgery toward splenic conservation. Although rare, patients may be susceptible to overwhelming infection following total splenectomy. In addition to parenchymal sparing surgery, there has been an attempt made to treat some splenic injuries without operative interventions. These non-operative management strategies have been particularly true in pediatric patients.

Trauma surgeons classify splenic injuries according to extent of parenchymal disruption including the depth of laceration and associated segmental or hilar vessel disruption. Attempts to classify splenic injuries with CT have been found to only have limited success. Relatively trivial splenic injuries may result in a delayed hemorrhage, that at times can be major. Conversely, some patients with extensive splenic injuries may do well with non-operative management.

One unique contribution of CT has been the ability to diagnosis active bleeding from splenic trauma (**figure 1**). This finding

generally correlates with the need for surgical intervention or angiographic embolization. Patients treated non-operatively must be followed with diligence. Some authors feel that follow-up CT to demonstrate parenchymal healing is essential prior to having patients return to normal activities.

Hepatic Injuries

Because the liver is predominantly perfused with low-pressure venous blood, hepatic parenchymal injuries can often be treated non-operatively in stable patients. In the absence of definable active arterial extravasation, even extensive lacerations may be treated conservatively. It should be kept in mind that hepatic injuries may be associated with other significant parenchymal and musculoskeletal injuries. Right hepatic lobe injuries are associated with injuries to the right lung and rib cage as well as right adrenal and right renal injuries. Left lobe injuries may be associated with a midline vector force that can also injure the pancreas and transverse colon and result in myocardial contusion and/or sternal fracture.

A very serious form of hepatic injury is a vascular injury to the confluence of hepatic veins. The surgical management to this injury requires a combined thoracic-abdominal approach that controls hemorrhage as the critical first step.

Although less common than with splenic injuries, active arterial extravasation may rarely be seen with hepatic trauma and can be treated with either angiographic embolization or surgical resection.

Renal Injuries

The kidney is often injured after blunt abdominal trauma but rarely requires surgical intervention. Well over 95% of renal injuries can be managed with conservative therapy. Renal injuries can be classified according to the depth of parenchymal laceration. Superficial cortical lacerations that do not extend to the collecting system may be associated with peri-renal hemorrhage, but virtually never require surgery in the absence of active arterial extravasation (**figure 2**). Subcapsular hematomas flatten the contour of the kidney and may result in hypertension late in the clinical course due to cortical ischemia. Renal fractures that traverse the cortex through the renal hilum will often require surgical intervention due to laceration of major segmental vessels and to disruption of the collecting system.

The most devastating form of renal injury is one that involves the renal pedicle (**figure 3**). Traumatic renal injury that leads to artery occlusion may occur due to an intimal dissection that results in thrombosis of the main renal artery. This has a characteristic CT appearance, because there is absence of contrast enhancement or excretion from the kidney. Early recognition of this finding with prompt vascular repair is crucial in restoring renal function.

As a routine part of the CT exam for trauma, delayed images of the kidney should be obtained to assess for renal excretion. A laceration of the collecting system may require surgical intervention to prevent large retroperitoneal urinomas. Alternatively, ureteral stents may be used in selected patients to decompress the collecting system.

Blunt Trauma to the GI Tract

Blunt trauma to the gut is uncommon as an isolated injury and usually occurs in patients who sustained poly-trauma with severe life-threatening injuries requiring urgent surgical intervention. On occasion, patients with isolated visceral injuries to the gut may be evaluated by CT due to their hemodynamic stability.

The most common sites of injury are at locations where the bowel is tethered by adjacent mesenteric or peritoneal ligaments. These include the jejunum just distal to the ligament of Treitz and the ascending and descending colon. A distended stomach may also rupture from blunt trauma, particularly in children. Occasionally, trauma can result in a laceration to the mesentery itself (**figure 4**).

Signs of blunt trauma to the bowel are often subtle on CT. An extremely important fact to remember is that there is normally little or no bowel gas in the proximal jejunum. Thus, jejunal perforation may occur without evidence of pneumoperitoneum. Not infrequently a small amount of (water density) small bowel juice may leak from the intestine and be located in an interloop location. It should be noted that attenuation values of the interloop fluid are substantially lower than those of a hemoperitoneum. Because ascites is generally located in the pericolic gutters and pelvis, an interloop location of low-density fluid should be highly suspect for bowel injury. Other important secondary clues are intramural and mesenteric hematomas. On occasion,

extravasation of oral contrast may be seen in an interloop and/or intraperitoneal location as well as a subtle pneumoperitoneum. Pneumoperitoneum may only be visible anteriorly along the anterior surface of the liver or it may be only detected along the porta hepatis or undersurface of the liver. It is extremely important to view the abdomen with wide windows (greater than 500) in order to detect a subtle pneumoperitoneum.

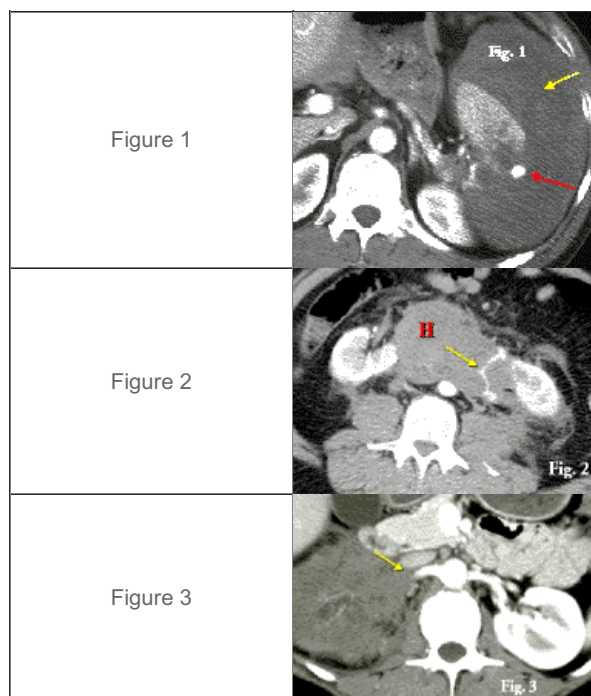
Blunt Trauma to the Pancreas

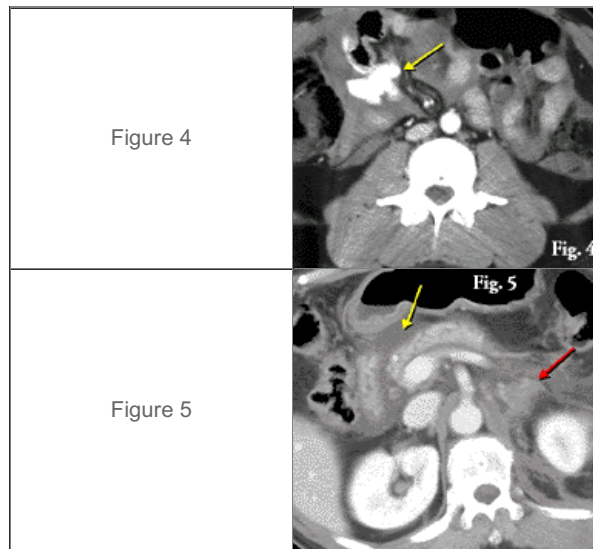
Fortunately, isolated blunt pancreatic injuries are relatively uncommon. However, unlike other lacerations involving the liver, spleen and kidney, they are often exceedingly subtle to detect on CT. Often the most evident findings of pancreatic injury are post-traumatic pancreatitis with blood, edema, and soft tissue infiltration of the anterior pararenal space (**figure 5**). The changes of post-traumatic pancreatitis are time dependant and may not be visualized within several hours following trauma. The most common site of pancreatic injury is at the junction of the body and tail. The pancreas is impaled against the lumbar spine from a blow to the mid-epigastrium. On occasion, a low attenuation laceration may be identified within the substance of the pancreas at the site of the injury; however, this is invariably seen soon after injury.

Surgical classification of pancreatic injuries largely depends upon the depth of the laceration and the status of the main pancreatic duct. It is important to remember that ductal disruption cannot be directly identified by CT, and can only be inferred following visualization of a through and through laceration of the pancreas. In patients with strong clinical evidence of pancreatic injury and an equivocal CT scan, emergency ERCP may be quite valuable in patient management. In patients with a pancreatic contusion or superficial lacerations without ductal disruption, conservative management may be warranted. However in patients with transection of the duct, morbidity and mortality greatly increase unless surgery is undertaken within the first 24 hours.

Figures:

1. **Splenic Fracture with Active Bleeding.** Contrast CT demonstrates a large amount of peri-splenic hemorrhage (yellow arrow) with high attenuation focus (red arrow) of active bleeding.
2. **Horseshoe Kidney with Active Bleeding.** Contrast CT demonstrates large hematoma (H) in isthmus of horseshoe kidney. Note high attenuation of active bleeding (arrow).
3. **Renal Pedicle Injury.** On contrast CT note "cutoff" right renal artery (arrow) due to arterial occlusion from intimal dissection.
4. **Mesenteric Vascular Injury.** Contrast CT demonstrates high attenuation active bleeding (arrow) secondary to arterial laceration of the mesentery.
5. **Pancreatic and Left Adrenal Trauma.** On contrast CT note peripancreatic fluid (yellow arrow) due to laceration of the pancreatic duct. Left adrenal hematoma is also noted (red arrow).





References or Suggested Reading:

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About the Author(s)

Dr. R. Brooke Jeffrey is currently a Professor of Radiology and is the Chief of Abdominal Imaging at Stanford University School of Medicine. He is active in clinical practice and is a member of various professional organizations, including the American College of Radiology.

Dr. Jeffrey is a well-known speaker and he has lectured on many different radiology topics at numerous conferences around the country. He is active in research and has authored several publications in peer-review medical journals.

