Diagnostic Imaging for Blunt Abdominal Trauma

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ABSTRACT

Background: Blunt abdominal trauma is a common cause of morbidity and mortality among patients encountering traumatic injuries, especially motor vehicle accidents, which are the leading cause of injury worldwide. Focused abdominal sonogram for trauma, computed tomography with or without contrast, and laparotomy are the most common ways of diagnosis and treatment. With advancement of diagnostic medicine, the physicians are making use of non-operative methods to achieve quick results quicker and with fewer complications. **Methodology:** We conducted this review using a comprehensive search of MEDLINE, PubMed, and EMBASE, January 2001, through February 2017. The following search terms were used: blunt abdominal injury, FAST scan, US in abdominal trauma, CT for abdominal trauma, trauma management **Aim:** In this review, we aimed at evaluating the various methods of diagnosis using imaging for blunt abdominal trauma.

Conclusion: The growing tendency of non-operative management necessitates early identification of the injury sites, which is aided by the increasing sophistication of the CT techniques. Additionally, CT also provides a very significant method for following up the patients and for detecting complications which were not diagnosed initially.

Keywords: imaging in abdominal trauma, non-invasive diagnosis of blunt abdominal trauma, FAST scan, CT scan for abdominal trauma

INTRODUCTION

Blunt abdominal trauma is a frequent cause of morbidity and mortality amid patients admitted after sustaining various traumatic injuries. Many patients present with multisystem injuries as a consequence of high velocity mechanisms. Furthermore, the existence of associated injuries may cover overt clinical manifestations or distract the attention of the admitting staff away from possibly life-threatening intra-abdominal bleeding[1].

Mechanisms of blunt trauma that lead to major intra-abdominal injuries often comprise of compression and deceleration forces. Motor vehicle accidents are the leading cause of injury, throughout the world. Even though the possibility of injuring an individual organ rests upon the specific mechanism of trauma and the susceptibility of the patient at the time of the incident. All published series established that the liver and spleen are the most repeatedly injured organs. Further potentially injured organs consist of the kidneys, pancreas, bowel and mesentery, adrenals, intra-abdominal vessels, and diaphragm[2]. Previously, diagnostic peritoneal lavage was used commonly to confirm the presence of hemoperitoneum before laparotomy; this practice has been mostly abandoned. Presently, ultrasonography, particularly, focused abdominal sonogram for trauma (FAST), completed at the bedside by a knowledgeable ultrasonographer, is more commonly used for this purpose. FAST evaluation involves visualization of the pericardium using a subxiphoid view, the hepatorenal (i.e., Morrison's pouch) and the splenorenal spaces, right and left paracolic gutters, and lastly, the pouch of Douglas. Several studies have revealed the benefit of a FAST study in the emergency decision-making

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method of the acutely traumatized patient. Meanwhile, CT imaging remains the diagnostic tool of choice for the assessment of abdominal injury due to blunt trauma in a hemodynamically-stable patient. CT scans can offer a rapid and accurate assessment of the abdominal viscera, retroperitoneum as well as the abdominal wall. Moreover, an abdominal CT scan can help in the detection of coexisting abdominal injuries for example thoracic injuries and unanticipated pelvic or spinal fractures. The capability of CT to perform and yield fast-processing images, such as multiplanar reconstruction (MPR), is imperative for the precise interpretation of abnormalities[1].

METHODOLOGY

- **Data Sources and Search terms**

We conducted this review using a comprehensive search of MEDLINE, PubMed, and EMBASE, January 2001, through February 2017. The following search terms were used: blunt abdominal injury, FAST scan, US in abdominal trauma, CT for abdominal trauma, trauma management

- **Data Extraction**

Two reviewers have independently reviewed the studies, abstracted data, and disagreements were resolved by consensus. Studies were evaluated for quality and a review protocol was followed throughout.

The study was done after approval of ethical board of Taibah university.

DIAGNOSTIC IMAGING FOR ABDOMINAL INJURIES

Hemoperitoneum

CT has high sensitivity and specificity for the recognition of blood inside the peritoneal cavity. Hemoperitoneum begins near the site of injury and ranges along the predictable anatomic pathways. While the patient is in a supine position, blood from the liver assembles in Morison’s pouch and goes towards the right paracolic gutter down into the pelvis. From the spleen, blood travels through the phrenocolic ligament into the left paracolic gutter and pelvis **(Figure 1)**[3].

Figure 1: Bleeding due to splenic injury in perihepatic (single arrow), paracolic gutter (double arrow

Blood from a splenic injury may also travel to the right upper quadrant. Even though peritoneal lavage is a sensitive indicator of intraperitoneal bleeding, it is not able to detect the source of the bleeding. A significant amount of blood may accumulate in the pelvis compared to the upper abdomen[4].

Liver Trauma

The liver is amongst the most frequently injured solid organ in blunt abdominal trauma; Multiple detector computed tomography (MDCT) is regularly used in the diagnosis and classification of acute liver damage.

The American Association for the Surgery of Trauma (AAST) scale of liver injury considers findings for instance the size of subcapsular or parenchymal hematoma and laceration, along with indication of devascularization of the liver, findings that are easily identified on routine CT imaging **(Figure 2)**[3].

Figure 3: Sentinel clot sign is seen as a high-attenuation collection adjacent to the liver surface (arrow)

Subcapsular hematoma seems elliptical and conforms to the boundaries of the liver capsule on MDCT imaging. Intraparenchymal hemorrhage looks as a vague hypo-attenuating area within the liver. Lacerations look as hypo- attenuating linear, frequently branching regions inside the parenchyma of the liver[5].

Chief hepatic vascular injuries may also be described with CT. Direct suggestion of portal venous injury including unexpected termination of an intrahepatic portal vein branch can be identified. Parenchymal injuries could be seen to include central hepatic veins. The outcome of active extravasation of contrast material, when seen through routine portal venous phase images, put forward the ongoing bleeding from a hepatic arterial venous source. Pseudo-aneurysms, seen as hyper -attenuating foci on initial phase images while washout on late phase images, have been found to involve arterial along with hepatic and portal venous branches. Findings of subacute hemorrhage include identifying a comparatively hyper attenuating region adjacent to the liver, known as the sentinel clot sign.

MDCT trauma imaging, principally 16- and 64-detector row technologies, could help in characterizing complex vascular injuries with better multi-planarability[6].

The huge majority of hemodynamically stable patients with hepatic injuries are presently managed in a conservative manner. Transcatheter arterial embolization for management of doubted hepatic arterial injury is becomingly a progressively used option even in individuals with severe liver injury[3].

Splenic Trauma

The AAST grading system in case of traumatic splenic injury measures size and location of the hematoma and laceration along with the findings of devascularization of splenic parenchyma. A subcapsular hematoma follows to the borders of the splenic capsule whereas parenchymal hematomas typically appear somewhat less regular. Linear, branching, and hypo attenuating foci describe splenic lacerations. Devascularization seems as a geographic region of non-enhancing parenchyma owing to injury of major hilar vascular organizations. Although CT is regularly used in evaluating blunt traumatic injuries of the spleen, the clinical effectiveness of grading splenic injury by means of the AAST criteria by CT has shown mixed results[7].

Hyper attenuating foci may also be recognized on portal venous phase imaging of blunt trauma in spleen. Established on morphology and location in addition to signs of washout on delayed phase images, these areas may be additionally considered as active extravasation of contrast secondary to arterial injury or limited vascular injuries such as pseudo aneurysm or fistula. Spilling of contrast more often is less regular in morphology, may spread beyond the estimated borders of the spleen, and shows no sign of washout on delayed imaging. On the other hand, contained vascular injuries look more regular, are usually within the borders of the spleen, and shadow enhancement of adjacent arterial structures as displayed in **(Figure 3)**[8].

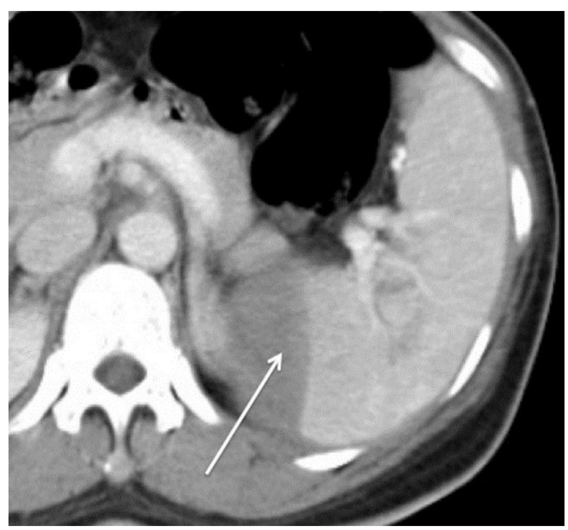

Figure 4: CT showing splenic extravasation

The incorporation of the above-mentioned CT results of splenic vascular injuries into grading schema has been projected[9].

Pancreaticobiliary Trauma

Pancreaticobiliary trauma, comprising injuries to the pancreas, biliary tract, and gallbladder may happen with blunt abdominal trauma. Pancreatic injuries often happen at the neck and body for crashing against the vertebral body resulting in fracture of pancreas.

Pancreatic injury, while infrequent, is difficult for imaging diagnosis. A central role of imaging in patients with pancreatic trauma is to evaluate presence of injury to the main pancreatic duct, which usually requires intervention such as operative management or endoscopic retrograde cholangio-pancreatography (ERCP) along with stent placement. The use of CT imaging to the diagnosis of acute pancreatic injury has consequently resulted in legitimately low diagnostic accuracy. The image quality given by 64-row MDCT may advance the detection of injury, although the morphology of the pancreas, with many clefts, remains to present a diagnostic challenge. The complexity of the pancreatic parenchymal laceration on CT may be useful in calculating which patients with pancreatic ductal injuries would necessitate further imaging and intervention. Subordinate signs of pancreatic injury for example isolated peripancreatic fluid may be useful in diagnosing acute pancreatic injury. Nevertheless, free intra-abdominal fluid, particularly in the peripancreatic fat, may also be noticed in patients getting fluid resuscitation or those in hypovolemic states [10].

Evidence indicates magnetic resonance cholangiopancreatography (MRCP) may be beneficial in diagnosing pancreatic injury. MRCP permits improved picturing of the main pancreatic duct and may be used for evaluation of main duct injury. Using secretin may additionally increase the diagnostic accuracy of MRCP in pancreatic ductal injury by temporarily growing ductal caliber and allowing for better visualization [11].

Lastly, ERCP may be used for diagnostic confirmation as well as treatment of pancreatic ductal injuries**(Figure 4)**[12].

If a pancreatic injury is intensely supposed because of direct visualization of a laceration or isolated peripancreatic fluid, the patient may require immediate operative exploration. When CT suspicion is low for acute pancreatic injury, MRCP is often used for evaluation of the pancreas to eliminate pancreatic ductal injury. The job of ERCP may be confirmatory in unsure cases prior to surgery or may be therapeutic in case when pancreatic duct stenting is a viable option for management [13].

Intrahepatic biliary ductal injury is frequently associated with acute liver injury. The site of the hepatic parenchymal injury may expect those patients more likely to experience bile leak. Central injuries frequently carry a greater likelihood of biloma development provided the increasing diameter of the bile ducts in this setting. Hepatobiliary scintigraphy is valuable in patients with severe liver injury to locate bile leaks. Scintigraphy diagnosis of bile leak necessitates retention of tracer beyond the expected sites of the biliary ducts or small bowel. MRCP has also been described to be beneficial in diagnosing bile leak in the trauma. In unsure cases, ERCP may also be used to evaluate for risk and manage bile leaks due to ductal injury [11].

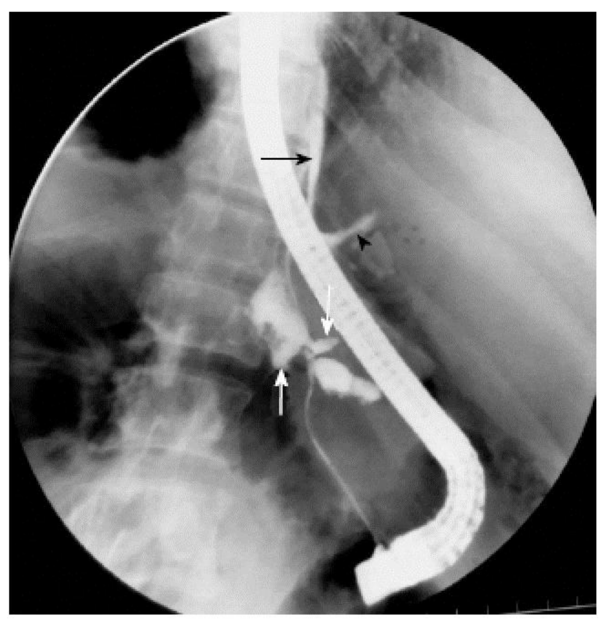

Fig 4: Endoscopic retrograde cholangiopancreatography showing main pancreatic duct disruptions

Bowel and Mesenteric Injury

Discovery of bowel and mesenteric injury (BMI) with blunt abdominal trauma in patients is one of the most puzzling aspects of understanding trauma CT examinations. Contrasting solid organ injury, it is unusual to visualize direct suggestion of bowel and mesenteric injury by CT alone. Instead, the radiologist has to depend on a number of indirect signs, all of them having varying degrees of sensitivity and specificity for the recognition of BMI. Twelve different CT signs that are reported to occur in the occurrence of BMI are: intramural hematoma, bowel wall disruption, bowel wall transection, intramural gas, abnormal bowel wall enhancement, free retroperitoneal/intraperitoneal air or fluid, mesenteric hematoma, mesenteric vascular beading, extra luminal oral contrast, mesenteric active contrast extravasation, and bowel wall thickening[14].

Meanwhile the detection of BMI is challenging, and so many described CT signs must not be neglected, as it may be more valuable to consider the CT detection of BMI founded on the type of injury and the likely appearance of such injury on CT scans. According to the AAST Injury Scale for bowel (including stomach, small intestine, duodenum, and colon), injuries range from mild grade I injuries for example simple bowel wall hematomas to severe grade V injuries comprising devascularization and complete bowel wall transection. Likewise, mesenteric vascular injuries vary from grade I like distal branch vessel injury to grade III and IV including superior mesenteric trunk and celiac axis injuries, with grade V injury set aside for major abdominal vessel injury such as aortic or extrahepatic portal vein. Therefore, individual CT signs for BMI must consider the type and severity of the injury that has happened [15].

Milder injuries, comprising grade I hematomas and contusions, when visible by CT, characteristically present with focal thickening of the bowel wall. The thickened area may appear hyper dense compared to the normal bowel wall because of the presence of blood. Depending on the severity of injury, the hematoma could be eccentric or concentric in look **(Figure 5)** [16].

Severe injuries including lacerations of the bowel wall, can be directly visualized at the time of first CT, meanwhile, less severe lacerations may be invisible. As an alternative, other secondary signs of bowel laceration might be present to propose such an injury. Free intraperitoneal air is one such finding in patients with bowel wall lacerations. Free air may arise nearby along the site of perforation, in the upper abdomen close to the surface of the liver, or along the undersurface of the peritoneum [17].

Free intraperitoneal fluid can also be a possibility due to focal laceration of the bowel wall. This fluid may be existent locally or may be seen diffusely all over the abdomen or pelvis. Previously, trauma surgeons frequently elected to surgically explore to fully assess the bowel for the presence of injury. Nevertheless, these patients are nowadays increasingly treated non-invasively. The presence of free fluid is often helpful in selecting patients for non-operative management [14].

Other than extraluminal air and fluid, oral contrast may also leak into the peritoneal cavity if a laceration is present. Nevertheless, this finding is not frequently present. It should be noted that focal lacerations of the duodenum may lead to free air and free fluid that is remote to the retroperitoneum. Furthermore to allowing the escape of air and fluid, lacerations can also produce local appearance changes of the bowel wall that can be noticed at initial CT scan. Subtle injuries may permit air to leak into the bowel wall crating focal pneumatosis. Moreover, acute injuries can yield focal thickening of the bowel wall. The wounded bowel may also enhance abnormally subsequent to intravenous contrast administration. In case of a bowel shock and focal injuries, the bowel wall may exhibit amplified enhancement after contrast administration. Severe devascularization owing to degloving injury may produce hypo-enhancement of the bowel segment; this sign is worry-some and deserves prompt surgical evaluation [17].

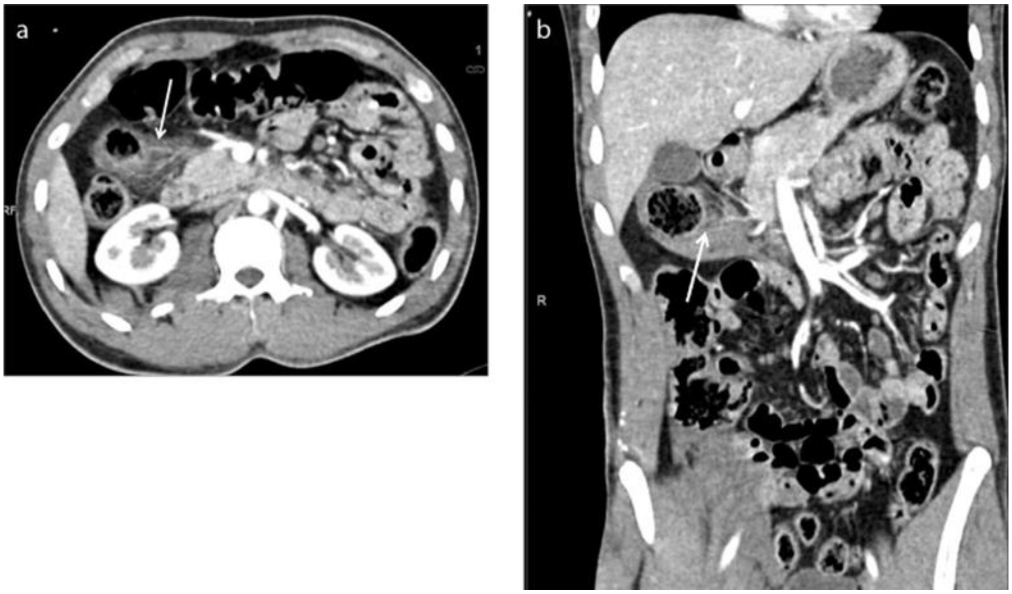

Fig 5: CT showing colonic hematoma (arrow) indicating isolated mesocolonic injury

Adrenal Injury

Adrenal injury is not an uncommon complication of major blunt abdominal trauma. Commonly, the CT shows an enlarged or obliterated gland indicating adrenal hematoma. Less frequently, active extravasation of contrast is seen owing to straight injury of the adrenal artery or vein. The right adrenal gland is most frequently injured, supposedly in 85% of cases of adrenal gland injury.

This could be as a result of the gland's hazardous position interjected between the liver and the spine. In patients with adrenal gland injury, there is a high relationship with injuries to adjacent solid viscera, generally the liver but also the kidney and spleen of the same side.

Complications seldom ensue subsequent to unilateral adrenal injury, while inferior vena cava thrombosis because to the compressive effects of an adrenal hematoma can be possible. Bilateral injury results in acute adrenal insufficiency. When noted on follow-up CT, the adrenal hematoma or diffuse gland enlargement normally regresses and calcifications or low attenuation pseudocysts may occur as result of acute adrenal injury [18].

Diaphragmatic Injury

Diaphragmatic rupture due to blunt trauma is infrequent and is found in 4% to 8% of patients who need emergency laparotomy. The left hemi-diaphragm is injured more frequently than the right. Even though most ruptures are spotted at the time of the injury, in some cases the acute injury possibly will go unrecognized and lead to delayed symptoms and complications including gastric or colonic obstruction or strangulation. Earlier, CT was regarded as a comparatively insensitive way for diagnosing acute diaphragmatic injuries [19]. Newer reports, including the use of MDCT technology, have attained better results. Several signs have been used to define the typical findings of diaphragmatic rupture on CT, comprising focal diaphragmatic discontinuity such as elevation, herniation of abdominal hollow viscera presenting as solid organs into the thorax, focal thickening leading to retraction of the diaphragm, and segmental indistinctness of the diaphragm. Additional findings comprise terms such as the "collar" sign (in case of left hemi-diaphragm) **(Figure 6)** [20], the "hump" sign (in case of right hemi-diaphragm), and the "dependent viscera" sign (used for both hemi-diaphragms) [20].

Fig 6: Coronal reformatted CT image shows constriction of the herniated stomach at the level of the ruptured diaphragm (collar sign)

CONCLUSION

Imaging modalities of choice in assessing blunt trauma patients are CT and FAST. CT enhanced with intravenous contrast remains the most prevalent and effective means of correctly classifying patients in order to decide management with respect to choosing non-operative techniques or surgery. The growing tendency of non-operative management necessitates early identification of the injury sites, which is aided by the increasing sophistication of the CT techniques. Additionally, CT also provides a very significant method for following up the patients and for detecting complications which were not diagnosed initially.

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