SPLENIC INJURY – HOW MDCT GUIDES TREATMENT

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Introduction

Diagnosis and treatment of patients admitted to a trauma center with potential blunt abdominal injury has been a difficult and challenging task for the trauma surgeon and emergency radiologist [1 – 4]. Unlike penetrating injury, the associate multi-system injuries often seen with blunt trauma may divert attention from the abdomen to these injuries making the diagnosis and triage more difficult and complex. Multi-detector row CT (MDCT) ability to obtain high resolution images during optimal contrast enhancement at unparallel speed has made MDCT the primary imaging modality of choice in evaluating hemodynamically stable patients with abdominal pain, tenderness, or a positive ultrasound examination for free intraperitoneal fluid. With the 40 and 16-slice MDCT scanners adjacent to the admitting area at the University of Maryland Shock Trauma Center (UMSTC) for instance, we currently can image the neck, chest, abdomen, and pelvis (from Circle of Willis to symphysis pubis) in less than 60 seconds [5]. This article will discuss the role of MDCT in the diagnosis and management of hemodynamically stable blunt trauma patient.

SPLENIC INJURY

The spleen is the most commonly injured solid abdominal organ following blunt trauma. Only recently has the vital role played by the spleen in the immune defense system been fully appreciated and this understanding has lead to a more conservative approach in the management of splenic injury both in adults and children [16 - 21]. Over the past two decades, CT has had a significant impact in helping to implement a new conservative approach to management of blunt splenic trauma [16, 20, 21].

Splenic Injury CT Grading Systems

Several attempts have been made over the last decade to show that the CT grade of injury could be used to predict outcome of NOM. A variety of CT grading systems have been proposed and studied, but, in general, these have not shown enough reliability in predicting outcome of NOM for a given patient. Mirvis et al. studied 35 patients with splenic injury who had preoperative CT scan. The failure rate was greater with Grade 1 & 2 injury than for Grade 3 and 4 injuries. Similarly, Schurr et al. showed using logistic regression that CT injury grade had no predictive value for outcome for a population of 89 patients managed without surgery, 12 of whom ultimately required surgery. Sutyak et al. have pointed out that CT scan is inaccurate for estimating the extent of splenic injury, typically with CT underestimating injury severity. Further, they showed a significant level of disagreement between radiologists in establishing a CT-based injury grade. These factors contribute to the poor correlation between CT appearance and outcome in NOM of splenic injury. CT grading is also hampered by the fact that the CT shows only a “single snapshot in time” of the injured spleen, but does not document progression or healing of injury without serial evaluations. One of the greatest contributions of abdominal CT in the setting of spleen injury is to exclude other intraperitoneal injuries that would otherwise mandate surgical exploration.

Many systems have been proposed to grade splenic injury following trauma. The splenic injury grades may be based on the extent of injury seen at laparotomy, CT, or autopsy [22, 23]. In order to compare outcome, treatment protocols, and standardize reporting of splenic injuries among patients in the same trauma center over a period of time the American Association for the Surgery of Trauma (AAST) formed a committee to develop an injury severity score [23]. This injury scale is based on an anatomic depiction of splenic disruption including the length and number of lacerations, the surface area involved, and the extent of subcapsular or intraparenchymal hematoma(s) seen at laparotomy among other factors.

A recent retrospective study performed at our institution compared a new CT based classification system which included vascular injuries (pesudoaneurysms and active bleeding) seen on MDCT with the AAST system in predicting which patients require surgery or angioembolization. In this study 400 patients were included. The new grading system was significantly better for splenic arteriography ($p=0.0036$) and the combination for arteriography and surgery ($p=0.0006$).

MDCT Appearances of Splenic Injury

Contrast enhanced CT can accurately diagnose the four principal types of splenic injury including hematoma(s), laceration(s), active hemorrhage, and vascular injuries including pseudoaneurysm and post-traumatic arteriovenonous fistula. High resolution overlapping thin axial images generated by MDCT can be used by sophisticated multi-planar postprocessing programs to generate high quality isotropic images. These images are used at the UMSTC to both detect and depict the relationship between the parenchymal lesions and vascular structure, and differentiate the spectrum of splenic injuries seen following blunt trauma.

Hematomas & Laceration

Splenic hematomas may be intraparenchymal or subcapsular. Single or multiple hematomas may be seen following blunt trauma. On unenhanced MDCT subcapsular hematoma is hyperdense relative to normal splenic parenchyma. On contrast enhanced CT subcapsular hematoma are typically seen as a low attenuation collection of blood between the splenic capsule and the enhancing splenic parenchyma. Subcapsular hematomas often compress the underlying splenic parenchyma and this CT finding helps to differentiate subcapsular hematomas from small amounts of blood or fluid in the perisplenic space. Uncomplicated subcapsular hematomas typically resolve within 4 to 6 weeks. Unless there is recurrent hemorrhage the attenuation value of the subcapsular hematoma usually decreases with the age of the lesion. On contrast enhanced CT, acute hematomas appear as irregular high or low attenuation areas within the parenchyma.

Acute splenic lacerations have sharp or jagged margins and appear as linear or branching low attenuation areas on contrast enhanced CT . With time the margins of splenic lacerations and hematomas become less well defined and the lesions decreases in size until the area becomes isodense with normal splenic parenchyma. Enlargement or extension of the lesion on follow-up CT should raise the possibility of injury progression warranting close clinical follow-up, further follow-up CT, or arteriography. Complete healing by CT appearance may take weeks to months depending usually on the initial size of the injury.

Active Hemorrhage

On contrast enhanced CT active hemorrhage in the spleen is seen as an irregular or linear area of contrast extravasation. Active splenic hemorrhage may be seen within the splenic parenchyma, subcapsular space, or intraperitoneally. On-going hemorrhage on MDCT may be seen as an increase in the amount of intravenous contrast material extravasated on images obtained in the identical anatomic region during the arterial and delayed renal excretion phases of contrast administration. The significant difference between the attenuation value of extravasated contrast material (range, 85 to 350 H, mean, 132 H) and hematoma (range, 40 to 70 H, mean, 51 H) is helpful in differentiating active bleeding from clotted blood.

Ability to scan during peak contrast enhancement in the early arterial or portal venous and during the excretory phases with MDCT has been helpful to differentiate active bleeding from posttraumatic splenic pseudoaneurysms or arterio-venous fistulas. Usually posttraumatic vascular injuries are similar in attenuation value to active hemorrhage in the arterial phase but “wash out” in the excretory phase becoming minimally hyperdense or isodense compared to normal splenic parenchyma. Significant correlation of MDCT findings of active splenic hemorrhage and need for angiographic or surgical intervention to treat hemorrhage has lead to an aggressive diagnostic and therapeutic pursuit of splenic vascular injury with MDCT and splenic angiography at the UMSTC. Patients with CT evidence of splenic vascular contrast extravasation without vascular injury on splenic arteriography undergo prophylactic proximal main splenic artery embolization to potentially increases the number of patients with blunt splenic injuries managed successfully without surgery.

Splenic Vascular Injuries

The appearance of posttraumatic splenic pseudoaneurysms and arteriovenous fistulas are similar on contrast enhanced MDCT and could only be differentiated using splenic angiography. Both of these lesions appear on MDCT as well-circumscribed focal areas of increased CT density, higher in attenuation than the normal enhanced splenic parenchyma (measure within 10 HU of the density of an adjacent major artery) [12, 21]. On images obtained in the delayed renal excretory phase these lesions become minimally hyperdense or isodense to the normal splenic parenchyma.

Gavant et al reported, demonstration of arterial contrast material extravasation or vascular abnormalities in the spleen seen on contrast-enhanced conventional and single slice spiral CT associated with an 82% (9/11) failure rate of nonoperatively managed blunt splenic injuries. In this retrospective study, among the 11 patients who failed nonoperative management, nine (82%) patients had vascular injuries including pseudoaneurysms in eight patients and active hemorrhage in one. However, in a retrospective study performed by Omert et al 11% (30/274) of patients with splenic injury had splenic vascular lesions ("contrast blush") and 25% (7/30) of these patients did not require surgical or angiographic intervention. The likelihood of surgical or angiographic intervention in patients with splenic vascular lesion was 9.2 times higher than patients without this lesion.

Post-Traumatic Splenic Infarction

On contrast enhanced CT post-traumatic splenic infarcts are seen as well-demarcated segmental wedge shape low attenuation areas with the base of the wedge towards the periphery of the splenic parenchyma. These infarcts may be the only CT finding of blunt splenic trauma and occur without any adjacent free fluid. Splenic infarcts may also be seen in association with splenic lacerationsand segmental infarcts in the kidney. Injury to the intima of splenic artery branches from sudden deceleration at the time of impact can lead to thrombosis and infarction of the splenic parenchyma from lack of perfusion distal to the intimal injury. Similar injuries have been observed on CT of the kidneys following blunt trauma. Though the exact natural history of this injury is not known, the majority of these lesions usually heal without need for surgical or angiographic intervention. Delayed complications of post-traumatic splenic infarction include splenic abscess formation and delayed rupture of spleen.

Nonoperative Management of Blunt Splenic Injury

Recently attempted nonoperative management is being firmly established as the primary method of splenic salvage in adult patients when other medical considerations permit. Compared to the observation rate of only13% reported in studies performed in the 1980s, 63% of patients with blunt splenic injuries were observed during the mid and late 1990s, demonstrating a major change in approach among trauma surgeons to primarily nonoperative management of blunt splenic injuries. Criteria used to select patients for nonoperative management of splenic injuries described in the literature include hemodynamic stability on admission, grade of splenic injury, amount of hemoperitoneum seen on CT, age less than 55 yr., ability to elicit reliable physical signs on serial physical examination, limited blood transfusion requirements, and exclusion of other injuries that may require laparotomy. The ability to accurately diagnose splenic injuries using CT, recognition of life-long susceptibility to infectious complications following splenectomy, the high post-operative complications rates and the longer hospital stays reported in patients undergoing splenic surgery have been a major impetus to increase splenic salvage.

A retrospective multi-center study was performed in 1997 by Peitzman et al for the Eastern Association for the Surgery of Trauma involving 1,488 adults (age > 15 years) with blunt splenic injuries to determine factors that predicted successful outcome by observation alone. Planned observation of splenic injuries was attempted in 63% (913/1448) of blunt splenic injuries. Failed nonoperative management occurred in 11% (97/913) of patients selected for observation. Factors associated with successful outcome in this study included a low splenic injury grade, a small amount of hemoperitoneum, a blood pressure > 100 mm Hg, and a near normal hematocrit. The majority of failures (61%) occurred within 24 hr. of admission as a result of hemorrhage. A high failure rate was observed in the patients with grade IV and grade V splenic injuries.

Studies have shown that splenic arteriography can be used to diagnose and embolize traumatic splenic vascular lesions. These studies reported a 93 to 97% success rate for patients with all grades of blunt splenic injury diagnosed by CT followed by splenic arteriography to embolize splenic vascular injuries. Other prospective and retrospective studies have demonstrated that aggressive pursuit of splenic pseudoaneurysms detected on contrast enhanced CT with splenic angiography and embolization resulted in an improvement in the success rate of nonoperative management of blunt splenic injuries from 87%to 94%.

NOM of Spleen Injury: CT Follow-up

The appropriate long-term clinical and imaging follow-up of splenic injury managed non-operatively is not established. Specifically, the value of obtaining a follow-up CT scan after initial identification of splenic injury by CT is debated. Patients who develop hemodynamic instability or increasing resuscitation requirements during attempted NOM either undergo repeat CT or proceed directly to celiotomy. Lawson et al has demonstrated that routine follow-up CT scans were not useful in 22 clinically stable patients with splenic injury managed non-operatively. Similarly Thaemert et al. assessed the role of follow-up CT for non-operatively managed splenic injuries in 73 children and adults. Only one of 49 stable patients undergoing follow-up CT had management altered by the CT result with procedure charges exceeding $54,000. Federle has pointed out that from 8-29% of blunt trauma patients with splenic injury have delayed bleeding from hours to weeks after injury and follow-up CT might show early progression of injuries. Also, he argues that follow-up CT can be very helpful in demonstrating splenic healing as a prelude to resumption of full physical activity. As noted by Federle, one criterion for return to full physical activity (particularly contact sports) might be demonstration of complete healing by repeat CT at 6 -12 weeks after injury. Lynch et al. described use of serial sonography to follow splenic injury to document healing after initial CT diagnosis. He demonstrated a correlation between injury grade by CT and time to complete injury healing. In the practice at the Shock-Trauma Center at University of Maryland I have observed several instances in which repeat follow-up CT in clinically stable patients revealed progression of splenic injury or delayed appearance of pseudoaneurysms requiring splenic angiography or surgical inspection of the spleen. I encourage our clinicians to obtain at least one follow-up CT at 3-5 days after injury or prior to discharge to exclude progression of injury and another to document splenic healing of patients prior to returning to physically demanding jobs or contact sports.

Finally, Krupnick et al have reported a 38% incidence of *missed* splenic injury and a 53% incidence of injury down-grading in pediatric patients based on sonography (radiologist/technologist performed) as compared to CT for initial diagnosis, arguing strongly against the use of sonography for initial the diagnosis of splenic injury. In addition, 7(22%) of 32 splenic injuries in this series had no associated hemoperitoneum raising questions about the role of sonography in screening for abdominal injury based on the presence or absence of free intraperitoneal fluid.

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