New technology in the management of liver trauma

Konstantinos Chatoupis, Glikeria Papadopoulou, Ioannis Kaskarelis

Asklepieion Voulas General Hospital, Athens, Greece

Abstract

The liver is the second most frequently injured solid organ in patients with blunt abdominal trauma. Hence the diagnosis and clinical assessment of hepatic trauma is of great importance because of the relationship of the liver to high morbidity and mortality. Multi detector-row computed tomography is the main diagnostic modality for the examination of hepatic parenchyma and other associated organ injuries, such as acute or delayed complications. Based on clinical and radiological findings, the majority of patients are managed conservatively, with the most important criterion of surgical therapy being hemodynamic instability. Radiologists must demonstrate a high knowledge of imaging recommendations and standardization of reporting to enable the selection of the appropriate treatment algorithm. Transcatheter embolization therapy is a method of great potential for the management of patients with traumatic hepatic injuries.

Keywords Liver trauma, computed tomography, transcatheter embolization

Ann Gastroenterol 2013; 26 (1): 41-44

Introduction

Second only to the spleen, the liver is the most frequently injured solid intra-abdominal organ. In 45% of liver injuries, there is also associated damage to the spleen. Deceleration injuries constitute the most common trauma mechanism.

Hepatic injury is often accompanied by ipsilateral rib fractures, right pneumothorax, contusion of the lung and damage to the right kidney or/and adrenal gland.

Severe liver trauma is associated with a high mortality rate ranging from 4.0% to 11.7% [1-3].

The right hepatic lobe is generally susceptible to trauma, while left lobe injuries are usually caused by a direct blow to the epigastrium, often accompanied by injuries to the duodenum, pancreas and transverse colon.

Organ injuries include:

1) Laceration
2) Subcapsular hematoma
3) Intraparenchymal hematoma
4) Contusion

Department of Radiology, Asklepieion Voulas General Hospital, Athens, Greece

Conflict of Interest: None

Correspondence to: Konstantinos Chatoupis, Radiology Department, Asklepieion Voulas General Hospital, Vas. Pavlou 1, 16673 Athens, Greece, Tel.: +30 210 8959 522, Fax: +30 210 8923 122, e-mail: kchatoupis@yahoo.gr

Received 13 May 2012; accepted 26 July 2012

Diagnostic imaging

Computed tomography (CT) is the modality of choice for the diagnosis and evaluation of severe hepatic injury in hemodynamically stable patients [4-7] as it facilitates the accurate diagnosis of parenchymal injury, the detection of potential damage to the hemoperitoneum and other solid organs including the retroperitoneal structures as well as a ruptured gastrointestinal tract [8,9].

Multi detector-row CT (MDCT) has enhanced imaging resolution and reduced scanning times while further permits the fast and reliable examination of patients with hemodynamic instability.

Non-operative management of liver trauma is currently the preferred management approach for those patients with hemodynamic stability, while high-quality CT has contributed significantly to the reduction in routine surgery [10-15].

It is essential that radiologists be familiar with the hepatic injury scoring system established by the American Association for the Surgery of Trauma (AAST).

CT scanning has proved equally beneficial in the detection of delayed liver injury complications such as hemorrhage, hepatic or perihepatic abscess, post-traumatic pseudoaneurysm or hemobilia, as well as biloma or bile peritonitis. CT monitoring is vital in those patients with a high grade hepatic injury to identify potential complications that require immediate intervention, as well as in those who are managed conservatively so that any imaging improvement can be recorded. Furthermore, the wide application of interventional radiology in hepatic trauma management has enabled an increase in the non-operative approach. Such techniques include angiographic embolization for the control of active bleeding, image-guided percutaneous drainage of bile and infected collections [16-18].

During the 80s and the early part of the 90s, several publications confirmed that up to 86% of liver injuries had stopped bleeding before surgery and up to 67% of exploratory laparotomy procedures for abdominal trauma proved non-therapeutic [9].

Major hepatic injuries identified by CT involve lacerations, subcapsular and parenchymal hematomas, active bleeding and hepatic venous injury. Minor injuries that can be revealed include disturbed periportal circulation and a flat inferior vena cava.

CT classification of severe hepatic injury

Severe hepatic injury is mostly graded in accordance with the classification defined by the AAST [19], which also describes abdominal injuries based on autopsy, laparotomy or CT findings. Injuries are stratified as grades I to VI. This system includes certain criteria that cannot be defined by CT as intraoperative findings have revealed significant differentiations. A CT-based classification can often underestimate the severity of the injury. Consequently, the surgeon's decision of surgical or conservative management should not rely solely on CT criteria as it is not uncommon for high grade injuries to respond to conservative therapy. The main criterion to determine the need for surgical management of a severe hepatic injury is not the extent of severity as shown by CT but the hemodynamic stability of the patient [7,20]. Notwithstanding, radiologists should be familiar with the CT classification system to confer better with the trauma surgeon [21].

Active contrast CT extravasation is considered a significant finding as it indicates a potentially life-threatening hemorrhage.

Hepatic laceration

Lacerations are the most common type of hepatic parenchymal injury. They are classified as superficial (≤3 cm depth) or deep (>3cm).

Lacerations that extend to the superoposterior area of segment VII, the "bare" area of the liver, can be accompanied by retroperitoneal hematomas around the inferior vena cava and also adrenal hematomas. Lacerations extending to the porta hepatis are commonly associated with bile duct injury, rendering them more likely to lead to the development of a biloma [4].

CT imaging findings:

1) Several linear low attenuation areas that frequently parallel hepatic veins (noncontrast CT)
2) Wedge-shaped low attenuation areas extending towards the surface of the liver (noncontrast CT)
3) Focal extravasation (contrast-enhanced CT)
4) Periportal low attenuation "tracking of blood"; a common finding and occasionally the only evidence of hepatic trauma (contrast-enhanced CT)
5) May involve vascular branches and/or biliary ducts.

Hematoma

Severe hepatic injury can cause subcapsular or intraparenchymal hematoma. Subcapsular hematoma appears as an ellipsoid-shaped collection of low attenuation blood between the liver capsule and the enhanced hepatic parenchyma at contrast-enhanced CT. Subcapsular hematomas can be differentiated from free intraperitoneal blood in as much as hematomas cause indentation or flattening of the underlying liver margin as opposed to the free blood which does not [4].

CT imaging findings:

1) High attenuation around the hepatic parenchyma (noncontrast CT)
2) Low attenuation around the hepatic parenchyma (contrast-enhanced CT)
3) Possible high attenuation of central region (blood clot)
4) Ruptured hepatic vein, commonly the right hepatic vein adjacent to the inferior vena cava

Contusion (rarely observed)

CT imaging findings:

1) Low attenuation around the hepatic parenchyma (contrast-enhanced CT)
2) Does not extend to portal or hepatic venous branches

Active bleeding

Active bleeding caused by severe hepatic injury is identified in the early arterial phase CT as a focal high attenuation area that represents a collection of extravasated contrast agent. Active arterial extravasation can be differentiated from clotted blood by measuring attenuation. Willmann *et al* [22] reported that enhanced active arterial extravasation on MDCT ranged in attenuation from 91 to 274 HU (mean value 155 HU), while that of blood clotting lay between 28 and 82 HU (mean value 54 HU).

Active bleeding appears as extravasated contrast material either locally in a parenchymal hematoma or freely in the peritoneal space as a "jet" [22,23].

Several researchers have demonstrated that active contrast extravasation is a strong predictor of non-operative management failure and recommended immediate surgical or angiographic intervention [22,24,25]. Fang *et al* [23] reported that 6 of 8 patients (75%) with active extravasation of contrast material became hemodynamically unstable and required surgery.

CT scanning that reveals lacerations or hematomas extending to one or more hepatic veins or to the inferior vena cava (IVC), should raise suspicion for hepatic venous injury

[6]. Such injuries could prove life threatening and warrant surgery [6,26]. Poletti *et al* [6] reported that liver surgery is 6.5 times more common in cases where lacerations extended to one or more hepatic veins. Furthermore, they added that hepatic vein injury is 3.5 times more commonly associated with arterial bleeding.

Periportal low attenuation

Periportal low attenuation is displayed on CT scanning as areas of low attenuation parallel to the portal vein and its branches. Areas observed close to a hepatic laceration are likely to signify bleeding in the periportal connective tissue. However, they may indicate dilatation of the periportal lymphatics due to high central venous pressure following intense intravenous fluid administration, tension pneumothorax or pericardial tamponade [4]. In the absence of any evidence of parenchymal injury, patients with periportal low attenuation can be managed conservatively.

Flat IVC

The IVC is considered flat if the anteroposterior diameter beneath the level of the renal vein is less than one-fourth of its lateral diameter and when this change is not the result of external compression [25]. Hypovolemia, poor fluid resuscitation and shock can manifest as a flattened IVC on CT scanning. A study by Wong *et al* [25] recorded that flattened IVC was not observed in any of the patients that had been successfully managed conservatively, as opposed to 29.6% who had undergone surgery and displayed a flat IVC at initial CT.

Interventional techniques in hepatic trauma management

Conservative management is the standard of care for hepatic trauma in hemodynamically stable patients. Eighty percent of adults and the majority of children do not require surgical or image-guided percutaneous intervention. The golden rule demands the close monitoring of the patient's hemodynamic condition. It should also be kept in mind that: a) subcapsular hematoma could initially increase in size before its absorption; b) contusions generally heal within 5-7 days; and c) while lacerations can heal within weeks, it is quite common for small bilomas to remain.

Active extravasation of CT contrast is a significant finding as it may denote a potentially life-threatening hemorrhage. Such findings or clinical signs of active bleeding prompt the need for arteriography and embolization [21].

The embolization agents are separated to:

1) Temporary (Gelfoam, autologous clot)
2) Permanent (coils or microcoils, particles, occlusion devices, glue and onyx)

In practice, coils, microcoils and Gelfoam cubes (often combined) are the most preferred embolic materials employed in hepatic trauma.

Microcoils are the agents of choice for supraselective approach (using microcatheters), getting close to the point of hemorrhage. Because of the rich collateral hepatic circulation it is better to embolize the vessels on both sides of the bleeding (deploying the coils beyond and proximal to the bleeding point). We also suggest that the procedure can be finished with more proximal vessel embolization, always bearing in mind the viability of liver parenchyma.

If it is not possible to get at the bleeding area with a supraselective mode then the choice is proximal vessel embolization either with an occlusion device or with larger coils and/or particles.

Transcatheter embolization for hepatic hemorrhage generally involves the following high lights:

1) The use of microcatheters ≈3F) and microcoils
2) Temporary embolization (Gelfoam is most commonly used)
3) Permanent embolization (generally with coils, polyvinyl alcohol particles, small plastic particles, cyanoacrylate glue)
4) In cases of large arteriovenous malformations (AMVs), detachable balloons are normally used

Angiographic embolization has proved to be the safest and most effective method for the control of active hepatic arterial bleeding [16,27-31].

Several researchers have recently reported that timely angiographic embolization in patients with severe hepatic trauma is associated with a lower rate of transfusions and surgical procedures [29,31]. Asensio *et al* [30] claim that angioembolization is linked to reduced mortality in patients with a high grade of complicated hepatic injury. Other studies have demonstrated similar or better results with angioembolization, with complication rates as low as 0% [32-35].

References

1. Matthes G, Stengel D, Seifert J, et al. Blunt liver injuries in polytrauma: results from a cohort study with the regular use of whole-body helical computed tomography. *World J Surg* 2003;**27**:1124-1130.
2. Croce MA, Fabian TC, Menke PG, et al. Nonoperative management of blunt hepatic trauma is the treatment of choice for hemodynamically stable patients: results of a prospective trial. *Ann Surg* 1995;**221**:744-755.
3. Pachter HL, Spencer FC, Hofstetter SR, Liang HG, Coppa GF. Significant trends in the treatment of hepatic trauma: experience with 411 injuries. *Ann Surg* 1992;**215**:492-500.
4. Shanmuganathan K, Mirvis SE. CT scan evaluation of blunt hepatic trauma. *Radiol Clin North Am* 1998;**36**:399-411.
5. Becker CD, Mentha G, Terrier F. Blunt abdominal trauma in adults: role of CT in the diagnosis and management of visceral injuries. *Eur Radiol* 1998;**8**:553-562.
6. Poletti PA, Mirvis SE, Shanmuganathan K, Killeen KL, Coldwell D. CT criteria for management of blunt liver trauma: correlation with angiographic and surgical findings. *Radiology* 2000;**216**:418-427.

7. Delgado Millan MA, Deballon PO. Computed tomography, angiography, and endoscopic retrograde cholangiopancreatography in the nonoperative management of hepatic and splenic trauma. *World J Surg* 2001;**25**:1397-1402.
8. Pachter HL, Hofstetter SR. The current status of nonoperative management of adult blunt hepatic injuries. *Am J Surg* 1995;**169**:442-454.
9. Pachter HL, Knudson MM, Esrig B, et al. Status of nonoperative management of blunt hepatic injuries in 1995: a multicenter experience with 404 patients. *J Trauma* 1996;**40**:31-38.
10. Romano L, Giovine S, Guidi G, Tortora G, Cinque T, Romano S. Hepatic trauma: CT findings and considerations based on our experience in emergency diagnostic imaging. *Eur J Radiol* 2004;**50**:59-66.
11. MacLean AA, Durso A, Cohn SM, Cameron J, Munera F. A clinically relevant liver injury grading system by CT, preliminary report. *Emerg Radiol* 2005;**12**:34-37.
12. Fang JF, Wong YC, Lin BC, et al. The CT risks factors for the need of operative treatment in initially hemodynamically stable patients after blunt hepatic trauma. *J Trauma* 2006;**61**:547-554.
13. Jacobs DG, Sarafin JL, Marxs JA. Abdominal CT scanning for trauma: how low can we go? *Injury* 2000;**31**:337-343.
14. Carrillo EH, Platz A, Miller FB. Non operative management of blunt hepatic trauma. *Br J Surg* 1998;**85**:461-468.
15. Boone DC, Federle M, Billiar TR, Udekwu AO, Peitzman AB. Evolution of management of major liver trauma: identification of pattern of injury. *J Trauma* 1995;**39**:344-350.
16. Hagiwara A, Yukioka T, Ohta S, et al. Nonsurgical management of patients with blunt hepatic injury: efficacy of transcatheter arterial embolization. *Am J Roentgenol* 1997;**169**:1151-1156.
17. Carrillo EH, Spain DA, Wohltmann CD, et al. Interventional techniques are useful adjuncts in nonoperative management of hepatic injuries. *J Trauma* 1999;**46**:619-622.
18. Goffette PP, Laterre PF. Traumatic injuries: imaging and intervention in post-traumatic complications (delayed intervention). *Eur Radiol* 2002;**12**:994-1021.
19. Moore EE, Cogbill TH, Jurkovich GJ, et al. Organ injury scaling: spleen and liver (1994 revision). *J Trauma* 1995;**38**:323-324.
20. Poletti PA, Wintermark M, Schnyer P, Becker CD. Traumatic injuries: role of imaging in the management of the polytrauma victim. *Eur Radiol* 2002;**12**:969-978.
21. Boyd-Kranis R. Solid organ trauma. *Semin Intervent Radiol* 2003;**20**:71-80.
22. Willmann JK, Roos JE, Platz A, et al. Multidetector CT: detection of active hemorrhage in patients with blunt abdominal trauma. *Am J Roentgenol* 2002;**179**:437-444.
23. Fang JF, Chen RJ, Wong YC, et al. Pooling of contrast material on computed tomography mandates aggressive management of blunt hepatic injury. *Am J Surg* 1998;**176**:315-319.
24. Fang JF, Chen RJ, Wong YC, et al. Classification and treatment of pooling of contrast material on computed tomographic scan of blunt hepatic trauma. *J Trauma* 2000;**49**:1083-1088.
25. Wong YC, Wang LJ, See LC, et al. Contrast material extravasation on contrast-enhanced helical computed tomographic scan of blunt abdominal trauma: its significance on the choice, time, and outcome of treatment. *J Trauma* 2003;**54**:164-170.
26. Hagiwara A, Murata A, Matsuda T, Matsuda H, Shimazaki S. The efficacy and limitations of transcatheter embolization for severe hepatic injury. *J Trauma* 2002;**52**:1091-1096.
27. Ciraulo DL, Luk S, Palter M, et al. Selective hepatic arterial embolization of grade IV and V blunt hepatic injuries. *J Trauma* 1998;**45**:353-359.
28. Johnson JW, Gracias VH, Gupta R, et al. Hepatic angiography in patients undergoing damage control laparotomy. *J Trauma* 2002;**52**:1102-1106.
29. Wahl WL, Ahrns KS, Brandt M, et al. The need for early angiographic embolization in blunt liver injuries. *J Trauma* 2002;**52**:1097-1101.
30. Asensio JA, Roldan G, Petrone P, et al. Operative management and outcomes in 103 AAST-OIS grades IV and V complex hepatic injuries: trauma surgeons still need to operate, but angioembolization helps. *J Trauma* 2003;**54**:647-654.
31. Mohr AM, Lavery RF, Barone P, et al. Angiographic embolization for liver injuries: low mortality, high morbidity. *J Trauma* 2003;**55**:1077-1082.
32. Wallis A, Kelly MD, Jones L. Angiography and embolisation for solid abdominal organ injury in adults – a current perspective. *World J Emerg Surg* 2010;**5**:18.
33. Letoublon C, Morra I, Chen Y, et al. Hepatic arterial embolization in the management of blunt hepetic trauma: indications and complications. *J Trauma* 2011;**70**:1032-1037.
34. Misselback TS, Teicher EJ, Cipolle MD, et al. Hepatic angioembolization in trauma patients: indications and complications. *J Trauma* 2009;**67**:769-773.
35. Monnin V, Sengel C, Thony F, et al. Place of arterial embolisation in severe blunt hepatic trauma: A multidisciplinary approach. *Cardiovasc Intervent Radiol* 2008; **31**:875-882.