RadioGraphics

CT in Blunt Liver Trauma[1]

CME FEATURE

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LEARNING OBJECTIVES FOR TEST 3

After reading this article and taking the test, the reader will be able to:

- Discuss the role of CT in the diagnosis and management of blunt liver trauma and the current status of the nonsurgical management of this entity.
- Describe the CT-based liver injury grading system established by the American Association for the Surgery of Trauma.

Nonsurgical treatment has become the standard of care in hemodynamically stable patients with blunt liver trauma. The use of helical computed tomography (CT) in the diagnosis and management of blunt liver trauma is mainly responsible for the notable shift during the past decade from routine surgical to nonsurgical management of blunt liver injuries. CT is the diagnostic modality of choice for the evaluation of blunt liver trauma in hemodynamically stable patients and can accurately help identify hepatic parenchymal injuries, help quantify the degree of hemoperitoneum, and reveal associated injuries in other abdominal organs, retroperitoneal structures, and the gastrointestinal tract. The CT features of blunt liver trauma include lacerations, subcapsular or parenchymal hematomas, active hemorrhage, juxtahepatic venous injuries, periportal low attenuation, and a flat inferior vena cava. It is important that radiologists be familiar with the liver injury grading system based on these CT features that was established by the American Association for the Surgery of Trauma. CT is also useful in the assessment of delayed complications in blunt liver trauma, including delayed hemorrhage, hepatic or perihepatic abscess, posttraumatic pseudoaneurysm and hemobilia, and biliary complications such as biloma and bile peritonitis. Follow-up CT is needed in patients with high-grade liver injuries to identify potential complications that require early intervention.

Abbreviations: AAST = American Association for the Surgery of Trauma, IVC = inferior vena cava

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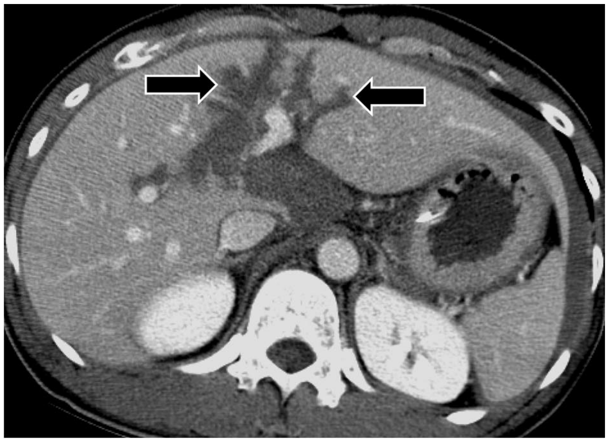
1.



2.

Figures 1, 2. **(1)** Hepatic laceration. Contrast-enhanced CT scan shows multiple linear and branching low-attenuation areas in the right hepatic lobe (arrows) that represent lacerations. **(2)** Complex hepatic laceration. Contrast-enhanced CT scan shows multiple linear lacerations ("bear claw" lacerations) in the left hepatic lobe (arrows). Note that the lacerated area extends to the porta hepatis. This type of laceration is commonly associated with biliary system injury.

Introduction

The liver is the most frequently injured abdominal organ in blunt trauma. The prevalence of liver injury in patients who have sustained blunt multiple trauma has been reported to be 1%–8% (1). However, liver injuries can be detected in up to 25% of patients with blunt trauma if whole-body computed tomography (CT) is performed as the initial diagnostic procedure in severely injured patients admitted to the trauma center (1). Blunt liver trauma still carries a significant morbidity and mortality. The reported mortality rate attributable to blunt liver injury ranges from 4.1% to 11.7% (1–3).

During the past decade, there has been a paradigm shift in the management of blunt liver trauma (4). Nonsurgical management has now become the preferred strategy in hemodynamically stable patients with blunt liver trauma. Recent studies at well-organized trauma centers suggest that 71%–89% of all patients with blunt liver trauma are treated nonsurgically, with success rates of 85%–94% (4–8). However, patients who are hemodynamically unstable despite fluid resuscitation and who have peritonitis, a finding that is suggestive of hollow viscus injury, should undergo emergency laparotomy (8–11).

The notable shift from routine surgical to nonsurgical management of blunt liver injuries can be attributed to several factors. The generalized use of helical CT in the diagnosis and management of blunt liver trauma is mainly responsible for this change. CT can accurately delineate the pathologic anatomy, help determine the severity of injuries and quantify the degree of hemoperitoneum, and reveal associated injuries to other abdominal organs, retroperitoneal structures, and the gastrointestinal tract (12,13). CT can also be used to assess complications of liver trauma and document the healing process in liver injuries while the patient is treated nonsurgically. Moreover, the widespread use of interventional radiologic techniques for the management of blunt liver trauma, including angiographic embolization for control of active arterial bleeding and imaging-guided percutaneous drainage of a biloma or infected fluid collection, has also promoted nonsurgical management (14–16). In the 1980s and early 1990s, many surgical reports confirmed that up to 86% of hepatic injuries have stopped bleeding by the time of surgery, and that up to 67% of all exploratory celiotomies performed for blunt abdominal trauma were nontherapeutic (13). Nonsurgical management requires fewer blood transfusions than does the surgical approach, and patients have less intraabdominal sepsis and a better survival rate (4,6).

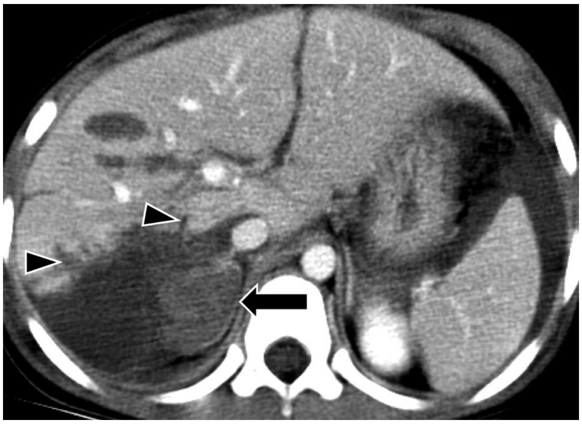


Figure 3. Bare area hepatic injury. Contrast-enhanced CT scan shows multiple lacerations (arrowheads) and a parenchymal hematoma that extend into the bare area of the liver, resulting in retroperitoneal hematoma. Note the hemorrhagic fluid surrounding the IVC and the associated hematoma in the right adrenal gland (arrow).

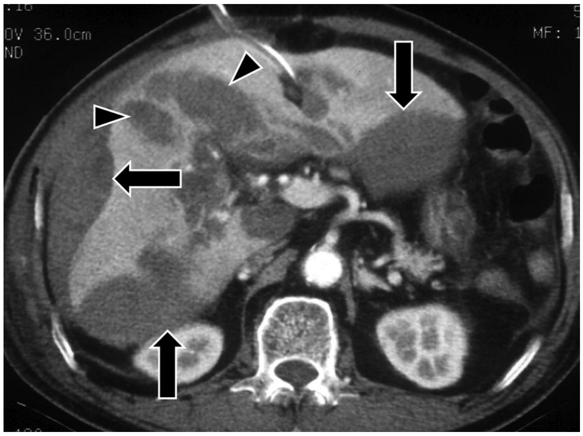


Figure 4. Subcapsular hematoma. Contrast-enhanced CT scan shows multiple subcapsular hematomas in the right and left hepatic lobes (arrows). Multifocal intraparenchymal hematomas are also seen (arrowheads).

In this article, we review the spectrum of CT findings in patients with blunt liver trauma and describe the role of CT in the treatment of these patients. We also describe a CT-based liver injury grading system that was developed by the American Association for the Surgery of Trauma (AAST). In addition, we discuss and illustrate the role of interventional radiologic techniques, including angiographic embolization and percutaneous drainage of fluid collections, in the management of blunt liver trauma.

CT Features of Blunt Liver Trauma

CT is currently the diagnostic modality of choice for the evaluation of blunt liver trauma in hemodynamically stable patients (17–20). CT can help accurately diagnose parenchymal injuries and exclude surgical lesions such as bowel or pancreatic injuries. The recent introduction of multi–detector row CT has greatly enhanced image resolution and markedly decreased the time required for scanning, thereby allowing examination of the whole body within a few minutes. Motion artifacts can be minimized with this shorter acquisition time. Furthermore, the integration of a helical CT scanner in an emergency unit allows rapid and accurate examination even in patients with some degree of hemodynamic instability.

Parenchymal liver injuries can be accurately detected on contrast material–enhanced CT scans. The major CT features of blunt liver trauma are lacerations, subcapsular and parenchymal hematomas, active hemorrhage, and juxtahepatic venous injuries. Minor CT features include periportal low attenuation and a flat inferior vena cava (IVC).

Laceration

Hepatic lacerations are the most common type of parenchymal liver injury and appear as irregular linear or branching low-attenuation areas at contrast-enhanced CT (Figs 1, 2) (17). Lacerations can be classified as superficial (≤3 cm in depth) or deep (>3 cm). Lacerations that extend to the posterosuperior region of segment VII, the bare area of the liver, may be associated with retroperitoneal hematomas around the IVC and accompanied by adrenal hematoma (Fig 3) (21). Lacerations that extend to the porta hepatis are commonly associated with bile duct injury and are thus likely to lead to the development of a biloma.

Hematoma

Subcapsular or intraparenchymal hematomas may manifest following blunt liver trauma. Subcapsular hematoma appears as an elliptic collection of low-attenuation blood between the liver capsule and enhancing liver parenchyma at contrast-enhanced CT (Fig 4). Subcapsular hematomas can be differentiated from free intraperitoneal blood in the perihepatic space in that the

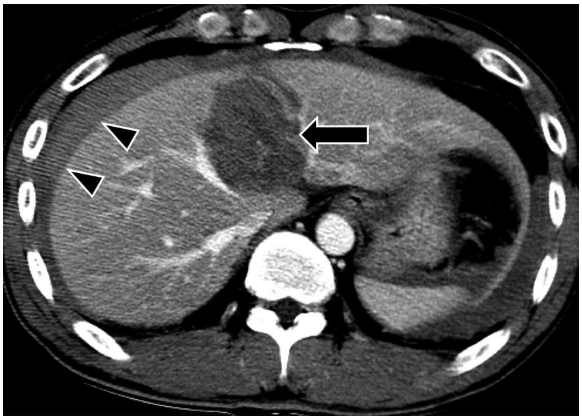


Figure 5. Intraparenchymal hematoma. Contrast-enhanced CT scan shows a 5-cm intraparenchymal hematoma in the medial segment of the left hepatic lobe (arrow). Arrowheads indicate associated hemoperitoneum in the right subphrenic space.

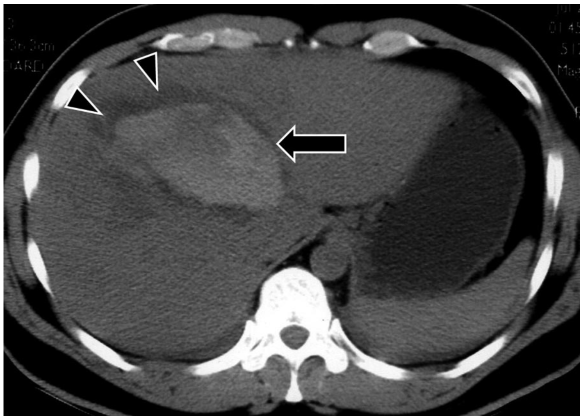
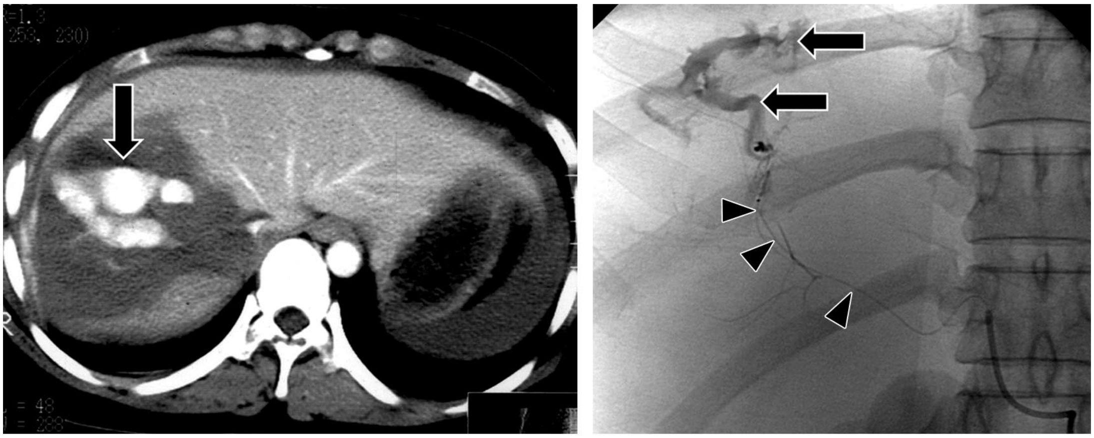


Figure 6. Hepatic hematoma. Unenhanced CT scan shows a high-attenuation hematoma in the anterior segment of the right hepatic lobe (arrow). Note the halo of low attenuation surrounding the hematoma (arrowheads).



a. **b.**

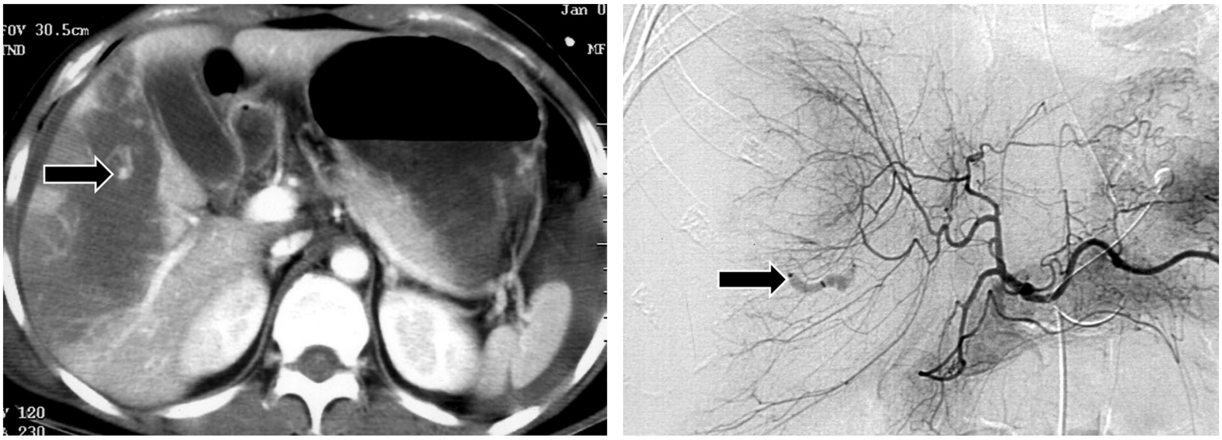
Figure 7. Active hemorrhage. **(a)** Arterial phase contrast-enhanced CT scan shows high-attenuation contrast material extravasation (arrow) within a massive hematoma in the posterior right hepatic lobe. **(b)** Radiograph obtained after injection of contrast material through a microcatheter in the right hepatic artery (arrowheads) shows active contrast material extravasation from the superior segmental branch of the artery (arrows).

former cause indentation or flattening of the underlying liver margin, whereas the latter does not (17).

Parenchymal hematomas or contusions are characterized by focal low-attenuation areas with poorly defined irregular margins in the liver parenchyma at contrast-enhanced CT (Fig 5). Acute hematomas are typically hyperattenuating (40–60 HU) relative to normal liver parenchyma at unenhanced CT (Fig 6).

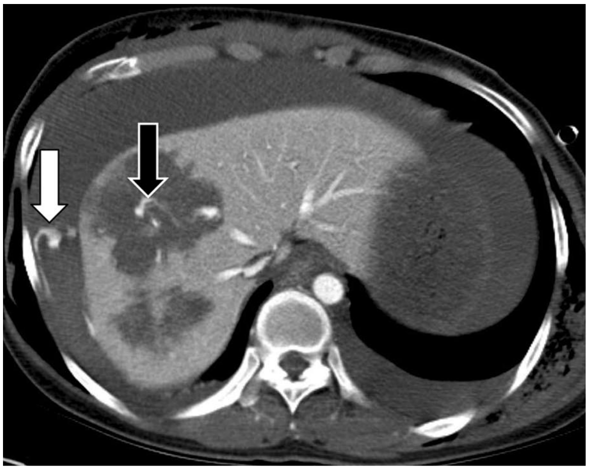
Active Hemorrhage

Active hemorrhage following blunt liver trauma is typically identified at early phase contrast-enhanced CT as focal high-attenuation areas that represent a collection of extravasated contrast material secondary to arterial bleeding (5). Active arterial extravasation can be differentiated from clotted blood by measuring CT attenuation. Willmann et al (22) reported that the attenuation of active arterial extravasation at multi–detector row CT ranged from 91 to 274 HU (mean, 155 HU),



a. b.

Figure 8. Active hemorrhage. **(a)** Contrast-enhanced CT scan shows high-attenuation arterial extravasation (arrow) within an intraparenchymal hematoma in the right hepatic lobe. **(b)** Celiac arteriogram shows active extravasation from a branch of the right hepatic artery (arrow).



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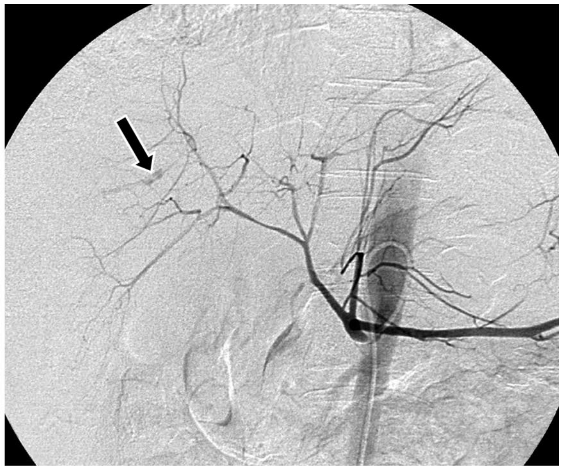

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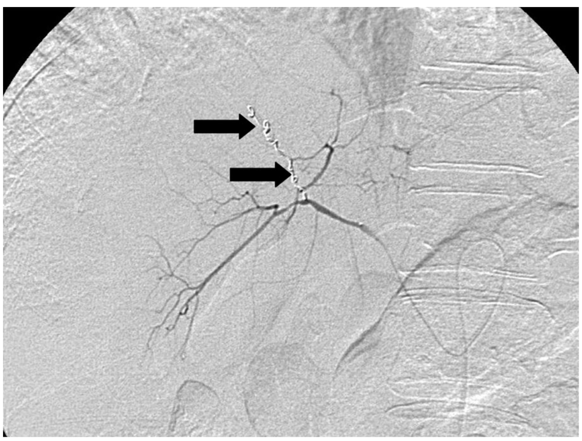

c.

Figure 9. Active hemorrhage. **(a)** Contrast-enhanced CT scan shows active arterial bleeding (arrows). **(b)** Celiac arteriogram shows contrast material extravasation from a branch of the right hepatic artery (arrow). The patient was treated with transarterial embolization. **(c)** Postembolization angiogram shows embolized microcoils (arrows) and no further extravasation.

whereas that of clotted blood ranged from 28 to 82 HU (mean, 54 HU). Active hemorrhage after blunt liver trauma can manifest as extravasation of contrast material either locally into a parenchymal hematoma (Figs 7, 8) or freely into the peritoneal space as a “jet” (Fig 9) (5,22).

The detection of active contrast material extravasation at CT is important because it indicates an ongoing, potentially life-threatening hemorrhage. Several investigators clearly demonstrated that active contrast material extravasation

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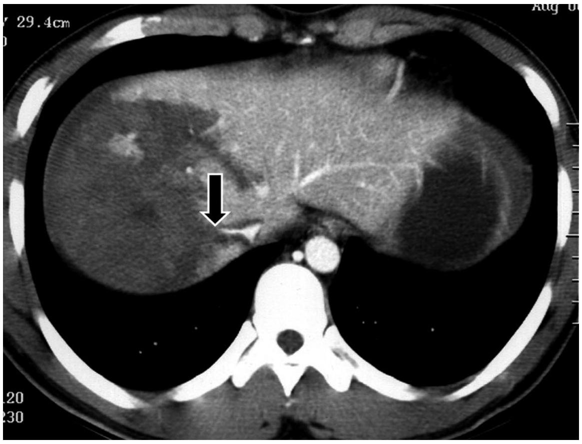


Figure 10. Hepatic venous injury. Contrast-enhanced CT scan shows a laceration that extends into the IVC and cutoff of right hepatic venous drainage (arrow). Hemorrhagic fluid is seen around the IVC. Surgery revealed a laceration of the right hepatic vein.

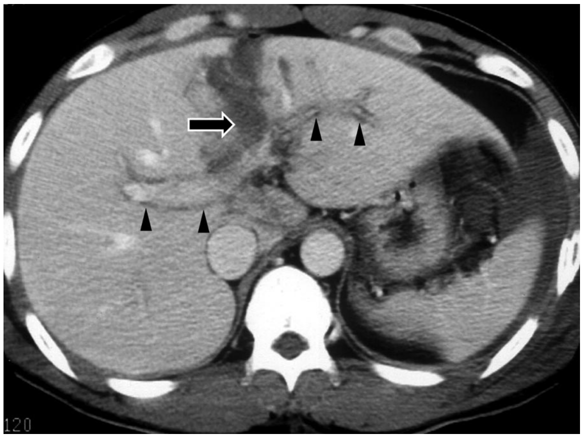


Figure 11. Periportal low attenuation. Contrast-enhanced CT scan shows low-attenuation areas around the portal vein and its branches (arrowheads). Note the laceration that extends into the porta hepatis (arrow). A finding of marked distention of the IVC may indicate vigorous fluid replacement.

at contrast-enhanced CT is a strong predictor of failure of nonsurgical management and recommended prompt surgical or angiographic intervention (5,23,24). Fang et al (5) reported that six (75%) of eight patients with active contrast material extravasation became hemodynamically unstable and required a liver-related celiotomy. With the growing use of multi–detector row scanners, this CT finding may no longer be uncommon in patients with blunt trauma (22).

Angiographic embolization has been shown to be safe and effective in the management of hepatic arterial hemorrhage in patients with blunt trauma (14,25–29). Evidence of active contrast material extravasation at CT or clinical signs of ongoing hemorrhage without other sources should be considered indications for arteriography and embolization (Fig 9) (30). Recently, several authors reported that the early use of angiographic embolization in patients with high-grade liver injuries is associated with fewer transfusions and a reduced need for further liver-related surgeries (27,29). Asensio et al (28) reported that angioembolization is independently associated with decreased mortality in high-grade complex liver injuries.

Major Hepatic Venous Injury

Major hepatic venous injuries are suspected if CT reveals hepatic lacerations or hematomas that extend into one or more major hepatic veins or the IVC (Fig 10) (19). Such lesions can be life threatening and are an indication for surgical treatment (19,31). Major hepatic venous injury seen at CT should be considered an indication of severe injury. Poletti et al (19) reported that liver-related surgery was 6.5 times more frequently required when the laceration extended into one or more hepatic veins than when it did not. In addition, they noted that CT findings of major hepatic venous injury may be an indirect sign of arterial

Figure 12. Flat IVC. Contrast-enhanced CT scan shows the IVC with a flat appearance (arrow) below the level of the right renal vein, a finding that suggests hypovolemia or shock. Active hemorrhage into the peritoneal cavity is also seen (arrowheads).

AAST Liver Injury Grading System

Grade	Description
I	Hematoma: subcapsular, <10% surface area Laceration: capsular tear, <1 cm in parenchymal depth
II	Hematoma: subcapsular, 10%–50% surface area; intraparenchymal, <10 cm in diameter Laceration: 1–3 cm in parenchymal depth, <10 cm in length
III	Hematoma: subcapsular, >50% surface area or expanding or ruptured subcapsular hematoma with active bleeding; intraparenchymal, >10 cm or expanding or ruptured Laceration: >3 cm in parenchymal depth
IV	Hematoma: ruptured intraparenchymal hematoma with active bleeding Laceration: parenchymal disruption involving 25%–75% of a hepatic lobe or one to three Couinaud segments within a single lobe
V	Laceration: parenchymal disruption involving >75% of a hepatic lobe or more than three Couinaud segments within a single lobe Vascular: juxtahepatic venous injuries (ie, retrohepatic vena cava or central major hepatic veins)
VI	Vascular: hepatic avulsion

Source.—Reference 32.

Figure 13. Grade I hepatic injury. Contrast-enhanced CT scan shows a focal capsular tear in the posterior right hepatic lobe (arrow). An associated small perihepatic hemorrhage is also seen (arrowheads).

hemorrhage and probably of a venous origin as well. Injuries that extended into one or more major hepatic veins were 3.5 times more frequently associated with hepatic arterial bleeding than were injuries without major hepatic venous involvement (19).

Periportal Low Attenuation

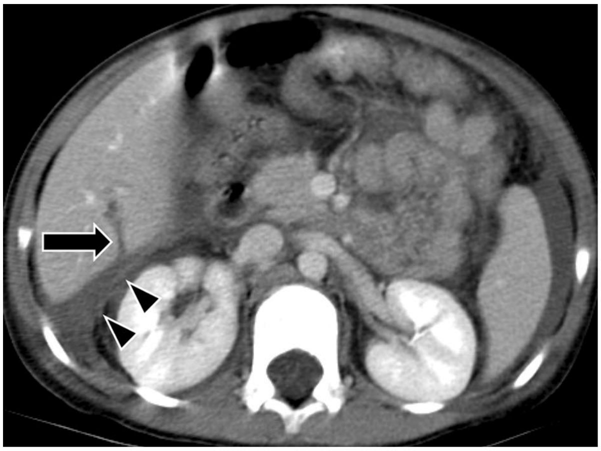
Periportal low attenuation manifests as regions of low attenuation that parallel the portal vein and its branches on CT scans. Periportal low attenuation seen in proximity to a hepatic laceration may represent a hemorrhage dissecting into the periportal connective tissue. However, it can also be due to distention of the periportal lymphatic vessels secondary to elevated central venous pressure following vigorous intravenous fluid administration (Fig 11), tension pneumothorax, or pericardial tamponade (17). Patients with periportal low attenuation without evidence of significant parenchymal injury can be successfully treated conservatively.

Flat IVC

The IVC is considered to be flat if its anteroposterior width below the level of the renal vein is less than one-fourth of its lateral width and the change is not caused by external compression (Fig 12) (24). Hypovolemia, poor fluid resuscitation, or shock may manifest as a flattened IVC at CT. Wong et al (24) reported that none of the patients in their study who responded to conservative treatment had a flat IVC, whereas 29.6% who required interventional treatment had a flat IVC at initial CT.

CT-based Injury Grading System

The most widely used grading system for blunt hepatic injury is the liver injury grading system established by the AAST (Table) (32). This system includes descriptions of injuries to abdominal organs that are based on the most accurate assessment at autopsy, laparotomy, or CT. Injuries may be categorized as grade I (Fig 13), grade II



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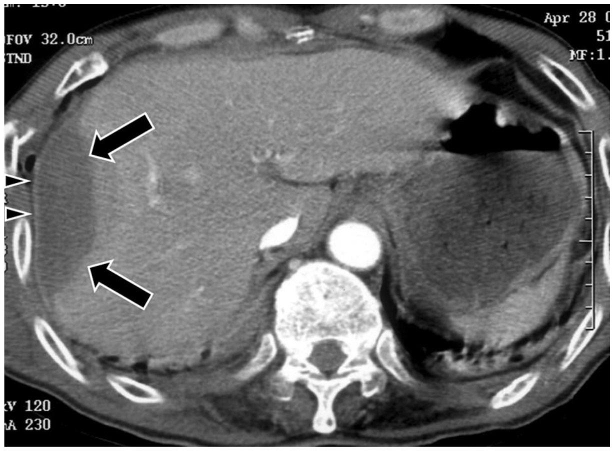
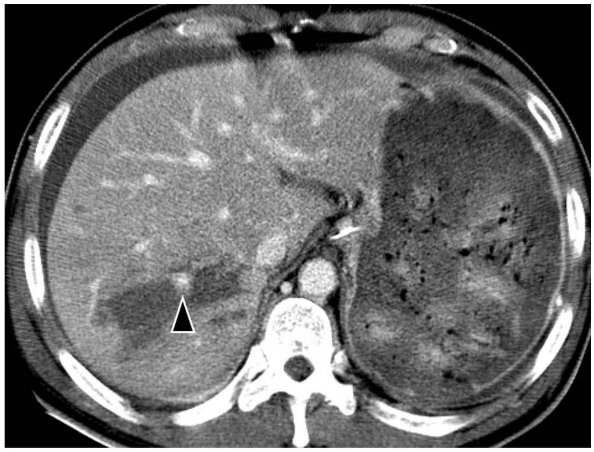


15.

Figures 14, 15. Grade II hepatic injury. **(14)** Contrast-enhanced CT scan demonstrates a hepatic laceration less than 3 cm in depth in the posterior right hepatic lobe (arrow). Note also the small fluid collection in the hepatorenal fossa (arrowheads). **(15)** Contrast-enhanced CT scan shows a lentiform, low-attenuation fluid collection (arrows) between the liver capsule (arrowheads) and enhancing liver parenchyma, a finding that suggests subcapsular hematoma. Note also the rib fracture.

16.



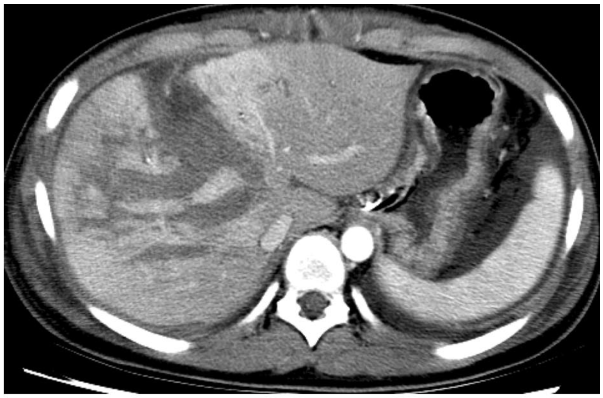
17.

Figures 16, 17. Grade III hepatic injury. **(16)** Contrast-enhanced CT scan shows a subcapsular hematoma in the right hepatic lobe (arrows). Note the high-attenuation foci within the hematoma (arrowhead), findings that indicate active contrast material extravasation. **(17)** Contrast-enhanced CT scan shows hepatic lacerations greater than 3 cm in parenchymal depth, with a focus of active hemorrhage (arrowhead).

(Figs 14, 15), grade III (Figs 16, 17), grade IV (Figs 18, 19) grade V (Figs 20, 21), or grade VI.

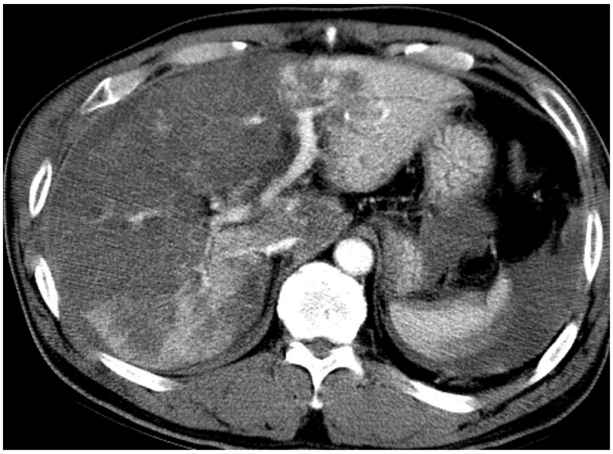
There are several drawbacks to the assessment of blunt liver trauma using this CT-based injury grading system. The AAST injury grading scale includes some criteria that cannot be assessed with CT, and wide discrepancies have been found between the CT injury grade and the intraoperative findings, with CT findings generally leading to underestimation of injury severity. In addition, surgeons should not determine on the basis of CT criteria alone whether to operate or to manage nonsurgically, since even high-grade injuries may often respond favorably to conservative treatment. It has been suggested that the best predictor of the need for surgical intervention in patients with blunt liver trauma is the loss of hemodynamic stability, not the severity of injury as determined with CT (20,33). However, to facilitate clinical research and communication with trauma surgeons, radiologists should be familiar with this CT-based injury grading system (30).

18.



19.

Figures 18, 19. Grade IV hepatic injury. **(18)** Contrast-enhanced CT scan shows a ruptured intraparenchymal hematoma with active bleeding in the right hepatic lobe. Note also the associated large hemoperitoneum. **(19)** Contrast-enhanced CT scan shows multiple hepatic lacerations in the right hepatic lobe, resulting in parenchymal disruption of about 50% of the lobe.



20.

21.

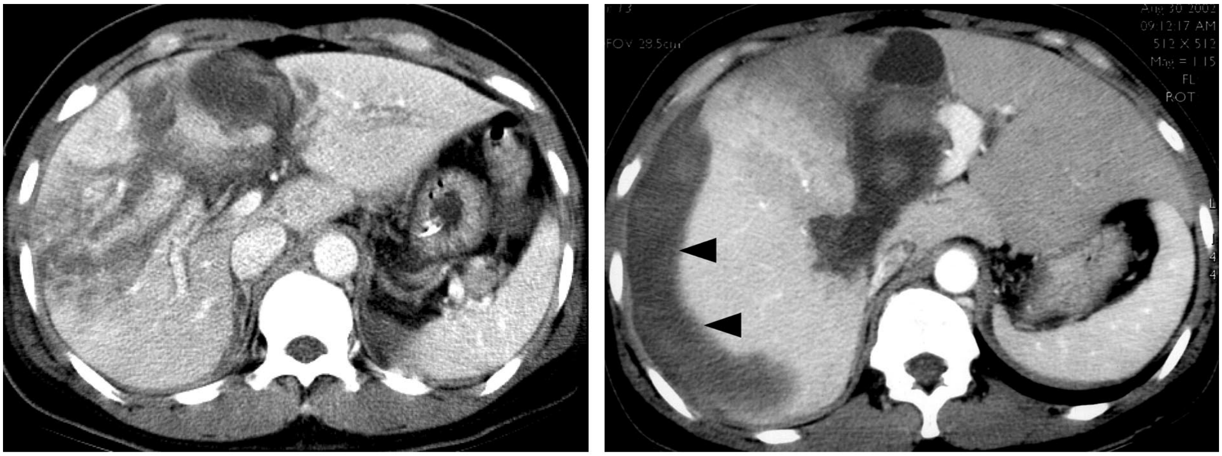
Figures 20, 21. Grade V hepatic injury. **(20)** Contrast-enhanced CT scan shows a large intraparenchymal hematoma and lacerations that involve the entire right hepatic lobe and the medial segment of the left hepatic lobe. **(21)** Contrast-enhanced CT scan shows a deep hepatic laceration that extends into the major hepatic veins. Note the discontinuity of the left hepatic vein (arrowhead), a finding that indicates laceration. This finding was confirmed at surgery.

CT Features of Delayed Complications

As more patients with complex (grade IV and V) liver injuries have been treated nonsurgically, the prevalence of delayed complications detected at follow-up CT has increased; such complications can arise weeks to months after injury (16). The reported prevalence of complications during nonsurgical management of blunt liver trauma ranges from 5% to 23% (13,15,34). These posttraumatic complications include delayed hemorrhage, abscess, posttraumatic pseudoaneurysm and hemobilia, and biliary complications such as biloma and bile peritonitis and are more common in patients with severe, complex liver injuries. Interventional radiology plays a major role in the initial management of such complications, and the early use of interventional procedures is advocated (15,16). Most of these complications can be successfully managed with interventional techniques with no reported mortality, although they also prolong the hospital stay.

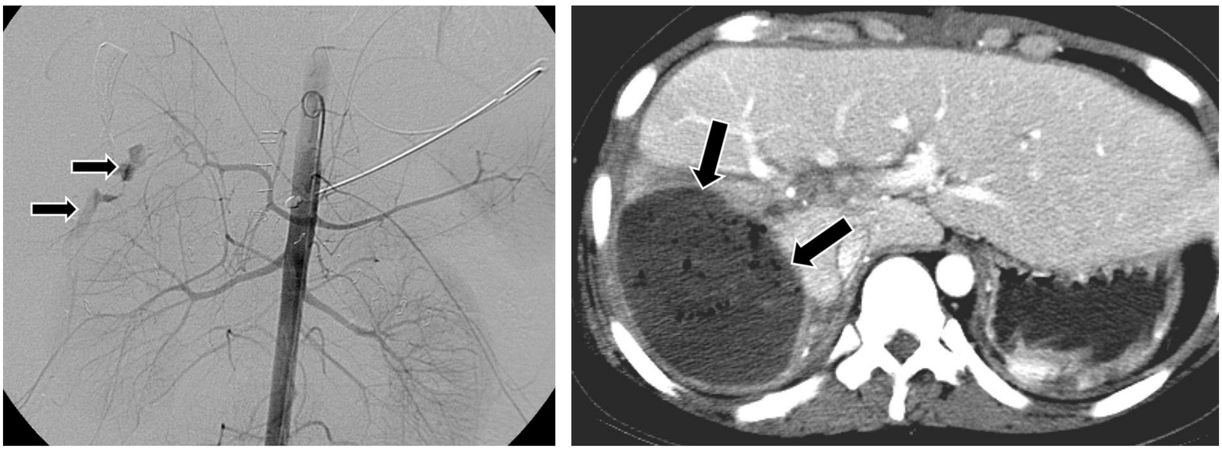
Delayed Hemorrhage

Delayed hemorrhage is the most frequently reported complication of the nonsurgical management of blunt hepatic injuries, with a prevalence



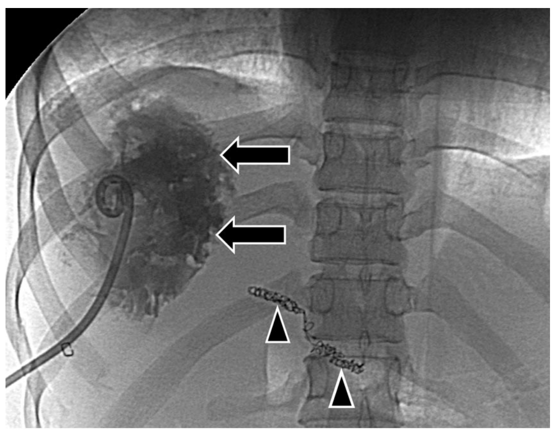
a. b.

Figure 22. Delayed hemorrhage. **(a)** Initial contrast-enhanced CT scan shows multiple hepatic lacerations and hematoma in both hepatic lobes. One month later, the patient complained of a sudden onset of right quadrant abdominal pain. **(b)** Follow-up contrast-enhanced CT scan shows marked resolution of the parenchymal injury but a newly developed subcapsular hematoma due to delayed hemorrhage (arrowheads). The patient was successfully treated conservatively.



a. b.

Figure 23. Hepatic abscess. **(a)** Aortogram shows active extravasation from a branch of the right hepatic artery (arrows). Arterial embolization was performed. **(b)** Contrast-enhanced CT scan obtained 3 weeks after embolization shows an encapsulated low-attenuation fluid collection (arrows) with multifocal gas bubbles, an appearance that suggests an abscess. Percutaneous catheter drainage was performed, and pus was aspirated. **(c)** Radiograph shows an abscess cavity (arrows) and embolized microcoils in the right hepatic artery (arrowheads).



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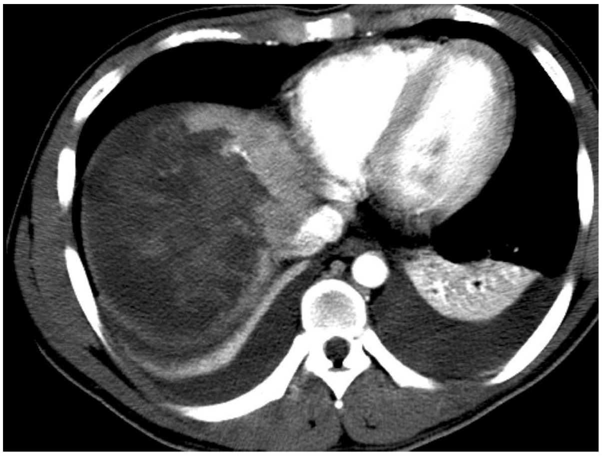

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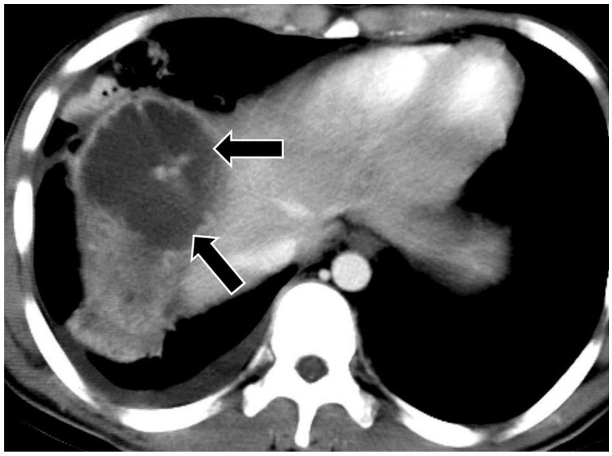


b.

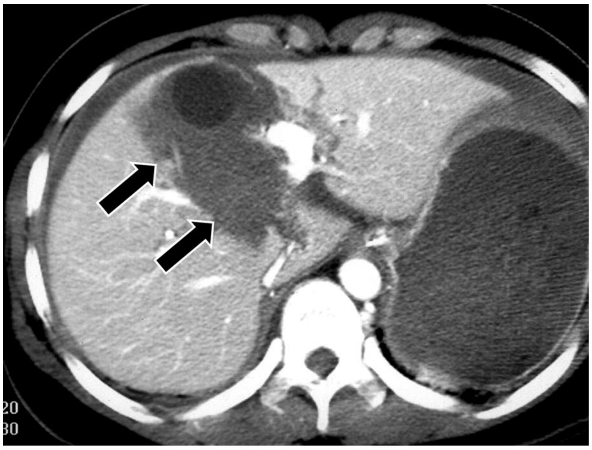
c.

Figure 24. Subphrenic abscess. **(a)** Initial contrast-enhanced CT scan shows a grade IV injury involving the hepatic dome. The patient was treated conservatively. **(b)** Follow-up contrast-enhanced CT scan obtained 21 days later reveals a well-defined low-attenuation fluid collection in the subphrenic region (arrows). Percutaneous catheter drainage was performed because the patient complained of high fever. **(c)** Contrast-enhanced CT scan obtained 28 days after percutaneous catheter drainage shows complete resolution of the abscess cavity.

ranging from 1.7% to 5.9% (15,44). Fisher and Moulton (35) analyzed 13 major reports on pediatric blunt hepatic injury and found delayed hemorrhage in 1.7% of patients who were treated nonsurgically. The overall mortality rate from delayed hemorrhage was 18% and was confined exclusively to patients who were treated surgically. Therefore, the authors suggested that prolonged nonsurgical management after delayed hemorrhage should be considered in the appropriate clinical setting (35). Delayed hemorrhage may be related to an initially minimal but expanding injury or to a biloma-induced pseudoaneurysm and may result in an expanding hematoma or free intraperitoneal rupture. This complication should be suspected in patients with ongoing transfusion requirements, a drop in hemoglobin level, pain arising in the right side of the abdomen, or increased parenchymal or subcapsular hematoma as demonstrated on serial follow-up CT scans (Fig 22) (16).

Abscess

At follow-up CT, hepatic or perihepatic abscess appears as a focal area of fluid attenuation with newly formed gas bubbles or an air-fluid level in the traumatized liver parenchyma or perihepatic space (Figs 23, 24). Clinical manifestations of hepatic abscess include abdominal pain and tenderness, fever, and leukocytosis. Abscess is a rare complication following nonsurgical management of blunt liver trauma and is usually seen in severely injured patients (grade IV or higher) (36). The reported prevalence of abscess during nonsurgical management of blunt liver trauma ranges from 0.6% to 4% (4,13,36). Percutaneous catheter drainage has now become the treatment of



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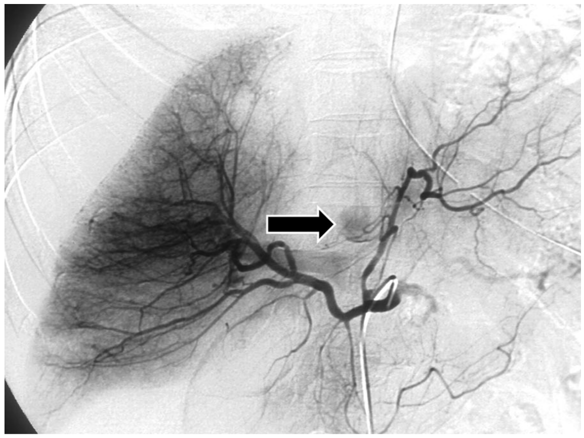


c.

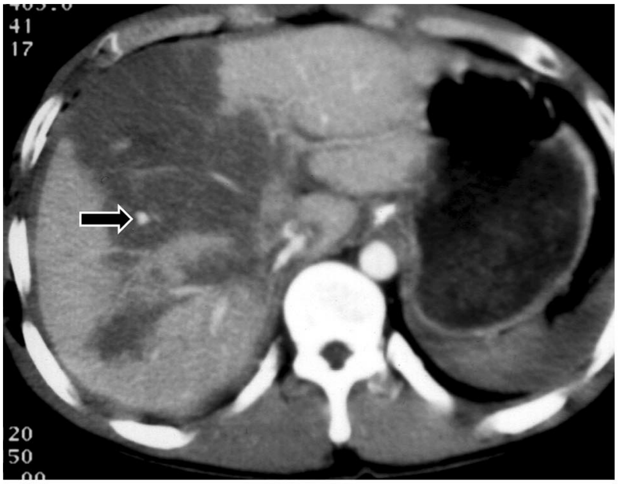
Figure 25. Posttraumatic pseudoaneurysm. **(a)** Initial contrast-enhanced CT scan shows a large hematoma in the medial segment of the left hepatic lobe (arrows). **(b)** Contrast-enhanced CT scan obtained 14 days later shows a newly developed, well-circumscribed pseudoaneurysm within the hepatic hematoma (arrow). **(c)** On a celiac arteriogram, the pseudoaneurysm (arrow) is seen to arise from the left hepatic artery.

choice for the majority of abscesses following blunt liver trauma, allowing successful treatment with no reported mortality (16).

Posttraumatic Hepatic Artery Pseudoaneurysms and Hemobilia

Hepatic artery pseudoaneurysms following blunt liver trauma originate from a disruption of arterial continuity with extravasation of blood into the parenchymal hematoma, where a fibrous tissue capsule is formed. Hepatic artery pseudoaneurysm is a rare complication of blunt abdominal trauma, with a reported prevalence of about 1% (37). A pseudoaneurysm typically manifests as a round focal lesion with high attenuation that is almost identical to major arterial structures at early phase contrast-enhanced CT (Fig 25). In general, asymptomatic hepatic artery pseudoaneurysms are found incidentally at follow-up CT. These asymptomatic pseudoaneurysms should be treated as early as possible because they have a high risk of rupture and are associated with high morbidity (38). Potential complications of hepatic artery pseudoaneurysms include rupture and associated hemorrhage or direct fistula formation to the duodenum. When a pseudoaneurysm is symptomatic, the clinical manifestations include abdominal pain, hematemesis, anemia, hypovolemia, and jaundice.

Decompression of a pseudoaneurysm into the biliary system causes hemobilia, and subsequent drainage into the duodenum can manifest as



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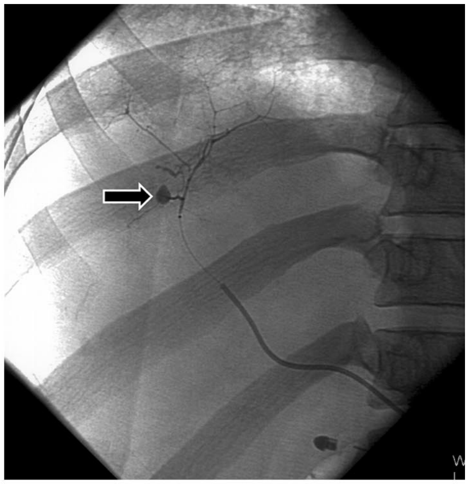

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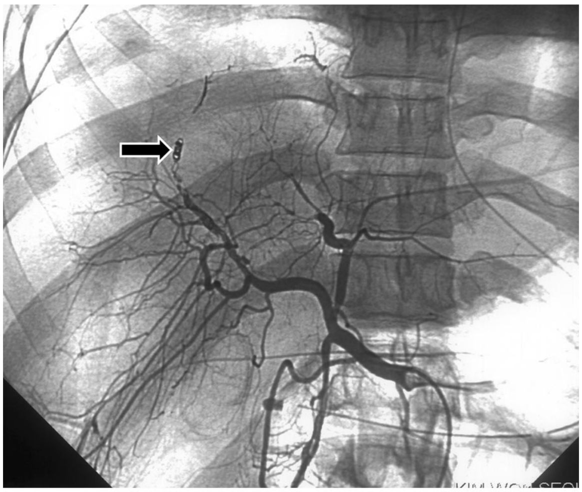


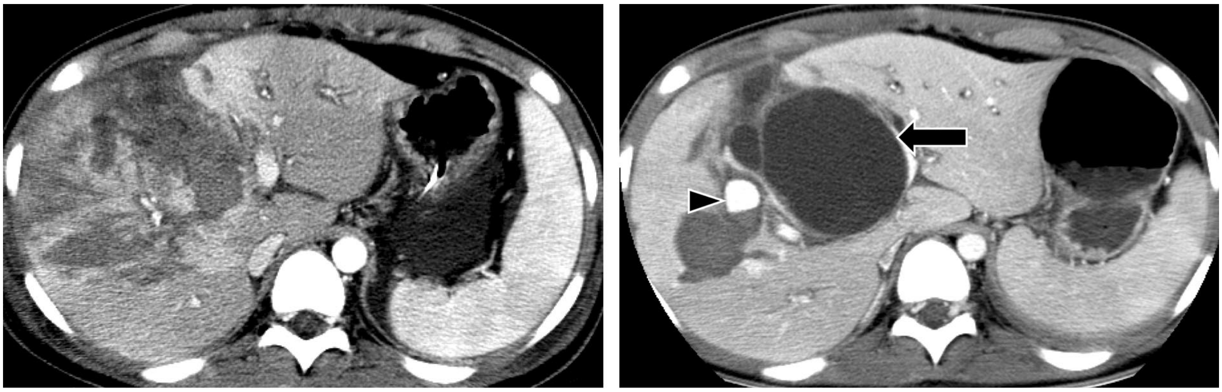
c.

Figure 26. Hemobilia due to posttraumatic pseudoaneurysm in a 31-year-old man with a grade IV liver injury. The patient was treated conservatively. Twenty days later, the patient presented with massive hematemesis. **(a)** Contrast-enhanced CT scan shows a round, high-attenuation lesion within the hepatic contusion (arrow). **(b)** Radiograph obtained after injection of contrast material through a microcatheter demonstrates a pseudoaneurysm (arrow) that arises from a superior segmental branch of the right hepatic artery. **(c)** Common hepatic angiogram obtained after embolization shows complete occlusion of the segmental branch of the right hepatic artery with microcoils (arrow). The clinical outcome was uneventful.

melena or hematemesis (Fig 26). Endoscopic visualization of bleeding from the ampulla of Vater or angiographic demonstration of a pseudoaneurysm in patients who present with melena or hematemesis following blunt liver trauma can help confirm the diagnosis (16,39). Angiographic embolization is the treatment of choice for hepatic artery pseudoaneurysm; it can be performed immediately after diagnostic arteriography and has a high success rate.

Biliary Complications

Leakage of bile from a hepatic laceration is quite common but in most cases is limited and transient, with no adverse sequelae. Significant injury to an intrahepatic or extrahepatic bile duct that requires definite treatment is relatively rare. Biliary complications as a result of bile leakage caused by injury to the bile duct system include



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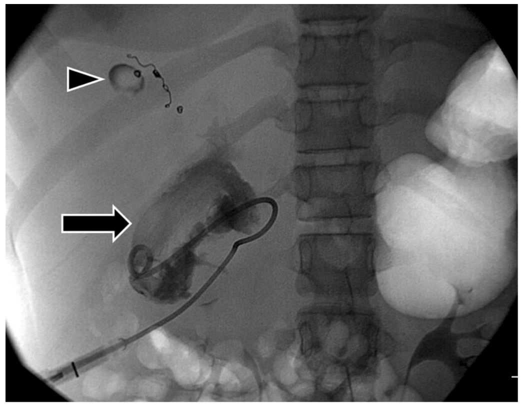


c.

Figure 27. Biloma and pseudoaneurysm. **(a)** Initial contrast-enhanced CT scan shows multiple lacerations and a hematoma in the right hepatic lobe and the medial segment of the left hepatic lobe. **(b)** Follow-up contrast-enhanced CT scan obtained 26 days later shows development of a biloma (arrow) and a pseudoaneurysm (arrowhead). The patient underwent transarterial embolization and percutaneous catheter drainage. Clear noninfected bile was drained. **(c)** Radiograph shows a drainage catheter within the biloma (arrow), partial filling of the pseudoaneurysm with contrast material (arrowhead), and embolized microcoils.

biloma, biliary fistula, bilhemia, and bile peritonitis. These complications have been seen in 2.8%–7.4% of patients with blunt liver trauma (12,15).

When injury to the intrahepatic bile ducts occurs, influx of bile into the hematoma may increase the pressure within the hematoma, leading to necrosis of the surrounding liver tissue and formation of a biloma (40). At CT, progressive growth of a well-circumscribed, low-attenuation intraparenchymal or perihepatic collection after liver trauma strongly suggests the diagnosis of biloma (Figs 27, 28) (41). Imaging-guided percutaneous aspiration is needed to confirm the diagnosis of biloma in symptomatic patients; CT cannot demonstrate bile duct injuries. Endoscopic retrograde cholangiopancreatography can be used to diagnose as well as treat ductal injuries and clearly documents the extravasation of injected contrast material from injured bile ducts (42). Most traumatic bilomas regress spontaneously. Bilomas that enlarge and cause pain or obstructive symptoms or that become infected can be successfully treated with percutaneous catheter drainage. A combination of percutaneous catheter drainage and therapeutic endoscopic retrograde cholangiopancreatography with endobiliary stent placement can be used to successfully treat the biloma and allow healing of the ductal disruption (15,41–43).

Bile leakage into the peritoneal cavity caused by injury to an intra- or extrahepatic bile duct may result in bile peritonitis. Liver trauma patients who subsequently develop fever, persistent abdominal pain, tenderness, distention, and leukocytosis are highly likely to develop bile peritonitis (16). However, these signs and symptoms may evolve gradually, making diagnosis difficult and leading to increased morbidity or mortality. At CT, persistent or increasing amounts of low-attenuation free fluid in the peritoneal cavity and enhancement and thickening of the peritoneum suggest the diagnosis of bile peritonitis (Fig 29) (17). The conventional treatment of bile peritonitis has been laparotomy. A combination of laparoscopic irrigation and drainage of the peritoneal cavity with endoscopic stent placement in bile ducts provides an alternative to conventional celiotomy (15,44).

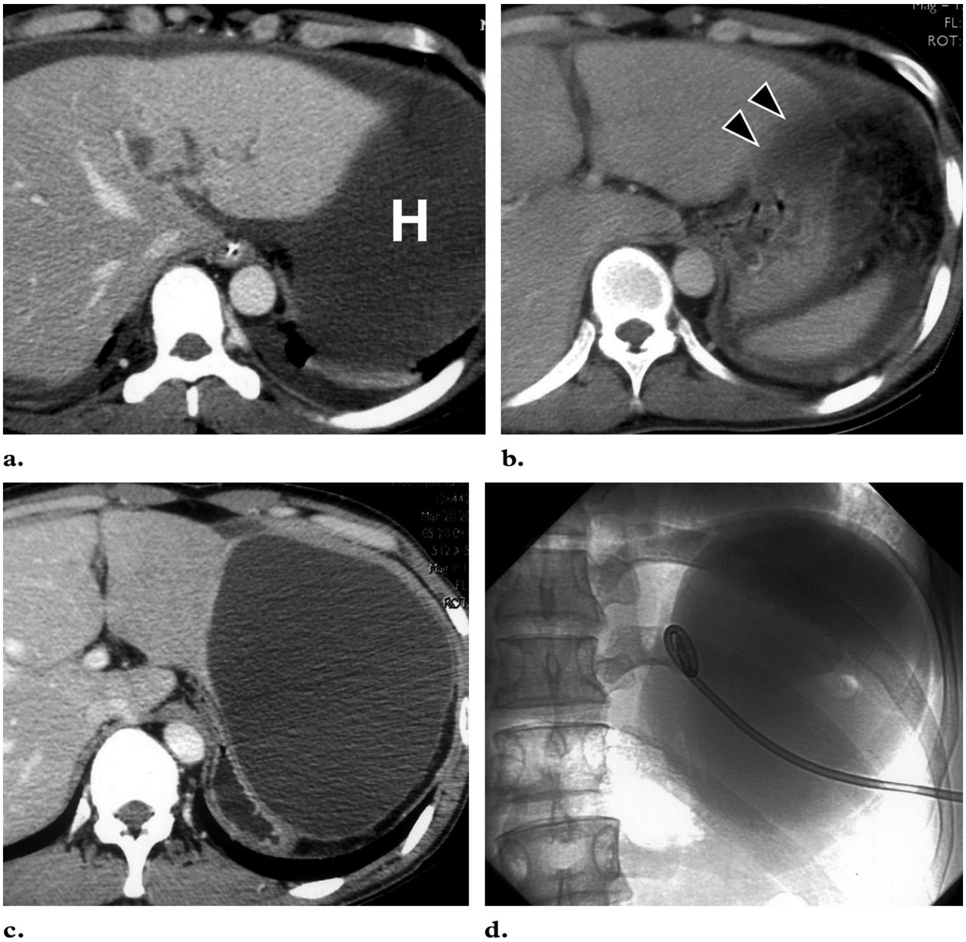


Figure 28. Biloma. **(a)** Initial contrast-enhanced CT scan shows lacerations in the left hepatic lobe. Note the extensive hemoperitoneum *(H)*. **(b)** Follow-up contrast-enhanced CT scan obtained 1 week later reveals complete resolution of parenchymal injury. A small amount of hemoperitoneum persists in the left perihepatic space (arrowheads). The patient presented with fever and left upper quadrant pain 1 month after sustaining blunt liver trauma. **(c)** Follow-up contrast-enhanced CT scan reveals a large cystic lesion that had developed in the left upper abdominal cavity. **(d)** Radiograph obtained during percutaneous catheter drainage reveals a noninfected bile collection.

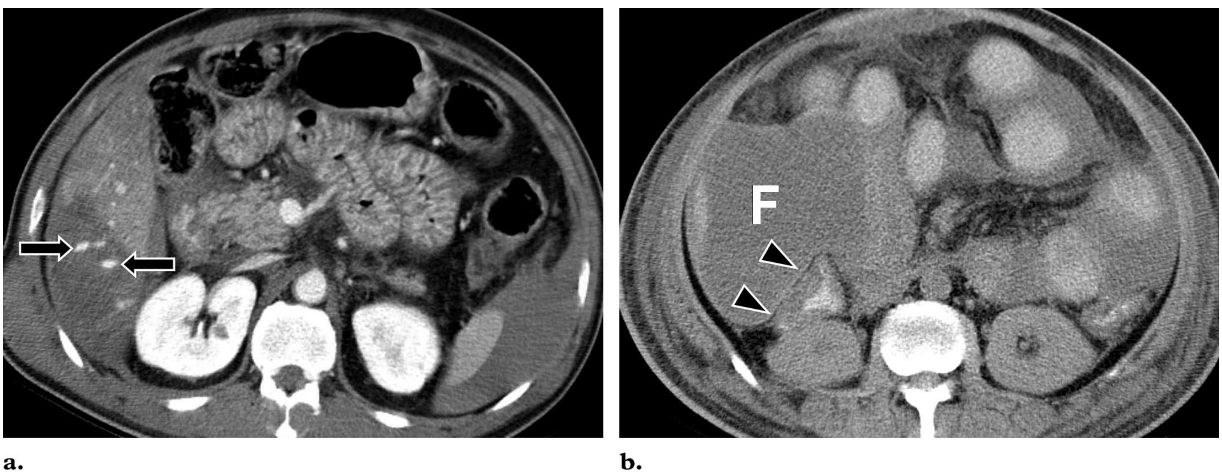
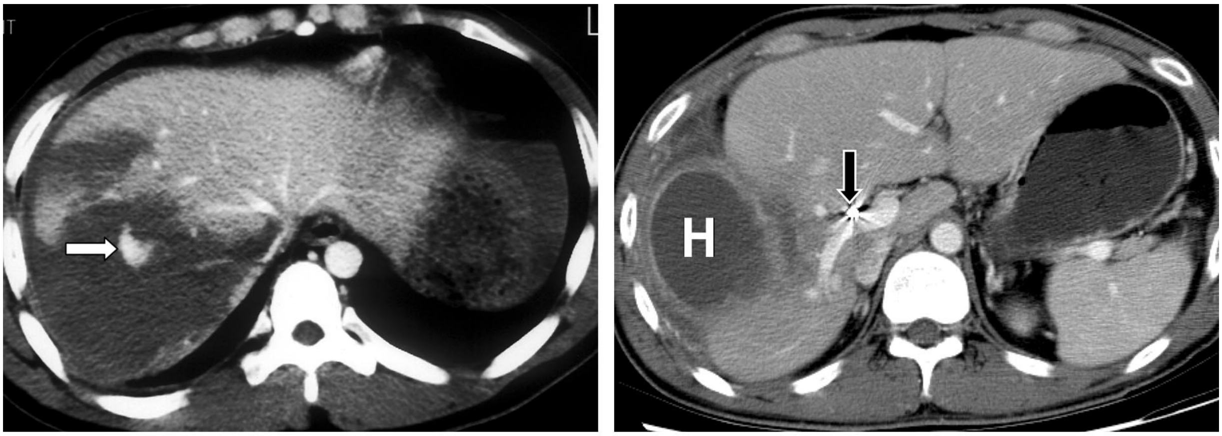
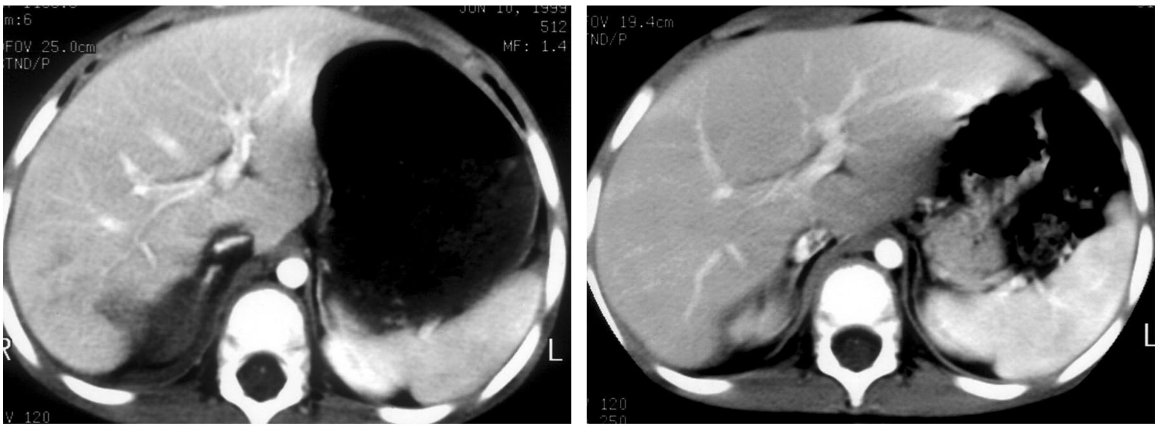


Figure 29. Bile peritonitis. **(a)** Initial contrast-enhanced CT scan shows foci of arterial extravasation (arrows) within a hepatic contusion in segment VI of the liver. **(b)** Unenhanced CT scan obtained 5 weeks later shows a large intraperitoneal fluid collection *(F)*. The peritoneum is slightly thickened (arrowheads). The presence of intraperitoneal bile and bile peritonitis was confirmed at aspiration. The patient died of sepsis and acute renal failure 1 month later.



a. b.

Figure 30. Nonsurgical management of severe hepatic injury. **(a)** Contrast-enhanced CT scan obtained at the time of admission shows grade IV injury with contrast material extravasation in the posterior right hepatic lobe (arrow). The patient was successfully treated with transcatheter arterial embolization. **(b)** Follow-up contrast-enhanced CT scan obtained 2 weeks later reveals resolution of the hepatic injury, with a well-defined subcapsular hematoma *(H)*. Note the microcoils in the right hepatic artery (arrow).



a. b.

Figure 31. Complete resolution of a grade II liver injury with conservative treatment. **(a)** Contrast-enhanced CT scan obtained at the time of admission demonstrates a grade II injury with lacerations less than 3 cm deep in the posterior right hepatic lobe. **(b)** Follow-up contrast-enhanced CT scan obtained 1 week later shows complete resolution of the hepatic injury. The patient was discharged 1 day after undergoing follow-up CT.

Follow-up CT Findings in Blunt Liver Trauma

CT can play an important role in monitoring conservative treatment and in detecting delayed liver-related complications in patients with blunt liver trauma. It is generally accepted that follow-up CT is unnecessary in patients with low-grade injury if the patient remains asymptomatic (45). The decision to perform repeat CT in such patients should be prompted by clinical criteria, such as abdominal pain in the right upper quadrant, jaundice, fever, anemia, or melena. In contrast, because the prevalence of complications is higher for more severe injuries (ie, grade IV or V), follow-up CT may be necessary in this subset of patients to identify potential complications that are amenable to early intervention. The optimal time frame for follow-up CT in patients with high-grade injuries appears to be between 7 and 10 days from the original injury (13).

Karp et al (46) proposed that the physiologic characteristics of hepatic repair after blunt injury progress in a predictable fashion, resulting in virtually complete restoration of hepatic integrity at the end of 3 months. Follow-up CT can document the tissue healing process (Fig 30): Hemoperitoneum usually resolves within 1 week, subcapsular hematomas in 6–8 weeks, and lacerations in 3 weeks (Fig 31), whereas hematomas and bilomas may persist for years. Parenchymal homogeneity is restored in 4–8 weeks (20).

Conclusions

CT is the modality of choice for the evaluation of blunt liver trauma in hemodynamically stable patients. The widespread use of CT in guiding management enables trauma surgeons to more liberally and confidently treat these patients nonsurgically. At present, the majority of blunt hepatic injuries are successfully managed nonsurgically under CT guidance. CT can accurately depict various patterns of hepatic parenchymal injuries as well as associated bowel or pancreatic injuries that require emergency laparotomy. In addition, follow-up CT is particularly useful for the early detection and monitoring of delayed hepatic complications in high-grade liver injury.

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