Computed Tomography (CT) in Blunt Liver Injury: A pictorial Essay

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SUMMARY

Computed tomography (CT) is widely used in assessing clinically stable patients with blunt abdominal trauma. In these patients, liver is one of the commonest organs being injured and CT can accurately identify and assess the extent of the injury. The CT features of blunt liver trauma include laceration, subcapsular or parenchymal haematomas, active haemorrhage and vascular injuries. Widespread use of CT has notably influenced the management of blunt liver injury from routine surgical to nonsurgical management. We present pictorial illustrations of various liver injuries depicted on CT in patients with blunt trauma.

KEY WORDS:
computed tomography, blunt abdominal trauma, liver injuries.

INTRODUCTION

The prevalence of liver injury in patients with blunt abdominal trauma has been reported to be 1-8%[1,2]. If whole-body CT is performed as initial diagnostic evaluation of severely injured patients, liver injuries can be detected in up to 25% of patients1. Currently, CT scan is the imaging modality of choice in diagnosing blunt liver injury in clinically stable patients[3,4]. Even though the decision for operative intervention is usually based on clinical criteria rather than on imaging findings, CT information frequently increases the diagnostic confidence of the surgeons[5,6]. The use of CT in blunt liver injury has influenced the current trends in the management of these injuries towards non-operative approach[7,8].

Out of 153 cases of CT abdomen performed for blunt abdominal trauma in our centre within a two-year period (2008 to 2009), liver injuries were seen in 53 cases. The CT images of all these patients were traced and retrospectively reviewed. The spectrum of liver injuries seen with the appropriate clinical and surgical correlations is presented in this article. For all patients, the scans were performed using a four-row multislice CT scanner; Somatom Siemens Volume Zoom (Siemens Medical Systems, Erlangen Germany) with slice width of 10mm, 2.5 mm collimation, 0.75s rotation time, table feed of 15 mm and 3 mm reconstruction interval. Pre- and post-contrast scans were routinely performed and patients received 2ml/kg of intravenous contrast medium (Iohexol 300 mg I/ml). Oral contrast was not routinely administered. The contrast-enhanced CT scans were acquired during portal venous phase, approximately 80 seconds after contrast injection. When necessary, sagital and coronal images were acquired using the maximum intensity projection (MIP) and multiplanar reconstruction (MPR) technique.

CT FEATURES OF BLUNT LIVER INJURY

CT has high sensitivity and specificity for the detection of liver injury[9]. The CT features of blunt liver injuries are lacerations, subcapsular and parenchymal haematomas, active haemorrhage and vascular injuries[2]. Liver lacerations are the most common type of parenchymal injury[10] (Figure 1). Lacerations that extend to the porta hepatis are commonly associated with bile duct injury and are likely to lead to the development of biloma[2]. Intraparenchymal haematoma can be clearly depicted on contrast-enhanced CT scan (Figure 2). Liver injury can also manifest as subcapsular haematoma (Figure 3) and it is important to differentiate it with free blood in the perihepatic space (Figure 4).

Free intraperitoneal fluid is a common finding on CT scans of patients with blunt liver injury[3,9]. Typical attenuation values of free intraperitoneal blood observes on CT a few hours after trauma are 30-45 HU, whereas clot measures 50-60 HU or even more (Figure 5)[11]. Small amount of haemoperitoneum first accumulate in the compartment adjacent to the site of bleeding and as they become larger will flow from Morison's pouch via the paracolic gutters to the pouch of Douglas[4]. The degree of haemoperitoneum may be estimated with CT based on the compartments involved[12]. Minor haemoperitoneum is when blood accumulates in one compartment with an estimated blood loss of 100-200 mL, moderate haemoperitoneum is when two compartments are involved with blood loss estimation of 250-500 mL and major haemoperitoneum is defined when more than two compartments are involved with blood loss estimation of more than 500 mL. However, no correlation was observed between the degree of haemoperitoneum and the need for surgery[13]. Majority of patients with liver injuries can be managed conservatively even if CT demonstrates large quantities of free intraperitoneal blood[7]. Detection of active haemorrhage on CT is more important as this is a strong predictor of failure of nonsurgical management[13,14]. Prompt surgical or angiographic intervention is recommended in such cases[13]. Active haemorrhage is identified as region of extravasated contrast material and is depicted on CT as area of high attenuation with value that ranged from 85-350 HU (Figure 6)[15]. The site of active haemorrhage identified on CT scans corresponded to the site of bleeding seen on angiography (Figure 7)[13].

CT-BASED INJURY GRADING SYSTEM

The most widely used grading system for liver injury is the grading system established by the AAST (Table I)[16]. Injuries may be categorized as grade I (Figures 8 and 9), grade II (Figures 10, 11 and 12), grade III (Figures 13, 14 and 15), grade IV

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(Figures 16 and 17), Grade V (Figure 18) and grade VI. There are several drawbacks in assessing liver injuries using CT grading, which includes underestimation of injury severity and poor correlation with the need for surgical intervention[17]. However, radiologists should be aware of these CT grading systems to facilitate communications with the managing surgical team and for the purpose of clinical research.

FOLLOW-UP CT FINDINGS IN BLUNT LIVER INJURY

Routine CT follow up is not recommended in low-grade liver injuries[18,19]. However, CT can play an important role in monitoring conservative management and in detecting delayed liver-related complications. Follow up CT can demonstrate the tissue healing process (Figure 19)20. Haemoperitoneum usually resolves within one week, subcapsular haematomas in 6-8 weeks, and lacerations in 3 weeks. Haematomas and bilomas may persist for years (Figure 20)4. Complete restoration of hepatic integrity is seen at the end of 3 months[20]. The overall liver-related complication rate was low, reported as 5%21. The complications include delayed haemorrhage, abscess, posttraumatic pseudoaneurysm and haemobilia, and biliary complications such as biloma (Figure 21) and bile peritonitis.

CONCLUSION

CT can accurately depict various patterns of liver injuries and other associated injuries that require urgent surgical intervention in patients with blunt abdominal trauma. CT is also useful in follow-up of high-grade liver injuries for early detection and monitoring of delayed complications. Knowledge on CT appearance of liver injury is important to radiologists and surgeons to facilitate communication for optimal patient care.

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FIGURES AND TABLE

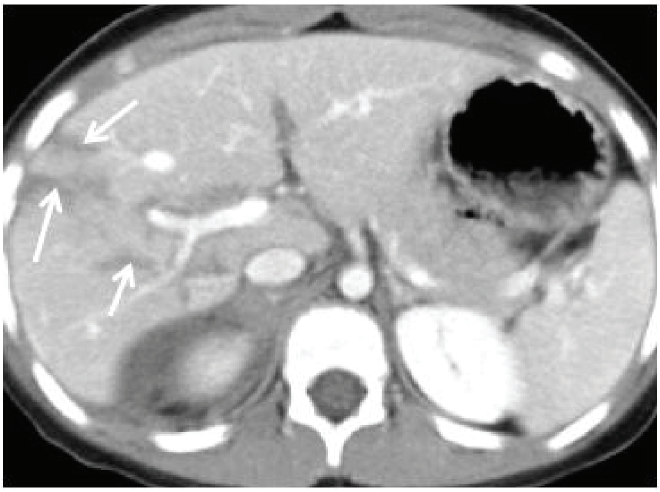


Figure 1: Liver lacerations. Contrast-enhanced CT scan shows multiple linear hypodensities in the liver (arrows) that represents lacerations.

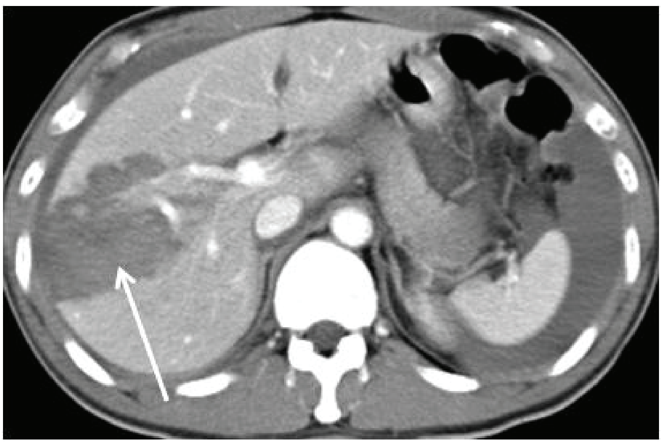


Figure 2: Intraparenchymal haematoma. Contrast-enhanced CT scan shows a focal hypodense area (arrow) with poorly defined irregular margins in the normally enhanced liver parenchyma.

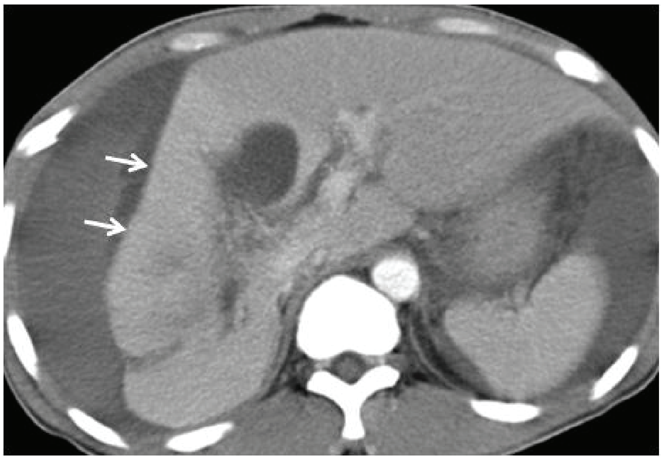


Figure 3: Subcapsular haematoma. Contrast-enhanced CT scan shows an elliptic hypodense collection compressing the normally enhancing liver parenchyma (arrows).

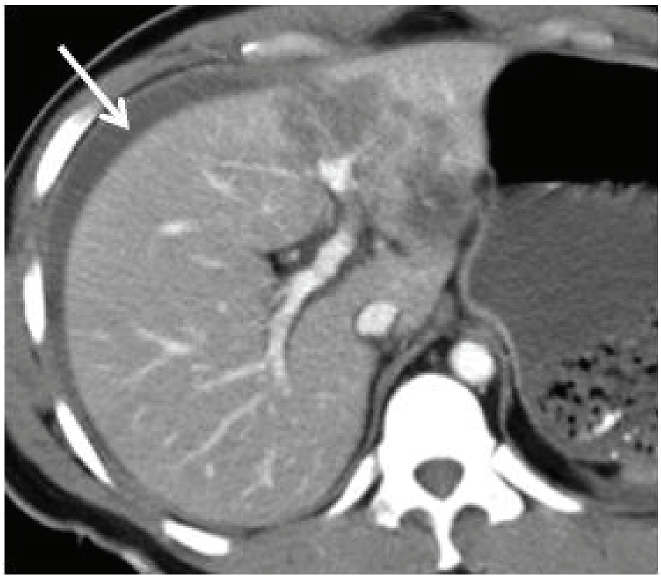
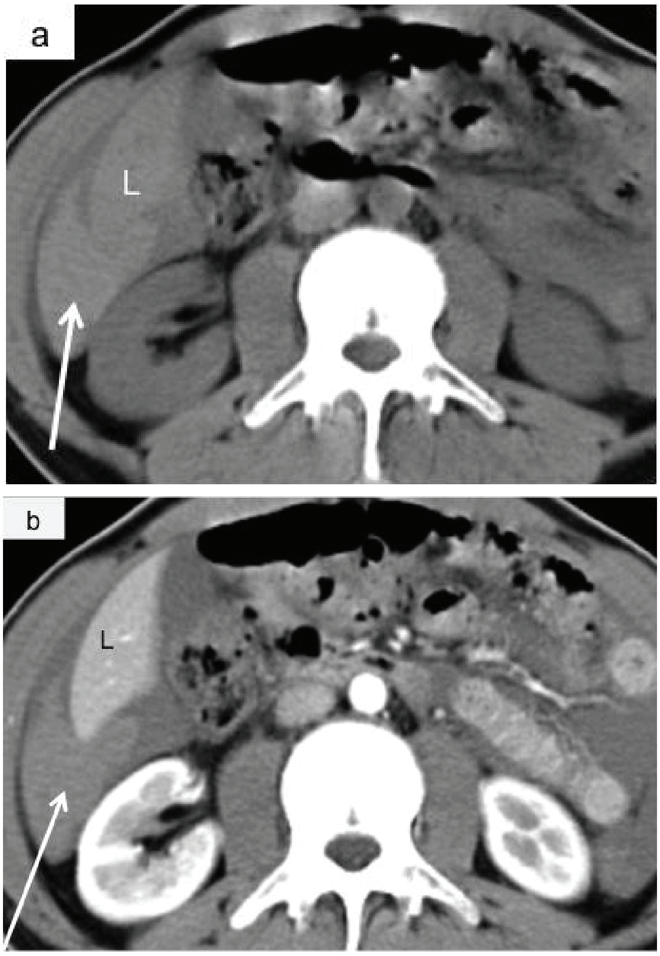


Figure 4: Free intraperitoneal haemorrhage in the perihepatic space also seen as elliptic hypodense collection (arrow) as a subcapsular haematoma, however it does not cause mass effect to the adjacent liver parenchyma. Also note the presence of the intraparenchymal haematoma.



Figures 5: Haemoperitoneum from liver injury. (a) Unenhanced CT scan shows hyperdense collection (arrow) compared to relatively hypodense unenhanced liver parenchyma (L). (b) CT scan after contrast injection shows the haemoperitoneum is relatively hypodense compared to normally enhanced liver (L).

Figure 6: Active haemorrhage. Contrast-enhanced CT shows high-attenuation contrast material extravasation (arrow) within a massive intraparenchymal haematoma. The finding was confirmed intraoperatively and total blood loss of 3 litres was recorded.

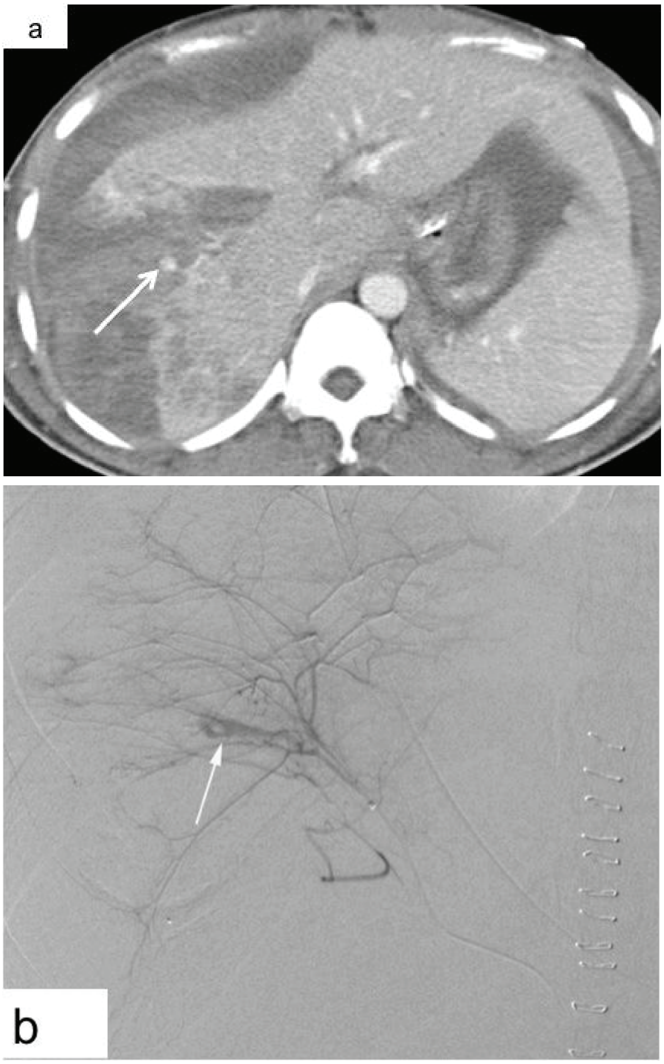


Figure 7: Active haemorrhage in a patient treated with transarterial embolization:

(a) Contrast-enhanced CT scan shows high-attenuation extravasation of contrast (arrow) within an extensive right hepatic lobe intraparenchymal haematoma

(b) Coeliac arteriogram shows active extravasation from a branch of the right hepatic artery (arrow) which was successfully embolized.

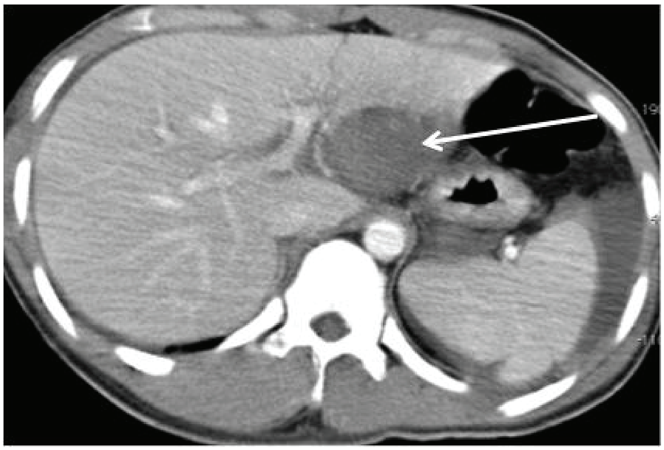


Figure 8: Grade I liver injury in a 15-year-old boy who was involved in a motor vehicle accident (MVA). Contrast-enhanced CT scan showed a subcapsular haematoma covering less than 10% of surface area (arrow). He was managed conservatively and recovered well.

Figure 9: Grade I liver injury. Contrast-enhanced CT scan shows a superficial capsular tear measuring less than one cm (arrow) in a patient who was assaulted. She was managed conservatively.

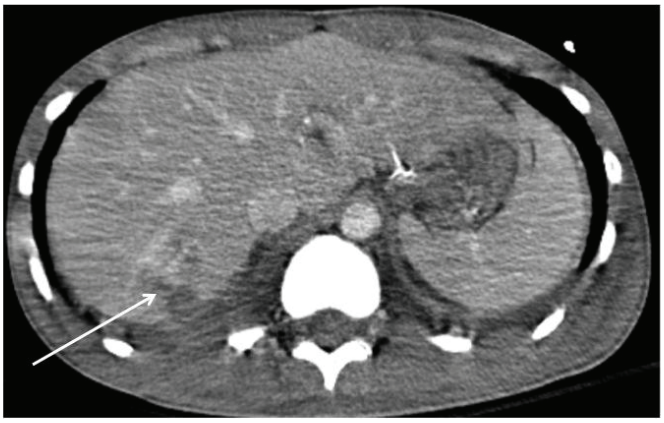


Figure 10: Grade II liver injury in a 16-year-old man with polytrauma. Contrastenhanced CT scan shows a hepatic laceration less than 3 cm in the posterior surface of right liver (arrow). He was managed conservatively.

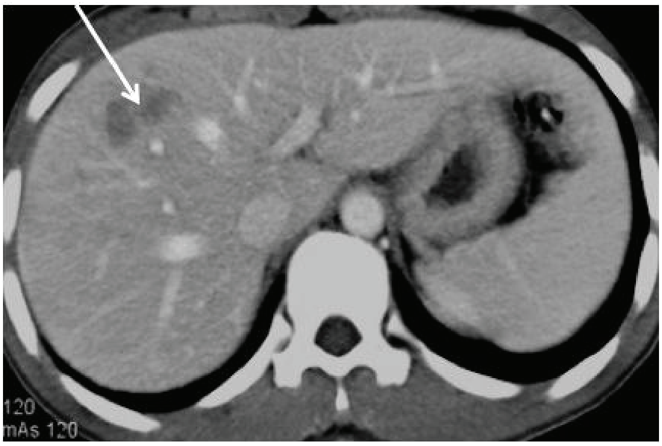


Figure 11: Grade II liver injury in a 16-year-old boy whose motorcycle skidded. Contrast-enhanced CT scan shows a small intraparenchymal haematoma less than 10 cm in diameter (arrow). He was managed conservatively with uneventful recovery.

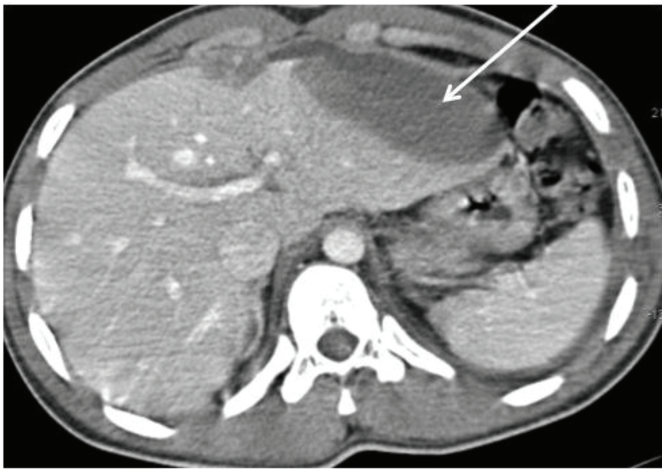


Figure 12: Grade II liver injury in a 48 years old man, a motorcyclist who was involved in a MVA. Contrast-enhanced CT scan show subcapsular haemorrhage 10-50% of surface area. He was managed conservatively.

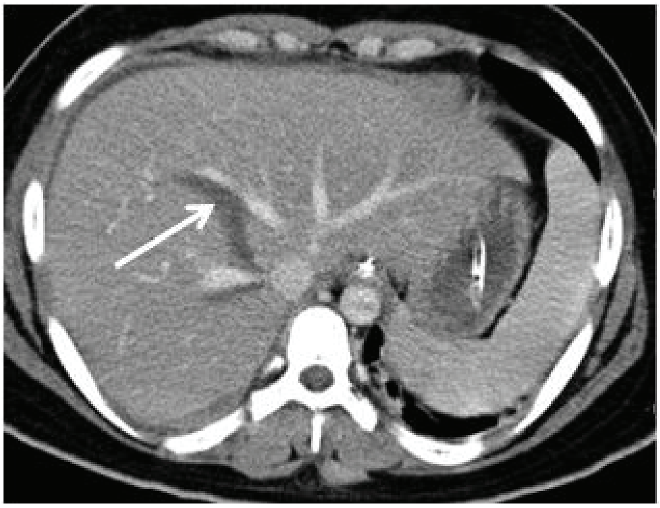


Figure 13: Grade III liver injury. CT scans show deep laceration (arrow), more than 3 cm in parenchymal depth. This 18-year-old male skidded motorcyclist was managed conservatively with uneventful recovery.

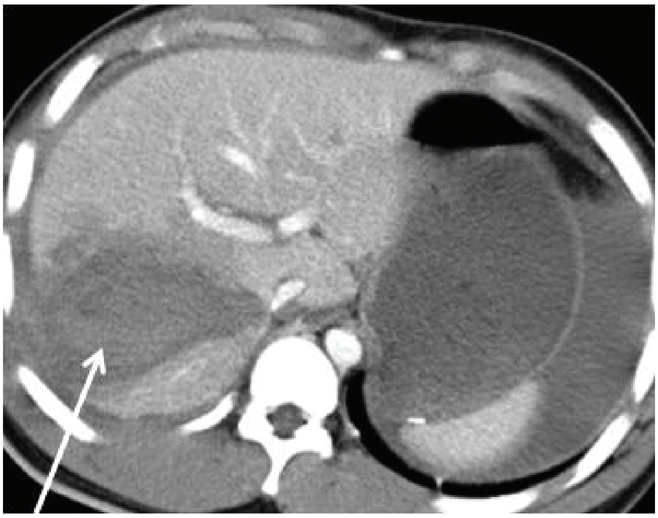


Figure 14: Grade III liver injury in a 19-year-old male whose motorcycle has skidded. CT scan shows a ruptured intraparenchymal haematoma (arrow) in the right hepatic lobe. The finding was confirmed intraoperatively.

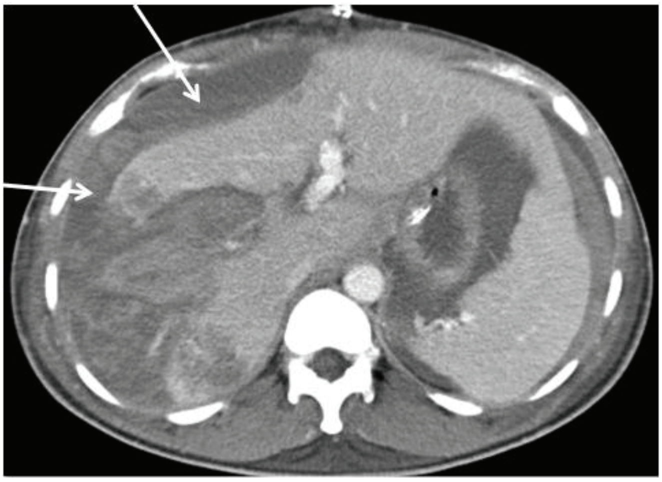


Figure 15: Grade III liver injury in a 38-year-old man with MVA. Contrastenhanced CT scan shows a large subcapsular haematoma (arrow) involving more than 50% of surface area. Laparotomy and liver packing was performed.

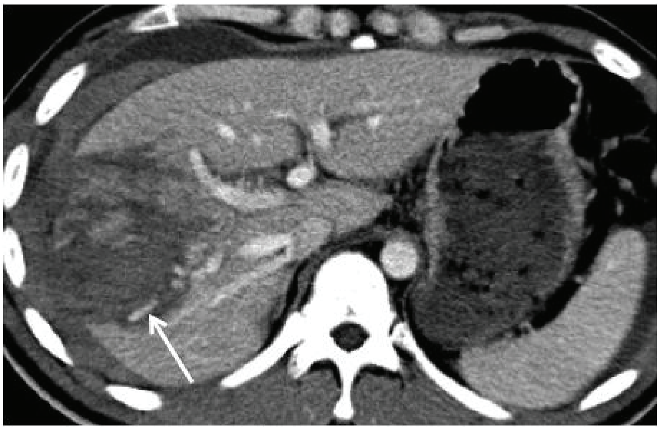


Figure 16: Grade IV liver injury in a 23 year-old man who was injured when his motorcycle hit a tree branch. Contrast-enhanced CT scan shows ruptured intraparenchymal haematoma with active bleeding (arrow) in the right hepatic lobe. He had undergone laparotomy with liver packing and recovered fully.

Figure 17: Grade IV liver injury in 17-year-old motorcyclist. Contrast-enhanced CT scan shows multiple lacerations in the right lobe of the liver resulting in parenchymal disruption of about 25-40% of liver lobe or two Couinaud segments of right hepatic lobe. He was successfully managed conservatively.

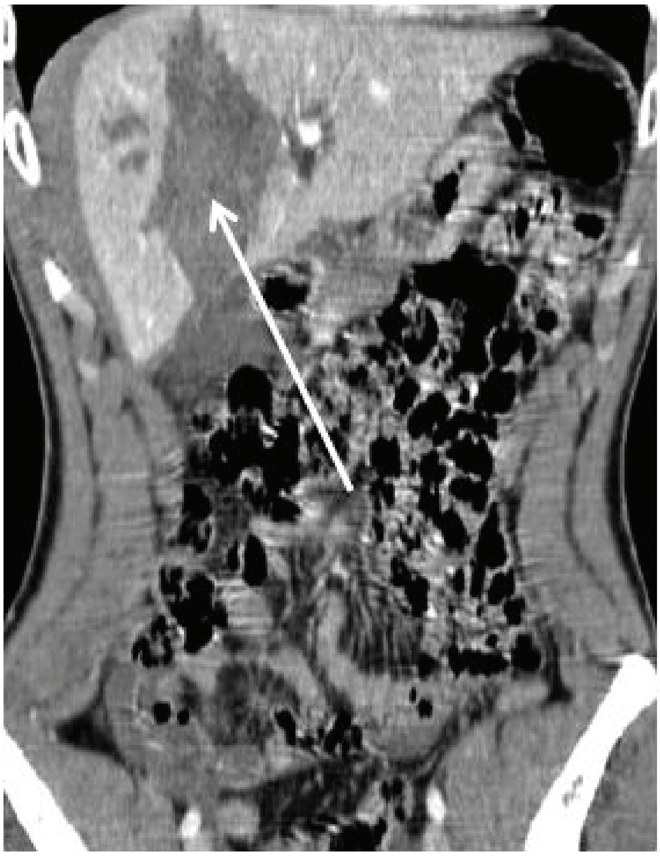
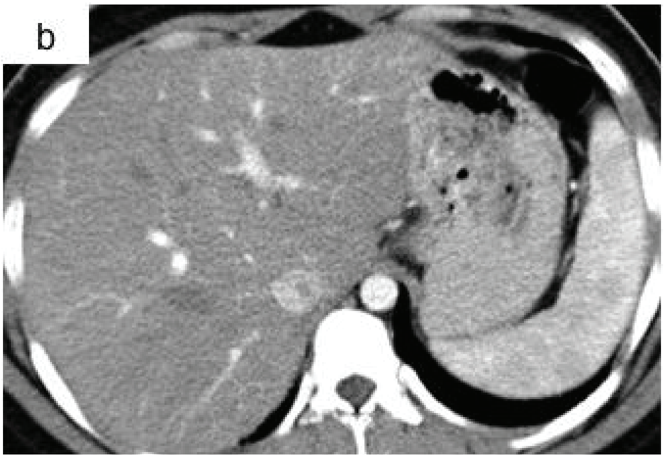


Figure 18: Grade V liver injury. Coronal image after multiplanar reconstruction (MPR) shows multiple lacerations in the right lobe of the liver with disruption of more than 75% of the liver lobe. This patient, a 19-year-old male was injured when his motorcycle collided with a lorry. He recovered well after a conservative management.

Figure 19: Complete resolution of a liver injury with conservative management.

(a) CT scan done during admission in this 18-year-old male who was involved in MVA shows deep liver laceration consistent with Grade III injury.



(b) Follow up contrast-enhanced CT scan after one year shows complete resolution of the hepatic injury. CT scan was performed to assess complication of right renal injury (images not shown).

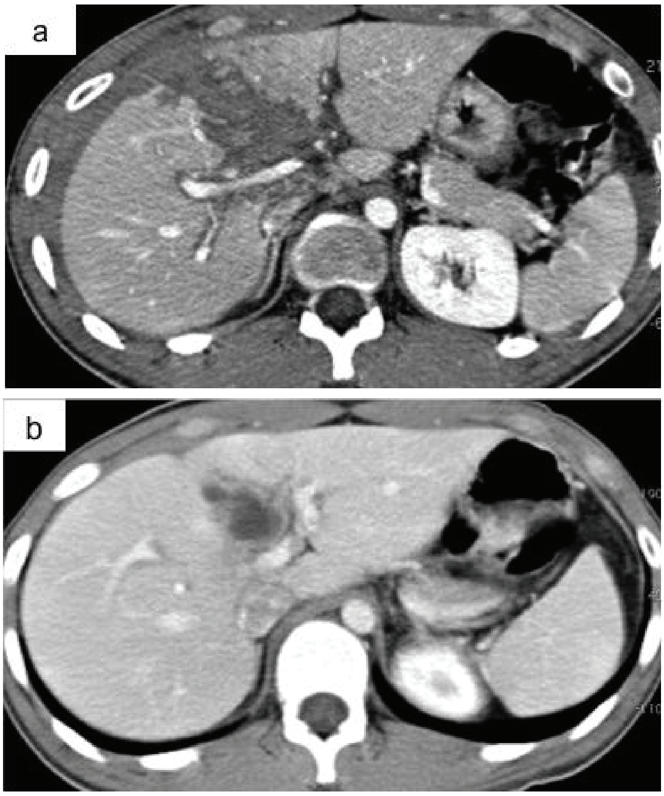


Figure 20. Conservative management of liver injury with residual haematoma on follow up in a19-year-old motorcyclist who was involved in MVA.

(a) Contrastenhanced CT scan on admission shows deep laceration in the liver parenchymal consistent with Grade III liver injury.

(b) Follow up CT scan 2 months later shows small residual haematoma at the previous site of injury.

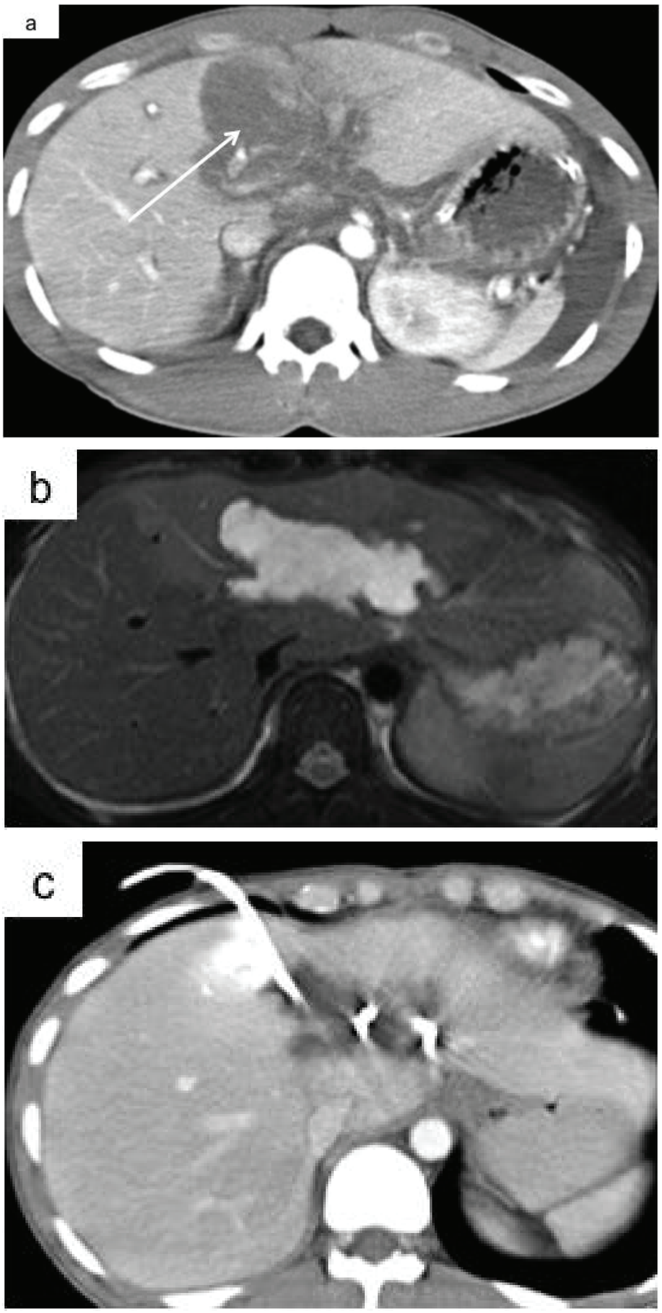


Figure 21. Complications of liver injury:

(a) Initial contrast-enhanced CT scan shows complex hepatic lacerations and parenchymal haematoma that extends to the porta hepatis (arrow) in a 30-year-old motorcyclist who collided with a cow.

(b) Axial T2-weighted MRI image one month after the injury shows hyperintense collection at the previous site of injury suggestive of biloma.

(c) He subsequently had percutanous drainage of the biloma.

Table I: AAST Liver Injury Grading System

Grade	Description
I	Haematoma: subcapsular, <10% surface area Laceration: capsular tear, <1 cm in parenchymal depth
II	Haematoma: subcapsular, 10%-50% surface area; intraparenchymal, <10 cm in diameter Laceration: 1-3 cm in parenchymal depth, <10 cm in length
III	Haematoma: subcapsular, >50% surface area or expanding or ruptured subcapsular haematoma with active bleeding; intraparenchymal, >10 cm or expanding or ruptured Laceration: >3 cm in parenchymal depth
IV	Haematoma: ruptured intraparenchymal haematoma 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

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