

Correlation of computed tomographic findings in blunt liver trauma with treatments and outcomes at King Chulalongkorn Memorial Hospital

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- Objective** : *This study is aimed to correlate the grading of blunt liver injury in patients who received computed tomography (CT) imaging to their treatments and outcomes at King Chulalongkorn Memorial Hospital (KCMH).*
- Design** : *Descriptive study.*
- Setting** : *Department of Radiology, Faculty of Medicine, Chulalongkorn University, King Chulalongkorn Memorial Hospital*
- Materials and Methods** : *One hundred and thirty-five patients with blunt abdominal injuries who underwent contrast enhanced abdominal CT scan before their treatments were recruited for review. Classifications according to the American Association for the Surgery of Trauma (AAST) were used. The CT gradings was correlated to the surgical findings and outcome.*

- Results** : *Eighteen out of 135 patients with hepatic injury (13.33%) who suffered a blunt abdominal injury were categorized into five grades: grade 1 in 2 patients were grade 1; 4 patients, grade 2; 8 patients, grade 4; and, 4 patients grade 5. There was no patient had grade 3 injury. Other organ injuries were also found such as fractures, splenic, kidney, and intestinal injuries. Conservative treatment was given to 11 patients; 2 patients with grade 1, 2 patients with grade 2, 5 patients with grade 4 and 2 patients with grade 5. Six patients underwent further intervention; 2 patients were grade 2,; 2 patients grade 4 and 2 patients grade 5. One patient was died from severe intracerebral hemorrhage.*
- Conclusion** : *Injury grading with CT may demonstrate the extension of liver parenchymal damage but it cannot determine the need of surgery in patients.*
- Keywords** : *Computed tomographic, Blunt liver trauma.*

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ของภาพถ่ายเอ็กซเรย์คอมพิวเตอร์ และผลการรักษาของผู้ป่วยที่ได้รับการบาดเจ็บของตับ
ที่เกิดจากการกระแทกในโรงพยาบาลจุฬาลงกรณ์. จุฬาลงกรณ์เวชสาร 2554 ก.ค. - ส.ค. ;
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- วัตถุประสงค์** : เพื่อเชื่อมโยงความสัมพันธ์ระหว่างการบาดเจ็บของตับในระดับ
ความรุนแรงต่าง ๆ และผลการรักษาของผู้ป่วยในโรงพยาบาลจุฬาลงกรณ์
- รูปแบบการวิจัย** : การศึกษาเชิงพรรณนา
- สถานที่ทำการวิจัย** : ภาควิชารังสีวิทยา คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย และ
โรงพยาบาลจุฬาลงกรณ์
- วิธีการ** : ผู้ป่วยที่ประสบอุบัติเหตุกระดูกกระแทกบริเวณท้องทั้งหมด 135 รายที่ได้รับการ
การตรวจเอ็กซเรย์คอมพิวเตอร์ก่อนได้รับการรักษา แบ่งการบาดเจ็บตาม
American Association for Surgery of Trauma แล้วจึงเชื่อมโยงความ
สัมพันธ์กับผลการรักษาที่ได้รับ
- ผลการวิจัย** : ผู้ป่วยจำนวน 18 รายจากทั้งหมด 135 รายที่ได้รับการบาดเจ็บจากของตับ
ถูกจำแนกตามความรุนแรงเป็น 5 ระดับ โดยมีระดับ 1 มี 2 ราย ระดับ 2 มี
4 ราย ระดับ 4 มี 8 ราย และระดับ 5 จำนวน 4 ราย การบาดเจ็บของ
อวัยวะอื่นที่พบร่วมด้วย เช่น กระดูกหัก การบาดเจ็บของไต ม้าม และ
ลำไส้ ผู้ป่วย 11 ราย ได้รับการรักษาแบบประคับประคอง โดยเป็นการ
บาดเจ็บในระดับ 1,2 และ 5 อย่างละ 2 ราย และระดับ 4 จำนวน 5 ราย
ผู้ป่วย 6 รายได้รับการรักษาเพิ่มเติม เป็นการบาดเจ็บในระดับ 2, 4 และ 5
อย่างละ 2 ราย ผู้ป่วย 1 รายเสียชีวิตจากภาวะเลือดออกในสมอง
- สรุป** : การเอ็กซเรย์คอมพิวเตอร์ในผู้ป่วยที่ได้รับการกระแทกในส่วนท้องสามารถ
บอกรายละเอียดการบาดเจ็บของตับ, อวัยวะใกล้เคียงและผลการรักษา
แต่ทั้งนี้ต้องสัมพันธ์กับการติดตามผลและอาการทางคลินิกของผู้ป่วยด้วย
- คำสำคัญ** : เอ็กซเรย์คอมพิวเตอร์, การบาดเจ็บของตับ.

The liver injury occurs frequently in blunt abdominal trauma, with an incidence varying from 3 - 8%. Isolated hepatic lesions are rare. Lesions of other organs are involved. ⁽¹⁾ The mortality rate of blunt liver injury ranges from 4% to 12%. ⁽²⁾ Unlike penetrating injury, the multiple organ injuries often seen with blunt trauma, making the accurate diagnosis more difficult and complicated. ^(1 - 5) Computed tomography (CT) scans are widely used to assess post blunt traumatic abdominal injury patients with stable in hemodynamic. Many institutes recommend CT as the primary modality for definite evaluation of hemodynamically stable blunt trauma victims because CT scan provides information on localizing site and extension of intraperitoneal and extraperitoneal injuries. ^(4,6,7) The published literatures documented that at least 20 - 40% of blunt hepatic injury can be successfully treated with conservative management. ^(4, 8) Recent surgical literatures also found that non-operative management of liver injuries following blunt abdominal trauma has become more widely accepted. ^(4,9,10) However, a non-operative management needs adequate monitoring and surgical intervention if it fails. Becker *et al.* believe that injury grading with CT enables the radiologist to distinguish patients who can be safely observed from those who may need surgery. ⁽⁸⁾ Major hepatic injuries with grade 4 severity and hemodynamically stable can be managed without surgery. ⁽⁸⁾

Early detection of arterial contrast material extravasation is solely important for improving the success of nonsurgical treatment. ⁽⁸⁾ Mirvis *et al.* retrospectively correlated the CT findings with the outcome of treatment by means of a simplified injury scale adapted for CT. ⁽¹¹⁾

In this study, our aim was to determine the value of CT in decision-making of the treatment. We propose a CT grading system to correlate with further treatment outcome.

Mechanism of liver injury

The liver is enclosed anteriorly and laterally by the lower rib cage. Its large size, its friability of its parenchyma, its thin capsule, and its fixed position, i.e., anterior to the spine makes the liver susceptible to injury. ⁽³⁾ The liver is vulnerable to any injury that occurs to the posterior right lobe from a simple compression against the fixed ribs, the spine, or the posterior abdominal wall.

Hepatic injury grading system

The AAST (American Association for the Surgery of Trauma) has developed a scoring system for assessment of the severity of an injury to the liver based on its anatomical structure, including the length and number of laceration, and the surface area. Hagiwara *et al.* demonstrated that high grades of (grade 3 to 5) hepatic injury were prone to higher risks of ongoing or delayed bleeding, whereas hepatic embolization in vascular injury is known to improve the success rate of non-operative management.

Materials and Methods

From January 2004 - December 2007, 166 of patients who were admitted with blunt abdominal trauma and underwent CT scanning during their acute imaging assessment together with stable hemodynamical status were recruited into this study. The mechanisms of injuries were as follows: motor vehicle collision, pedestrian struck by vehicles, falling

from height, and body assault. All initial abdominal CT scans were obtained within 48 hours after their admission. The CT scans were obtained by using a SOMATOM Sensation plus 4 and SOMATOM Sensation plus 16 (SIEMENS, Germany). The scanning was routinely performed with intravenous contrast enhancement by using power injected bolus machine of 90 ml of 300mg of iodine per milliliter at rate of 2-4ml per second. CT was performed from the lung base to the pubic symphysis. Thirty-one patients without post contrast study were excluded from the study.

The CT images were reviewed and interpreted by two radiologists (V.L., T.N.) in consensus. Other associated organs injuries were also reviewed and recorded. The surgical records of all the patients were reviewed to determine the

outcome of the surgery or nonsurgical management.

The CT imagings were retrospectively reviewed based on defined criteria. Different types of liver injuries were identified from review of the initial CT scans. Linear or stellate-shaped hypoattenuating lesions at the hepatic surface or within the hepatic parenchyma were interpreted as *capsular disruption* or as *intraparenchymal lacerations*; peripheral lenticular are as of hypoattenuation on contrast enhanced CT were interpreted as *subcapsular hematomas*; and round, ellipsoid, or irregular lesions within the hepatic parenchyma were interpreted as *intrahepatic hematomas*. Extravasation of contrast material into liver parenchyma was defined as *vascular injury*. CT grades of injury severity for blunt hepatic trauma were classified as in Table 1.

Table 1. CT - based injury severity of blunt hepatic injury.

Grade	Type of injury	Description of injury
I	Hematoma	Subcapsular < 10% surface area
	Laceration	Capsular tear < 1 cm parenchymal depth
II	Hematoma	Subcapsular 10 – 50% surface area; intraparenchymal < 10 cm in diameter
	Laceration	1 – 3 cm parenchymal depth; < 10 cm in length
III	Hematoma	Subcapsular > 50% surface area or ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma > 10 cm
	Laceration	> 3 cm parenchymal depth
IV	Laceration	parenchymal disruption involving 25 – 75% of hepatic lobe
V	Laceration	parenchymal disruption involving > 75% of hepatic lobe
	Vascular	Juxtahepatic venous injury
VI	Vascular	Hepatic avulsion

Note: Based on the American Association for the Surgery of Trauma (AAST)

The patient's age, gender, mechanism of injury, and clinical outcome were recorded and reviewed.

Results

Liver injury was found in 18 from 135 patients (13.33%): 4 women and 14 men. Their age ranged from 10 to 87 years old (mean = 33.5). The mechanisms of injuries were as follows: motor vehicle collision (n = 73), pedestrian struck by vehicles

(n = 24), falling from height (n = 20), and body assault (n = 18).

Initial CT findings

CT scans obtained with contrast material enhancement on the basis of the criteria in Table 1, 18 liver injuries were classified as CT grade 1 in 2 patients (Fig. 1), grade 2 in 4 patients (Fig. 2), grade 4 in 8 patients (Fig. 3, 4), grade 5 in 4 patients (Fig. 5). There was no patient with CT grade 3 injury.

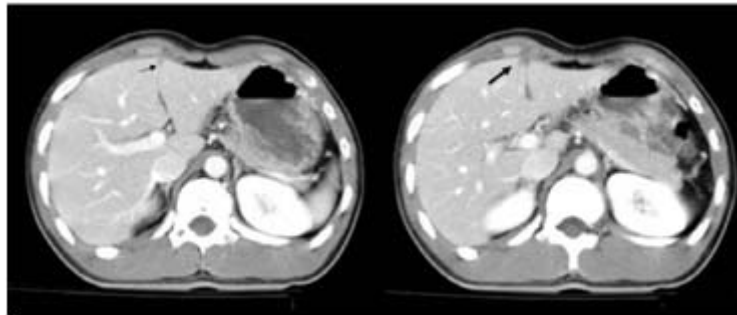


Figure 1. Grade 1 liver injury in 28-year-old male patient admitted following blunt abdominal injury. Axial post-contrast CT scan shows small linear hypodense lesion at subcapsular area of left hepatic lobe (black arrows).

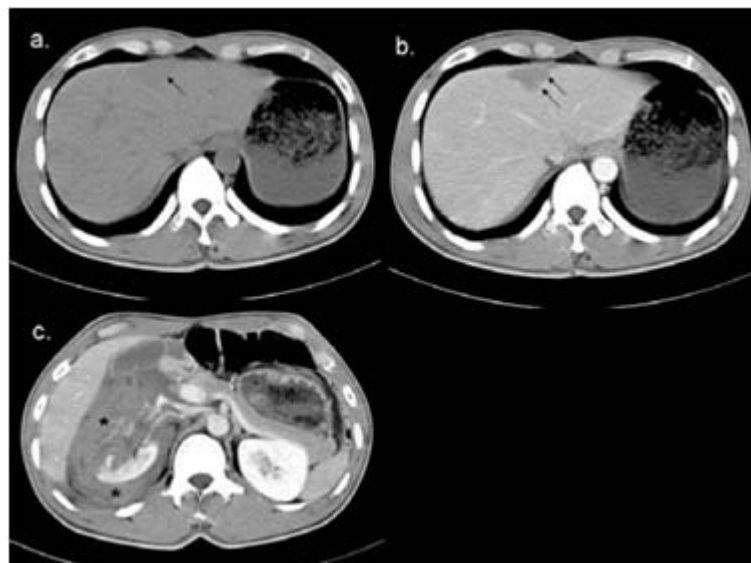


Figure 2. Grade 2 liver injury in 38-year-old male patient admitted following blunt abdominal injury. (a) Axial pre-contrast CT scan shows triangular wedge-shaped slightly hypodense area (arrowed) in left hepatic lobe which showing more hypodensity in post contrast study (double-arrows) (b) representing laceration (c). Severe right kidney laceration with perinephric hematoma (asterisks).

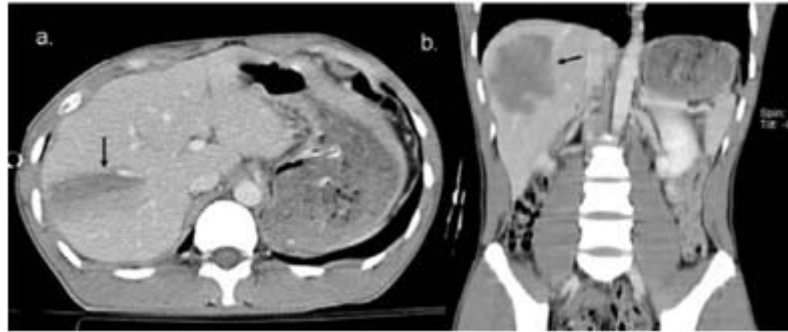


Figure 3. Grade 4 liver injury in 35-year-old female patient with falling from the height (a) Axial and (b) coronal post contrast CT scans show intraparenchymal disruption less than 75% of right hepatic lobe (arrowed).

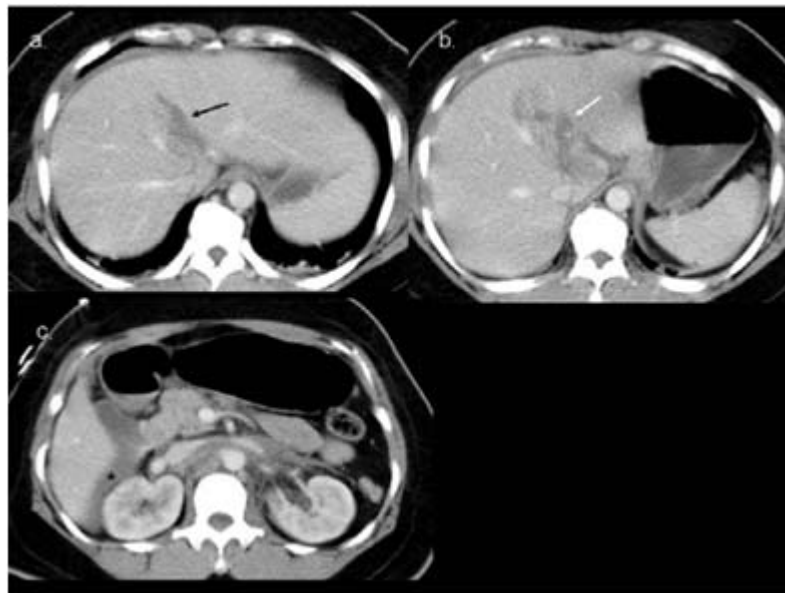


Figure 4. Grade 4 liver injury in 40-year-old male who attacked by horse (a, b) Axial post contrast CT scans reveals linear hypodense lesions involving left hepatic lobe (arrows) representing laceration with moderate amount of perihepatic hematoma (asterisk).

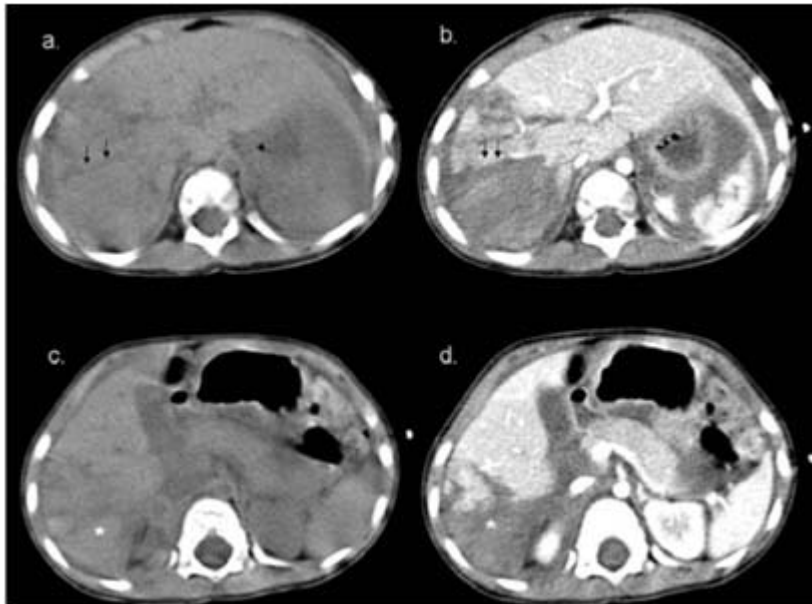


Figure 5. Grade 5 liver injury in 10-year-old boy with blunt abdominal trauma. Axial pre contrast (a) and post contrast (b) CT scans reveal severe parenchymal disruption (double arrows). 'Flip-flop phenomenon' (*) was found in posterior segment of right hepatic lobe (c, d).

Type of management

The eleven patients have been successfully treated nonoperative, there was one death in our study which defined as grade 4 liver injury. The cause of death was severe intracerebral hemorrhage. Four cases underwent laparotomy and two cases underwent hepatic angiography.

I. Patients Who Were Treated Conservatively

Eleven patients were treated conservatively, including 2 patients with grade 1 hepatic injury, 2 patients with grade 2 hepatic injury, 5 patients with grade 4 hepatic injury and 2 patients with grade 5 injury as in Table 2. Hepatic angiography was performed because vascular injury was suggested on CT scans in one patient with grade 5 injury as in Fig. 6, there was no evidence of extravasation of contrast material. This patient was successful in conservative management.

Table 2. Correlation of CT grading and treatment.

Grade	N of conservative
I	2
II	2
III	-
IV	5
V	2

II. Patients Who Underwent Operation or Hepatic embolization

Six patients who underwent operation were classified into liver injury-related and non liver injury-related as in Table 3. There were two patients with grade 2 liver injury who underwent operation. One was of mesentery tear. Another one was severe kidney laceration, this patient underwent right nephrectomy after conservative treatment due to unstable clinical status.

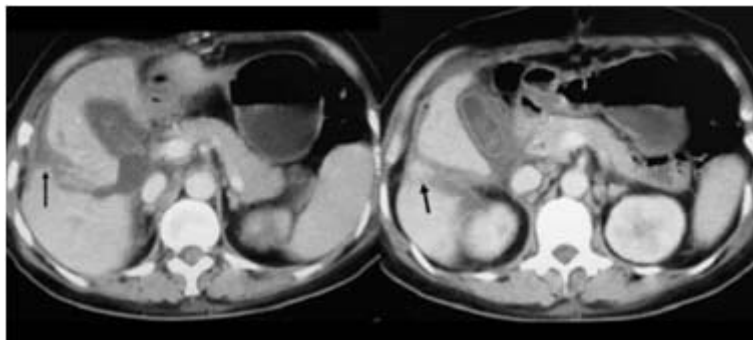


Figure 6. Grade 5 liver injury in 42-year-old male with blunt abdominal trauma. Axial post contrast CT scans reveal extravasation of contrast material (arrows). Hepatic angiography appears unremarkable.

Table 3. Correlation of CT grading with non conservative management.

Grade	Laparotomy		Finding	Angiography	
	Liver injury-related	Non liver injury-related		Embolization	Non embolization
I	-	-	-	-	-
II	-	2	severe kidney laceration, mesentery injury	-	-
III	-	-	-	-	-
IV	-	-	-	1	1
V	2	-	liver laceration with perihepatic hematoma	-	-

Operative findings in 2 patients with grade 5 liver injury were liver laceration and perihepatic hematoma. The operative management was simple liver packing to stop bleeding.

Hepatic angiography was performed in 2 patients with grade 4 liver injury. One of hepatic angiography demonstrated injury to right hepatic artery which subsequently obtained successful embolization. There was no vascular injury in the other one.

Associated organ injuries

One of benefit using CT scan in the assessment of blunt abdominal injury is the ability to evaluate the injury of other organs.⁽⁸⁻⁹⁾ In our study, this benefit was also appreciated, as shown in Table 4. Most of associated injuries are fracture of the pelvis while most injured solid organ is the spleen as also described in other literatures.⁽⁸⁻⁹⁾ Hemoperitoneum was the most common positive finding, found in 24 patients.

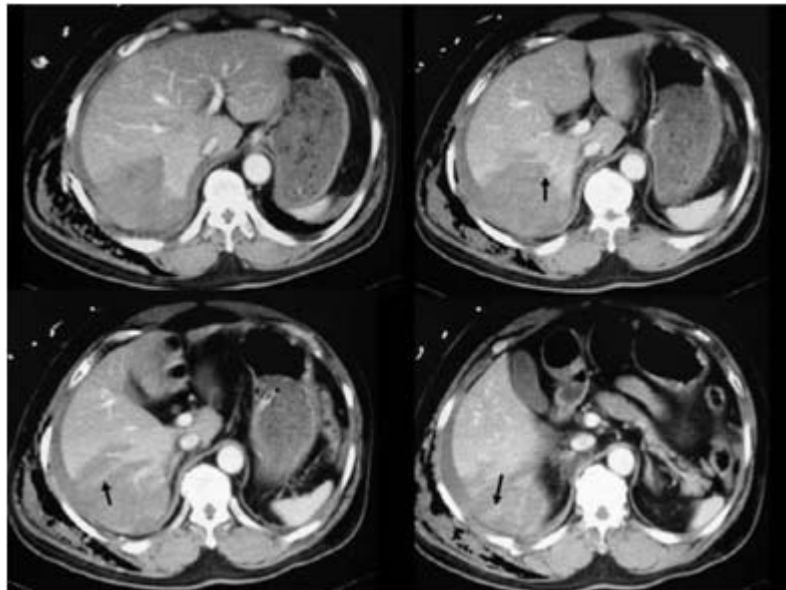


Figure 7. Grade 4 liver injury in 50-year-old male with blunt abdominal trauma Axial post contrast CT scans reveal extravasation of contrast material (arrows). Successful hepatic embolization was performed via right hepatic artery (not shown).

Table 4. Associated organs injuries.

Injury	Number	Injury	Number
Splenic injury	16	Fracture spine	13
Kidney injury	13	Fracture femur	12
Pancreatic injury	2	Intramuscular hematoma	5
Ruptured urinary bladder	1	Muscular contusion	2
Hemoperitoneum	24	Sacro-iliac joint dislocation	2
Intestinal injury	4	Renal vein injury	1
Extraluminal gas	6		
Fracture pelvis	23		

Discussion

Recently, conservative treatment has been widely accepted for blunt liver injury as it decreases surgical complications as well as shortens the length of hospital admissions. CT scan appears to be a desirable tool to assess whether or not a non-operative treatment in blunt liver trauma will be successful.

However, according to recent literatures, there is no reliable predictor for failed conservative management demonstrated on CT scans.^(1-4,8) Most of the reports agreed that hepatic injury grading did not predict whether a patient needed surgery. The AAST injury grading system appears to predict the need for surgical treatment, and patients who require a surgical

operation have a poorer prognosis. There has been an increase in the total number of adults with all grades of blunt hepatic injury that can be successfully managed without surgical treatment.

In our study, we divided the patients who underwent operative treatment into two groups: liver injury -related and non-liver injury -related. Even though the majority of the patients in the non-conservative management were in the liver injury -related group, there were two patients who underwent right nephrectomy and mesentery repair with conservative hepatic injury treatment. One patient with grade 2 liver injury obtained conservative treatment after CT scans but he developed unstable clinical status and underwent right nephrectomy. Therefore, a non-operative approach requires hemodynamic stability. The most common cause of the failure in non-operative management of hepatic injury is an ongoing bleeding.

Expectant management of a blunt liver injury was successful in 61.11% (11 of 18 cases) which included most CT grading scale, from grade 1 to grade 5. Low grade liver injuries (grade 1 and 2) were exclusively appreciated by non-operative treatment, whereas two of them who underwent laparotomy due to ongoing unstable hemodynamic and clinical status, from mesentery injury and massive perinephric hematoma. Twelve high grade liver traumas (grade 3 - 5) failed in non-operative treatment in 5 patients. One died from severe intracerebral hematoma with grade 4 liver injury. One of grade 4 injury underwent hepatic angiography with successful embolization of the right hepatic artery. Other two of grade 5 injury underwent laparotomy with severe liver laceration and hematoma; the surgeons were

successful in packing to stop bleeding.

The decision to perform laparotomy and angiography in 6 patients was made on basis of both clinical and radiologic findings but was not entirely based on the grading of CT imaging as defined in our retrospective analysis.

Croce *et al.* considered CT to be unreliable in the assessment of hepatic injury because in 84% of their patients, the CT grades were not correlated to the operative findings. Many lesions were either underestimated or overestimated. ⁽¹²⁾

Hemoperitoneum is another CT scan sign that has been receiving much discussion about. ^(6, 7) Hagiwara *et al.* successfully treated 54 blunt hepatic trauma patients non-operatively. Twenty-six of them had small to large amount of hemoperitoneum similar to our study that hemoperitoneum was the most common positive finding. Causes of hemoperitoneum were from the liver, spleen, kidney and pancreas which were determined on the basis of sentinel clot.

Limitation

We achieved the following retrospective study with a small number of patients with liver injury from blunt abdominal trauma. This may limit the reliability of the analysis.

Conclusion

Our data indicate that CT grading criteria can be used to guide further management of blunt hepatic trauma in hemodynamically stable patients. It can help the process of patient selection, i.e., who should or should not undergo hepatic angiography and/or who should receive embolization or close observation. Although injury grading with CT may reveal

the extension of the parenchymal damage, it does not accurately help to predict the outcome of a conservative management. Therefore decision to perform the proper treatment should be based on clinical status and the degree of injury extended to other abdominal organs injury. Our study could help clinicians to select their patients for initial non-surgical management of blunt hepatic injury.

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