Correlating MDCT Liver Injury Grade and Clinical Outcome in Patients Without Significant Extra-hepatic Injury

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Abstract The aim of the study was to correlate multi-detector computed tomography (MDCT) grading with clinical severity and outcome in liver trauma patients without significant extrahepatic injury. Over a period of 2 years (2011–2013), all patients showing evidence of liver injury on contrast-enhanced CT (CECT) abdomen and without significant extrahepatic trauma were prospectively included in the study. Correlation between the CT injury grade and outcome in terms of mortality, duration of ICU/hospital stay, fluid and blood requirements, need for intervention and complications were assessed. The significance of the difference in mortality, duration of ICU/hospital stay, fluid requirement and blood requirements among the patients with various injury grades was assessed by Kruskal-Wallis test. The significance of the difference in need for intervention and complications among the patients with various injury grades was assessed by Fisher's exact test. A total of 198 patients were found to have evidence of hepatic injury on CECT. Out of 198 patients, 117 had insignificant extrahepatic trauma. The overall mean age for these 117 patients was 25.74 ± 15.53 (age range 2–84 years). Death rates according to AAST grades were 0 % in grades II and III, 6.89 % in grade IV and 9.09 % in grade V ($p=0.053$). The mean ICU and total hospital stay for grade II was 1.32 and 5.91 days, for grade III was 1.76 and 8.48, for grade IV was 2.86 and 10.31 days and for grade V was 6.54 and 12 days, respectively ($p=0.0001$ for ICU, $p=0.0003$ for total stay).

Mean input and fluid deficit according to various grades were 8634/2607 ml for grade II, 9535/2555 ml for grade III, 15,549/6242 ml for grade IV and 19,958/8280 ml for grade V (p value input—0.0016, output-input (fluid deficit)—0.0001). Average unit of RBC and sum of the blood products transfused were 1.73 and 2.26 for grade II, 2.18 and 2.72 for grade III, 3.03 and 6.27 for grade IV, 6.85 and 38.12 for grade V, respectively (p value RBC—0.10, total—0.037). The difference in the need of active surgical/endovascular intervention and complication rates was not significantly higher in higher injury grades. The grading of liver injury based on CECT findings can predict the clinical course in liver trauma patients with insignificant extrahepatic injuries.

Keyword Liver trauma · MDCT AAST (American association for surgery of trauma) grading · Clinical correlation and AAST grading · Stay in hospital (ICU stay and ward stay) · Blood transfusion · Fluid deficit

Introduction

Abdominal exsanguination is responsible for 40–80 % of all the deaths due to abdominal trauma [1]. Liver injury is among the most common causes of abdominal exsanguinations. Approximately 1 to 8 % of patients who sustain blunt abdominal trauma have liver injuries [2]. Injuries result from both blunt and penetrating trauma. The most common mechanism of liver injury is road traffic accident (RTA). Because of difficulty in identifying hepatic injuries by physical examination, contrast-enhanced CT (CECT) is required to avoid missing a significant injury. Multi-detector computed tomography (MDCT) is the diagnostic modality of choice for evaluation of abdominal trauma in haemodynamically stable patients [2–5]. A liver injury grading system based on these CT

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features was established by the American Association for Surgery of Trauma [2]. The use of MDCT in the diagnosis and management of liver trauma is mainly responsible for paradigm shift during the past decade from routine surgical to non-surgical management of liver injuries [6–11]. Advances in MDCT technology have not translated to the same gains when it comes to the important question of clinical relevance and correlation of MDCT findings. MDCT findings and its correlation with clinical outcome are crucial in answering the question that how closely MDCT findings decide management and predict clinical outcome and associated complications. This study was conducted to correlate MDCT AAST grading with clinical severity and outcome.

Material and Methods

This prospective study was conducted in the department of radiology at the trauma centre of our institute in collaboration with the department of surgery, after obtaining ethical clearance from the institutional ethics committee. The duration of the study was approximately 2 years, from November 2011 to August 2013.

Study Population

At our institution, all haemodynamically stable patients with suspected abdominal visceral injuries on the basis of FAST, clinical findings or severe mode of injury undergo contrast-enhanced scan of the torso as a routine protocol. Patients with evidence of hepatic injury on CECT were recruited in the study. Patients with significant non-hepatic trauma were excluded from the study.¹

Imaging

The CECT was performed either on a 40-detector MDCT scanner (SOMATOM Sensation, Siemens, Erlangen, Germany) or a 64-detector MDCT scanner (Definition AS, Siemens, Erlangen, Germany).

A thoracoabdominal scan was obtained in craniocaudal direction 60–70 s after injection of 75 ml of non-ionic low-osmolar iodinated contrast pushed through hand injection (Iomeron, 400 mg/ml iodine). The injection rate was approximately 3–4 ml/s. The scanning parameters were a collimation of 24×1.2

and pitch of 1.4 on the 40-detector scanner and collimation and pitch of 16×1.2 and 0.8, respectively, on the 64-detector scanner. Axial images were acquired at 1.2 mm collimation. Images were then reconstructed at 1.5- and 5-mm sections. All images were viewed on the console at the time of acquisition. Delayed phase images were taken in patients showing evidence of vascular injury in the form of active contrast extravasation or pseudoaneurysm. All images were subsequently also reviewed in detail on the 3D workstation in three planes (axial, coronal and sagittal) to look for presence and extent of liver, and also other, associated injuries in the patient. All patients with hepatic injuries were graded on the basis of AAST grading [2] (Table 1).

For all patients included within the study, demographic profile, mode of trauma, the time gap between injury and presentation, pulse, blood pressure, respiratory rate and Glasgow coma scale scores were noted at the time of presentation.

Laboratory parameters, namely haemoglobin, haematocrit, blood urea, creatinine, alanine transaminase (ALT), aspartate transaminase (AST), alkaline phosphatase and base deficit were noted.

The injury descriptions were used to calculate scores of injury severities like the injury severity score (ISS) and new injury severity score (NISS).

Both ISS and NISS are anatomical scoring systems in which the different injuries to the patient are assigned to one of the six body regions (head, face, chest, abdomen, extremity and pelvis, external) and assigned a number (abbreviated injury scale= AIS) depending upon the severity (1=minor, 2=moderate, 3=serious, 4=severe, 5=critical and 6=unsurvivable) [12–14].

Parameters for Clinical Management and Outcome

During the hospital stay duration, morbidity parameters such as the length of ICU stay, total length of hospital stay, total amount of fluids, total units of red blood cells, platelets, fresh frozen plasma (FFPs) and cryoprecipitate were also recorded. Fluid and blood transfusion requirements were decided based on clinical parameter irrespective of CT injury grades. Development of known liver injury complications in these patients like collections, necrosis, abscess, biliary leak and peritonitis, biliary fistula, bilomas and pseudoaneurysm presenting as haematemesis and melena was also noted from subsequent imaging findings/clinical notes and “re-exploration laparotomy” notes.

The final outcome was noted as complete recovery and discharge; discharge with poor prognosis/near-vegetative state and death. The cause of morbid discharge was recorded. For patients who died, the cause of death was recorded.

Statistical Analysis

The AAST grade and finding on MDCT were correlated with parameters of clinical outcome. The significance of the difference in mortality, duration of ICU/hospital stay, fluid

¹ Significant non-hepatic trauma was defined on the basis of Abbreviated Injury Scale (AIS-90 scales) for individual organs [12]. Injury severity scores are used to classify the trauma patients in order of its severity. The Abbreviated Injury Scale (AIS) is an anatomical scoring system used for this purpose. Injuries are ranked on a scale (AIS) of 1 to 6, with 1 being minor, 2 is moderate, 3 is serious, 4 is severe, 5 being critical, and 6, a nonsurvivable injury. In most of the traumatic injuries to any organ in the body, an AIS score of 2 or less does not require any active intervention. If an extrahepatic organ of a patient scored more than 2 on AIS-90 scales, it was considered as significant extrahepatic trauma and was excluded from the study.

Table 1 AAST grading [2]

AAST Grade	Hepatic injuries
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 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
VI	Vascular: juxtahepatic venous injuries (i.e. retrohepatic vena cava or central major hepatic veins) Vascular: hepatic avulsion

Assessment of clinical severity and outcome

requirement and blood requirements among the patients with various injury grades was assessed by Kruskal-Wallis test. The significance of the difference in need for intervention and complications among the patients with various injury grades was assessed by Fisher's exact test. The Stata 11.2 software was used for the statistical analysis.

Results

During the course of study, a total of 198 patients were found to have evidence of hepatic injury on contrast-enhanced CT (CECT). Out of 198 patients, 117 had insignificant extrahepatic trauma, of which 89 were males and 28 were females. The overall mean age for these 117 patients was 25.74 ± 15.53 (age range 2–84 years). The ISS scores ranged between 4 and 33. The mean and median ISS for study population were 14.05 and 13, respectively. The NISS scores ranged between 4 and 38 and the mean and median NISS for overall study population were 15.3 and 18, respectively.

Comparison of Fluid Requirements (Input/Output), Blood Transfusions Received, ICU/Total Hospital Stay (N=117)

We found that fluid input and fluid deficit (input-output) increase progressively through grades III to V. To have an idea of fluid deficit (third space loss and bleeding), the difference of fluid input and output was calculated. We assumed that it would correlate roughly with fluid deficit, as insensible losses would be almost uniform in all patients (Fig. 1). We compared transfusion of RBC and sum of the blood products transfused including RBC, platelet, cryoprecipitate and FFP (Fig. 2). We found that blood transfusion requirement consistently increase

from grade II to grade V. Total blood products in particular were significantly higher in grade V injury. We found that ICU and total stay were maximum for grade V and increased progressively from grade II to grade V (Fig. 3).

Management and Outcome According to Grades (Table 2)

None of the patients with grade II injury needed angio-embolization. Rates of angio-embolization increased from grade III to grade V. A total of five patients needed surgical intervention. There was no significant difference in the need for surgical intervention among various grades.

Complications (Table 3)

Liver trauma patients were followed post discharge, and any complication either during hospital stay or after discharge with subsequent repeat presentation to trauma centre were noted. The various complications included were pseudoaneurysm, persistent bile leak, biloma and abscess.

We compared the complication rates in various grades of liver injury. The complications were mainly seen in higher grade injury as grades III, IV and V. There were a very small number of patients with complications and no clear increasing trend with increasing severity of liver injury.

Outcome Distribution According to Grades of Liver Injuries (N=117)

There were no deaths recorded in grades I–III. Two patients died with grade IV injury (6.89 %) and a single patient died in

Fig. 1 Comparison of fluid input and fluid deficit during hospital stay (ml). Chart shows progressive increase in fluid requirement and fluid deficit with higher injury grades. It was found to be statistically significant (input, $p=0.0016$ /deficit, $p=0.0001$)

grade V injury (9.09 %) with an overall mortality rate greater in grade V injury (p value 0.053).

Discussion

Blood loss related to hepatic trauma is a major contributor to the morbidity and mortality in patients with abdominal trauma [1]. Non-operative management is the current standard of practice for haemodynamically stable patients suffering from hepatic trauma [6–8, 15–21]. The use of multi-detector computed tomography (CT) in the diagnosis and management of liver trauma is mainly responsible for the shift during the past decade from routine surgical to non-surgical management of liver injuries. Prediction of outcomes in the form of clinical course and mortality according to grades of liver injury is of crucial importance in the current management practices to optimize resource utilization without compromising patient care. The current study examines the role of MDCT in evaluation of traumatic liver injuries with clinical correlation.

Patients with hepatic trauma form a heterogeneous group as many of these patients have extrahepatic injuries as well.

These extrahepatic injuries are significant contributors to the morbidity and mortality among such patients. Hence, to avoid the impact of extrahepatic trauma, we excluded patients with significant extrahepatic injuries from our study. However, we did not exclude patients with minor extrahepatic injuries, as those were less likely to affect morbidity and mortality. For exclusion purposes, various trauma severity scoring systems including ISS, NISS and abbreviated injury score (AIS) were used. After exclusion of patients with significant extrahepatic injuries, we were left with a sample size of 117 patients. Within this relatively homogeneous group, comparisons could be made to assess the outcome in relation to liver injury grades.

We compared fluid requirements in terms of input and fluid deficit in patients of different grades of liver trauma. Since output in the form of insensible fluid loss and urine output would be almost the same in patients with different grades of liver injuries. So, we calculated fluid deficit which would represent the amount of blood loss and third space fluid loss. In a higher grade injury, we observed a statistically significant progressive rise in input and fluid deficit from grades III to V. We are unable to find a relevant study comparing the CT grades with fluid input, output and fluid deficit.

Fig. 2 Comparison of blood transfusion (RBC/total blood products) during hospital stay ($N=117$). It shows progressive increase in the requirement of blood products. It was found to be statistically significant for total blood requirement (RBC; $p=0.10$ /total= 0.037)

Fig. 3 Comparison of ICU and total hospital stay (days) with respect to grades of liver injury. Both ICU and total stay were found to be statistically higher with higher injury grades (stay in ICU, $p=0.0001$ /total stay, $p=0.0003$)

Comparison of transfusion requirements including packed RBCs and total blood products shows a consistent increase from grade II to grade V. The difference in the total blood transfusion among various grades was found to be statistically significant. There are studies in the literature that support our findings of increased need of transfusion with higher liver injury grades [22–24]. Comparison of ICU stay and total hospital stay also shows an increasing trend from grade II to grade V. There is conflicting evidence in existing literature over the correlation of hospital stay and liver injury grade. The findings of Fregmen et al. [24] are consistent with our observation of a longer stay for patients with a higher grade of liver injury. However, Sandro et al. [25] and David et al. [26] concluded that there is no correlation between these two. The need for surgery was decided on the basis of clinical non-response to ongoing conservative management. A total of five patients needed surgical intervention. There was no significant difference in the need for surgical intervention among various grades. This might be a result of a small sample size in this sub-category. None of the patients with grade V injury underwent surgery. This finding can be explained by the fact that most patients with grade V hepatic injury undergo prophylactic embolization at our hospital. Moreover, many patients with such high-grade injury would have been unstable after initial resuscitation. So, these patients might have been directly taken for surgery, and this might have created a selection bias. There were a very small number of patients having these complications and no clear increasing trend with

increasing severity of liver injury. Sandro et al. [25] concluded the OIS grade was unable to predict the need for laparotomy in liver trauma patients. Ruess et al. [22] also found in their study that severity of injury by CT scan did not correlate with need for surgery.

Rates of angio-embolization increase from grade III to grade V. There is no meaning of interpreting this finding as significant because the need for embolization was decided only on the basis of CT grading.

We noted the death rates among the various grades and found that death rate increases as the liver injury grade increases from grade IV to grade V. Death rates according to grades were 0 % in grade II and grade III, 6.89 % in grade IV and 9.09 % in grade V.

So, according to our study, prediction of outcome and clinical course during hospital stay in liver trauma patients depends on the grade of liver injury in those liver trauma patients who had insignificant extrahepatic injuries. Our observations differ from that of Miller et al. [23] who retrospectively reviewed 36 children and suggested that mortality and morbidity rates in paediatric liver injuries, grades I to IV, correlate with associated injuries and not the degree of hepatic damage. David et al. [26] found that grades of liver injury did not correlate with mortality and morbidity of the patients. The reason for this difference could be due to inclusion of all patients with liver injury including those who had significant extrahepatic organ injury in their study. We excluded those patients who had significant extrahepatic organ injury for the purpose of evaluation of clinical outcome.

Table 2 Management according to grades of liver injury

Grades	No. of patients	Angio-embolization	Angio-embolization+surgery	Surgery
II	34	0	0	0
III	43	5	0	1
IV	29	4	1	3
V	11	8	0	0

Table 3 Complications according to injury grade

Complication	Grade II	Grade III	Grade IV	Grade V	Total
Pseudoaneurysm	0	1	1	4	6
Abscess	0	2	1	0	3
Persistent bile leak	1	0	2	0	3
Biloma	0	2	1	0	3

Conclusions

MDCT is an excellent modality for evaluating liver injury in patients who are haemodynamically stable. It is also crucial in management as it helps the surgeon to manage these patients with greater confidence. The AAST grading of liver injury is based on CECT findings which can predict the clinical course in liver trauma patients with insignificant other organ injury especially in higher-grade liver injury. Death rates, total hospital stay, ICU stay, need of fluids and blood products all were significantly higher in higher injury grades.

Conflict of Interest The authors declare that they have no competing interests.

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