Pediatric abdominal Injury
Nellensteijn, David

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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2015

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

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Chapter 2
Only Moderate Intra- and Inter-observer Agreement between Radiologists and Surgeons when Grading Blunt Paediatric Hepatic Injury on CT Scan


ABSTRACT

Introduction: The American Pediatric Surgical Association developed guidelines for the management of haemodynamically stable children with hepatic or splenic injury, based on grade of injury on CT scan. This study investigated the intra- and inter-observer agreement of radiologists, paediatric surgeons, trauma surgeons and hepatobiliary surgeons when scoring liver injury based on CT scan findings. Patients and Methods: CT scans of patients with blunt abdominal trauma were independently assessed twice by a fellow and a consultant radiologist, paediatric surgeon, trauma surgeon and one consultant hepatobiliary surgeon. Reviewers were unaware of the clinical course. All scans were multislice CTs with a slice thickness of 3 mm, and both the arterial and venous phase were assessed. Injury was scored using the American Association for the Surgery of Trauma (AAST) liver injury scale. Intra-observer agreement was tested using Cohen’s kappa coefficient. Inter-observer agreement was tested using Cohen’s kappa for the second reading of individual observers and Spearman’s rank correlation for the mean of both readings from each observer. Results: CT scans of 27 patients (11 girls and 16 boys, median age 11.7 ± 5.2 years) were reviewed. Mean AAST grade of liver injury was 3.3 ± 1.1 for radiologists, 2.9 ± 1.0 for paediatric surgeons, 3.0 ± 0.9 for trauma surgeons and 3.2 ± 0.8 for the hepatobiliary surgeon (p = 0.30). Intra-observer agreement was moderate, with kappa below 0.7 for all observers except for one of the radiologists. Inter-observer correlation using Cohen’s kappa coefficient was also moderate, with kappa below 0.5. In contrast, inter-observer correlation using Spearman’s test was good, suggesting that there is agreement on the general severity of injury but not on the exact grading of injury using the AAST scoring system. Conclusion: Intra-observer agreement is only moderate when assessing liver injury using the AAST grading system. Only the most experienced radiologist demonstrated good intra-observer agreement, which might indicate the necessity of the presence of a senior trauma radiologist at all times. However, this is not possible in most centres. Although there was agreement concerning the general severity of injury, inter-observer agreement is also moderate. These data cast doubt on the use of the AAST liver injury score alone as a decision-making tool when assessing haemodynamically stable children with blunt hepatic injury.
INTRODUCTION

In 2000 the American Pediatric Surgical Association (APSA) issued guidelines for the management of haemodynamically stable children with hepatic or splenic injury. These guidelines are based on the grade of injury as assessed by computed tomography (CT) scan\(^1\). Grading of injury was performed using the American Association for Surgery of Trauma (AAST) Organ Injury Scale (OIS). This grading system was developed in 1989, mainly for research purposes\(^2\). After being validated using a national registry data set, these guidelines have subsequently been prospectively validated as safe\(^3\). These guidelines also provide recommendations with regard to the days of bed rest, ICU stay, length of hospital stay and follow-up and the use of imaging during follow-up. Subsequently, haemodynamically stable children, but also adults, with liver or spleen injury have been treated all over the world based on the grading of CT images using the AAST OIS. However, as yet no study has ever attempted to assess the reliability of the AAST OIS CT grading with regard to inter- and intraobserver variability. The present study therefore set out to determine inter- and intra-observer agreement with regard to the scoring of liver injury on CT scan between radiologists, paediatric surgeons, trauma surgeons and hepatobiliary surgeons.

PATIENTS AND METHODS

Using the hospital trauma registry, paediatric patients with proven hepatic injury caused by blunt abdominal trauma since 2000 were identified. All identified patients were subsequently evaluated for the presence and the quality of CT images by a senior radiologist. All CT scans with a maximum of 3 mm slices and with early and late (arterial and venous phase) intravenous contrast were selected. All images were made with a Philips SR 4000 or a Siemens Sensation-64 scanner. Visipaque™ (Amersham Health, Princeton, NJ) was used as intravenous contrast (2.5 ml / kg body weight). The arterial phase was usually scanned at 20 s and the venous phase at around 60 s after injection. All CTs were independently assessed and scored twice by the following investigators: a senior radiology resident and a consultant radiologist, a fellow and consultant paediatric surgeon, a senior surgical trauma resident and consultant trauma surgeon and finally a consultant hepatobiliary surgeon. All participants were unaware of the clinical course of the patients. Injuries were scored according to the American Association for the Surgery of Trauma (AAST) hepatic organ injury scale (HIS or OIS) (Table 2). Intra-observer agreement was tested using Cohen’s kappa coefficient. Inter-observer agreement was tested using two different approaches: Cohen’s kappa for the second reading by the individual observers and Spearman’s rank correlation on the mean of both readings from each observer. SPSS 11 was used for all calculations.
Table 1: Liver injury scale (1994 revision).

<table>
<thead>
<tr>
<th>Grade*</th>
<th>Type of Injury</th>
<th>Description of injury</th>
<th>AIS-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Hematoma</td>
<td>Subcapsular, &lt;10% surface area</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>Capsular tear, &lt;1 cm</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>parenchymal depth</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Hematoma</td>
<td>Subcapsular, 10% to 50% surface area</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>Capsular tear 1-3 parenchymal depth, &lt;10 cm in length</td>
<td>2</td>
</tr>
<tr>
<td>III</td>
<td>Hematoma</td>
<td>Subcapsular, &gt;50% surface area of ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma &gt; 10 cm or expanding</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>&gt;3 cm parenchymal depth</td>
<td>3</td>
</tr>
<tr>
<td>IV</td>
<td>Laceration</td>
<td>Parenchymal disruption involving 25% to 75% hepatic lobe or 1-3 Couinaud’s segments</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>Laceration</td>
<td>Parenchymal disruption involving &gt;75% of hepatic lobe or &gt;3 Couinaud’s segments within a single lobe</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Vascular</td>
<td>Juxtahepatic venous injuries; ie, retrohepatic vena cava/central major hepatic veins</td>
<td>5</td>
</tr>
<tr>
<td>VI</td>
<td>Vascular</td>
<td>Hepatic avulsion</td>
<td>6</td>
</tr>
</tbody>
</table>

*Advance one grade for multiple injuries to the same organ up to grade III

Table 2: Intra-observer variation as evaluated using Cohen’s kappa coefficient for each individual observer.

<table>
<thead>
<tr>
<th></th>
<th>Cohen’s Kappa coëfficiënt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior radiologist</td>
<td>0.75</td>
</tr>
<tr>
<td>Junior radiologist</td>
<td>0.39</td>
</tr>
<tr>
<td>Senior pediatric surgeon</td>
<td>0.38</td>
</tr>
<tr>
<td>Junior pediatric surgeon</td>
<td>0.21</td>
</tr>
<tr>
<td>Senior trauma surgeon</td>
<td>0.58</td>
</tr>
<tr>
<td>Senior surgical resident</td>
<td>0.60</td>
</tr>
<tr>
<td>Senior Hepatobilliary surgeon</td>
<td>0.65</td>
</tr>
</tbody>
</table>

RESULTS

CT scans of 27 patients (11 girls and 16 boys with a median age of 11.7 ± 5.2 years) were retrieved and reviewed. The mean AAST grade of liver injury was 3.3 ± 0.8 for the whole observer group. It was 3.3 ± 1.1 for radiologists, 2.9 ± 1.0 for paediatric surgeons, 3.0 ± 0.9 for trauma surgeons and 3.2 ± 0.8 for hepatobiliary surgeons (p = 0.30) There were no significant differences in mean CT grade between the senior and junior specialists from the same discipline, except for the radiologists. The senior radiologist scored 3.7 ± 1.4
while the junior radiologist score was 3.0 ± 1.0 (p < 0.001). Intra-observer agreement was moderate, with kappa below 0.7 for all observers except for one of the radiologists (Table 1). This was the radiologist with the most experience of paediatric trauma imaging. Inter-observer correlation using Cohen’s kappa was also moderate, with kappa not exceeding 0.5. In contrast, inter-observer correlation using Spearman’s test was good, suggesting that there is an agreement between all observers on the general severity of injury, although not on the exact grading of injury. Non-operative management was successful in 23 of the 27 patients (83%). 4 patients had to undergo surgery for persistent haemodynamic instability.

DISCUSSION

Over the past decade, evidence-based guidelines have emerged in an attempt to standardise care and limit the financial costs associated with prolonged hospitalisation for paediatric blunt abdominal trauma. In 1998 the AAST developed different scales for various organs: the organ injury scales (OIS)⁴. The purpose of these scales was to develop injury severity scores for individual organs to facilitate clinical research. To maximise patient safety and assure efficient, cost-effective utilisation of hospital resources, the APSA subsequently developed guidelines for the management of haemodynamically stable children with hepatic or splenic injury, based on grades of injury visible on CT scan¹. These guidelines provide recommendations regarding the days of bed rest, ICU stay, length of hospital stay as well as follow-up and routine imaging. After being validated using a national registry dataset of 832 patients, these guidelines have subsequently been prospectively validated as safe³. Remarkably, the APSA guidelines have adapted the OIS as a guideline for treatment although the correlation between operative findings and CT images is known to be poor². In addition, grading based on CT imaging for hepatic injury fails to predict the success of non-operative management⁵.⁶. The clinical use of OIS is therefore debatable. Despite several attempts⁷–⁹, neither predictive parameters have been addressed in the management of hepatic or splenic injury nor has a validated new protocol been developed so far¹⁰–¹².

A useful classification of organ injury should ideally provide an accurate injury description, be of prognostic value for treatment options, create a basis for comparison for clinical research purposes, be reliable or easily reproduced and, most of all, be practical and simple in daily clinical use. All of these features have been evaluated for the AAST OIS with a focus on outcome in clinical trials except for reliability and reproducibility. One of the most important factors influencing reliability in diagnostic tools is inter- and intra-observer variability: the extent that an evaluation will yield the same result if repeated a second time by the same or by a second observer. To our knowledge no previous study has ever been
performed to assess the reliability of the AAST OIS based on CT images for blunt liver injury in children. The present data indicate an only moderate intra-observer agreement using the AAST grading system, even with modern high resolution multislice CT. Only the most experienced radiologist demonstrated good intra-observer agreement. This might indicate the necessity of the presence of a senior trauma radiologist at all times. However, this is not possible in most centres.

Although there was agreement regarding the general severity of injury, inter-observer agreement was also moderate. This suggests that different reviewers have a somewhat similar opinion about the general severity of injury, but that exact grading is much more difficult and should therefore not be used as guideline for treatment.

Taken together with the poor correlation of CT findings with intra-operative findings, and the poor predictive value of CT findings with regard to the success rate of non-operative management, the question rises whether the AAST OIS is the appropriate decision-making tool when assessing haemodynamically stable children with blunt hepatic injury. The poor inter- and intra-observer agreement found in the present study might even be the explanation for the poor correlation between imaging and clinical findings such as haemodynamic (in)stability and preoperative findings as well as for its poor predictive value for the outcome of (non-operative) treatment of injury of parenchymatous organs such as the liver and spleen in children. We therefore endorse the paradigm that isolated blunt spleen and liver injuries, regardless of their CT-based grade, might be safely managed using an algorithm based on haemodynamic status rather than radiological grading\(^6\). CT scanning provides important information about the anatomical extent of injury, including the possible presence of a “blush”, which could be of value for treatment options. The currently used grading systems are not accurate enough to serve as a guide for treatment.

**CONCLUSION**

There is significant intra- and inter-observer variation in the grading of paediatric liver injury using CT scan alone. Therefore the value of the AAST OIS as clinical treatment guidelines should be doubted. Management of haemodynamically stable paediatric patients with blunt liver injury should be dictated by clinical parameters, not based on radiological images alone.
REFERENCES

2. Croce MA, Fabian TC, Kudsk KA et al. AAST organ injury scale: Correlation of CT-graded liver injuries and operative findings. J Trauma 1991; 31:806–812