Accuracy of the AAST organ injury scale for CT evaluation of traumatic liver and spleen injuries

Georg Homann*, Christina Toschke, Peter Gassmann, Volker Vieth

【Abstract】Objective: Detection of abdominal injury is a very important component in trauma management, so a precise assessment of liver and spleen injuries including their severity degree is necessary. There is a good case to believe that in emergency situations the radiologists’ performance may profit from a systematic approach using established scoring systems. Score systems as the organ injury scale (OIS) drawn up by the American Association for the Surgery of Trauma are a valuable guidance for objective trauma assessment. Aim of this study was to evaluate retrospectively whether a structured approach using the OIS may help improve trauma assessment.

Methods: Fifty-three patients, 38 male and 15 female who underwent CT and laparotomy after abdominal trauma were included in this study. The laparotomy was performed by experienced surgeons with a minimum experience of 6 years. While the original CT reports were written by different radiologists with a minimum experience of 3 years, and then a radiologist with experience of 4 years reviewed the same original CT pictures, resulting in the structured report. Both the original and structured CT results on liver and spleen injuries were transferred into OIS grades. Finally, the initial and structured CT results were compared with the intraoperative findings gathered from the surgery report.

Results: Regarding the original CT report we found a mean divergence of 0.68±0.8 (r=0.45) to the OIS finding in the surgery report for liver injuries (0.69±1.17 for spleen injuries; r=0.69). In comparison with the structured approach, where we detected a divergence of 0.8±0.68; r=0.63 (0.47±0.77 for spleen injuries; r=0.91), there was no significant difference. However we detected a lower rate of over-diagnosis in structured approaches.

Conclusion: Our study shows that a structured approach to triage abdominal trauma using an imaging checklist does not lead to a significantly higher detection rate, but a nonsignificant trend to reduce the rate of over-diagnoses, thus being more precise in grading the severity grade. Concerning the bias by retrospective study design, further prospective investigations are needed to evaluate the impact of trauma scores on the workflow in emergency department procedure as structured reporting systems are a valuable guidance in other radiological disciplines.

Key words: Tomography, X-ray computed; Trauma severity indices; Abdominal injuries; Tomography, spiral computed

Detection of abdominal injury, especially solid organ injury, is a very important component in trauma management and should result in a fast and appropriate therapy. In this context an accelerated assessment of the occurrence of liver and spleen injuries including their degree of severity is necessary.

In most cases of abdominal trauma management, radiologists evaluate a full body CT scan in relatively short time using their own experience, knowledge and structure of diagnosis. There is a good case to believe that in emergency situations that require a rapid judgment of a substantial body of radiologic procedures, the radiologist’s performance may defer from a structured approach under non-emergency situations. Concerning this matter structured objective scores as the organ injury scale (OIS) drawn up by the American Association for the Surgery of Trauma are a valuable guidance for objective trauma assessment. But considering the increasing use and success of nonoperative management of solid organ injuries including...
angiographic methods, a precise decision aid is needed.

These scores are based on imaging parameters as location and size of the lesion, character of hematoma/laceration (ruptured/non-ruptured) and affection of vessels. On that account the basic definitions of the score system may be used as diagnostic questioning system, which can be easily applied as imaging checklist: (1) type of injury, (2) size of the lesion, (3) location (capsular/subcapsular/intraparenchymal), and (4) vascular damage. The results of this checklist are simply transferable on the OIS.

Aim of our study was to evaluate retrospectively whether a structured approach using the OIS differs from the real-time diagnosis under emergency conditions. Therefore, the OIS-based checklist was applied by an experienced radiologist on CT data of 53 patients who underwent laparotomy after abdominal trauma. These results and the initial CT findings were correlated with the intraoperative findings gathered from the surgery report (gold standard). Beyond the pure evaluation of the OIS as diagnostic instrument in this study, structured reports may improve the diagnostic procedure in trauma settings. Approval for this retrospective study was given by the ethics review committee of the University of Münster.

METHODS

From 2003 to 2012, 38 male and 15 female patients (age: 0-82 years) who underwent laparotomy after abdominal trauma at the University Hospital Münster were included in this study. All the CT and surgical reports were reviewed and only patients underwent laparotomy after abdominal trauma. These results and the initial CT findings were correlated with the intraoperative findings gathered from the surgery report (gold standard). Beyond the pure evaluation of the OIS as diagnostic instrument in this study, structured reports may improve the diagnostic procedure in trauma settings. Approval for this retrospective study was given by the ethics review committee of the University of Münster.

The original CT reports (CT1) were used as the base and the findings were transferred into OIS grades. The original CT reports were raised and written by different radiologists with a minimum experience of 3 years. In comparison, a radiologist with experience of 4 years reviewed the same original CT pictures, resulting in the structured report (CT2). The laparotomy was performed by experienced surgeons with a minimum experience of 6 years.

To compare both approaches we introduce the difference between the initial CT report or structured review and the surgery report (CT finding/gold standard) as subtraction of the OIS grades, introducing $\triangle CTm_{OP}$ as matched difference between surgical report (OP) and CT report:

$$\triangle CTm_{OP} = |OIS(OP) - OIS(CT)|$$

The variable CTm is substituted either by the original CT finding (CT1) or the standardized review (CT2). It follows that logically the mean grade of deviation is described by:

$$\bar{\triangle} CTm_{OP} = \frac{\sum_{i=1}^{n} \triangle CTm_{OP}}{n}$$

Therefore, the mean deviation between the original CT report and surgery report is defined as $\bar{\triangle} CT1_{OP}$, while $\bar{\triangle} CT2_{OP}$ displays the mean difference between the second survey and the surgery report. An OIS grade difference between the original or structured CT findings and the surgical report was defined as under- or over-diagnosis.

To evaluate the clinical relevance of the OIS grade shift between the CT report and the surgery report, OIS grades were ranked in dependence of primary surgical approach or nonoperative management. In detail, spleen and liver OIS grades 1-2 were defined as the major nonoperative group, while 4-5 were defined as rather surgically treated group (4-6 for liver injuries). Correlating to the literature, an OIS grade of 3 was stated as intermediate finding, and surgical management strongly depends on combined injuries. OIS grade deviations between CT and surgical report, when detected, were defined as therapy-relevant mismatch.

For statistical analysis, SPSS 15 software (SPSS Inc, USA) and SAS 9.2 software (SAS Institute Inc, USA) were used. A probability of error $P<0.05$ was considered significant. Data are given as mean±standard deviation, if not indicated otherwise.
RESULTS

Missing or incomplete data in the primary CT survey and the surgery report lead to different numbers of patients regarding spleen (n=36) and/or liver injuries (n=35). The general characteristics of patients are listed in Table 1.

Table 1. General characteristics of the patient population

<table>
<thead>
<tr>
<th>Item</th>
<th>Liver (n=35, %)</th>
<th>Spleen (n=36, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>36.1±18.4</td>
<td>36.6±17.9</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>6 (17.1)</td>
<td>9 (25.0)</td>
</tr>
<tr>
<td>Male</td>
<td>29 (82.9)</td>
<td>27 (75.0)</td>
</tr>
<tr>
<td>Trauma mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic accident</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>12 (34.3)</td>
<td>10 (27.8)</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0</td>
<td>2 (5.5)</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>2 (5.7)</td>
<td>2 (5.5)</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>11 (31.4)</td>
<td>10 (27.8)</td>
</tr>
<tr>
<td>Fall (&gt; 2 m height)</td>
<td>1 (2.9)</td>
<td>1 (2.8)</td>
</tr>
<tr>
<td>Horse accident</td>
<td>1 (2.9)</td>
<td>1 (2.8)</td>
</tr>
<tr>
<td>Others</td>
<td>8 (22.8)</td>
<td>10 (27.8)</td>
</tr>
</tbody>
</table>

Note: some patients had liver and spleen lesions synchronously and therefore the table’s values differ from the total number 53.

To estimate the deviation of CT findings to the gold standard/reference laparotomy (defined as “true finding”), we assessed the OIS grade difference between the CT report/structured approach and the laparotomy OIS grade (△CT_OP). Regarding the original CT report we found a mean divergence (△CT1_OP) of 0.68 (±0.8) to the OIS finding in the surgery report for liver injuries (Figure 1). In comparison with the structured approach, where we detected a divergence (△CT2_OP) of 0.47 (±0.77) related to the surgery report revealed no significant difference (P=0.42, t test). Likewise, regarding spleen injuries (Figure 2), the comparison between the original CT report (mean divergence △CT1_OP=0.69±1.17) and the surgery report as well as the structured approach (mean divergence △CT2_OP=0.47±0.77) related to the surgery report revealed no significant difference (P=0.42, t test).

The results of the statistical analysis of specificity, sensitivity, positive and negative predictive value (PPV and NPV) for liver and spleen injuries are summarized in Table 2. Concerning liver injuries the original CT findings contained 13 under-diagnoses and 4 over-diagnoses, while the structured approach provided 10 under-diagnoses and 1 over-diagnosis. Regarding the OIS-related correctness for spleen injury detection, the original CT findings coincide in 23 cases with surgery report with 9 under-diagnoses and 4 over-diagnoses, while the structured approach presents 25 correctly graded cases, 11 under-diagnoses and no over-diagnosis.

Table 2. Comparison of sensitivity, specificity, PPV and NPV regarding liver and spleen injuries

<table>
<thead>
<tr>
<th>Item</th>
<th>Liver</th>
<th>Spleen</th>
<th>Liver</th>
<th>Spleen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>72%</td>
<td>71%</td>
<td>72%</td>
<td>83%</td>
</tr>
<tr>
<td>Specificity</td>
<td>88%</td>
<td>91%</td>
<td>94%</td>
<td>99%</td>
</tr>
<tr>
<td>PPV</td>
<td>0.87</td>
<td>0.83</td>
<td>0.93</td>
<td>0.99</td>
</tr>
<tr>
<td>NPV</td>
<td>0.75</td>
<td>0.83</td>
<td>0.76</td>
<td>0.90</td>
</tr>
</tbody>
</table>

To evaluate where the CT report differed therapeutically from the gold standard laparotomy, therapy-relevant groups were defined as primary nonoperative (OIS 1-2), intermediate (OIS 3) and primary operative (OIS 4-5/6). If a difference occurred between CT and surgery which exceeded the borders of these groups, it was counted as therapy-relevant mismatch, e.g. a CT re-
port with OIS 2 and a surgical finding with OIS 4. In 22.2% of the spleen lesions such a mismatch was found in the primary survey, compared to 16.7% in the structured approach. Concerning liver injuries, we detected a mismatch in 37.1% of the cases in the original CT findings (22.9% in the structured approach). Similar to the other data, the small sample number did not reveal statistical significance \((P>0.05)\).

**DISCUSSION**

CT is widely accepted as diagnostic reference standard, but there are many opposing arguments regarding its effectiveness and sensitivity in trauma assessment. On one hand CT is a commonly available instrument in rapid trauma assessment with a high sensitivity \(^6,7\) and an indispensable predicting tool for the choice of therapy and patient outcome prediction \(^8\). On the other hand it has been shown that CT grading of abdominal solid organ injuries often derogates from autopsy findings. \(^9,10\) While previous sensitivity and effectiveness studies focus on the comparison of the original CT findings and the surgery report, we took into consideration that emergency room procedures and nighttime work may render radiologic judgment and eventually result in misdiagnosis. As imaging checklists were proposed for different diagnostic issues including preoperative settings with a view to the surgical access, \(^11\) we tried to evaluate the effectiveness of a structured trauma grading system as checklist for fast trauma assessment, which may help reduce subjective sources of error.

In our study we were surprised to find that there was no significant difference between the real-time and the retrospective findings concerning the detection of organ injury as assessed in the surgery report. Therefore it can be assumed that the introduction of structured CT analysis patterns is not profitable, but it needs to be pointed out that the structured or retrospective recheck of CT show a trend to describe the grade of injury more precisely with less over-diagnoses. Moreover, the percentage of therapy-relevant mismatches was reduced in the structured approach. Therefore, scores based on imaging parameters may be more precisely. Under consideration of current therapy guidelines inclining to nonoperative management, \(^12\) the practicability and relevance with therapy of the AAST-OIS have already been challenged for small lesions and lacerations \(^13\) and there is a need to adjust the scoring systems to adapt to the new therapy regimes. These may lead to a streamlined emergency CT procedure and improve indication for surgery.

Previous studies show that under- and mis-diagnosis occur often in trauma assessment and even more common in patients with more severe injuries or associated head injury. \(^10,14\) Correlating with this fact, we detected a relatively high rate of under-diagnoses, but remarkably the second-look/structured approach shows a trend to a lower rate of over-diagnoses. Maybe this over-estimating behavior results from the stressful abdominal trauma setting, in which the radiologist is afraid of under-diagnosis or misdiagnosis that may lead to insufficient therapy. \(^15\) Nevertheless, over-diagnoses should be avoided as they cumulate in redundant surgery accompanied by adverse effects of invasive therapy.

As a limitation it has to be mentioned that due to the decreasing number of patients who are treated surgically immediately after trauma CT, the sample size in our study did not reveal significant statistical results. Moreover, a minor number of CT findings and surgery reports contained detailed descriptions that could be transferred one-to-one into an OIS grade. However, the fact that we excluded less precise reports underpins the quality of the underlying data.

It has to be mentioned that the gold standard that we used, the laparotomy, is also methodically restricted by the reduced sensitivity for contained intraparenchymal hematomas. Therefore it can be assumed that some cases were incorrectly defined as over-diagnoses. But regarding the small number of over-diagnoses by CT in this study, this bias may be small. Moreover, only patients who underwent laparotomy were included, which results in selection bias.

One may point out that this study only reflects interobserver variability, but the fact that both radiological reviews were performed by physicians with nearly the same experience implies that the evaluated variability does not rely on interpersonal abilities. Therefore we state out that structured reporting as it is nowadays a standard in other radiological disciplines as the mammography may be also useful in trauma assessment. \(^16\)
Fast and focused CT is actually broadly implemented in trauma assessment and has been shown to positively affect the patients’ outcome,\textsuperscript{17} but the CT findings alone are still not the only criterion for the initiation of operative intervention, especially focusing spleen injuries whose therapy management relies on hemodynamic and clinical criteria.\textsuperscript{18,19} Relaying to therapy and outcome prediction models for head trauma,\textsuperscript{20} effective and clinical applicable evaluation checklists should contain radiological as well as clinical criteria. Unfortunately the AAST injury scale has to be seen as an imperfect grading system, because different important factors as pseudoaneurysms and vascular contrast agent extravasation are not taken into consideration. This may be the weakness of this relatively old scoring system as many interventional therapy options are based on this information. An improved CT-based scoring system has been proposed by Poletti et al\textsuperscript{21}, implementing angiographic aspects. In fact, the complexity of trauma assessment needs a new multidisciplinary, as more as the routine follow-up is designated as a mixture of clinical and radiological interaction based on different sensitivity of the initial CT scan for various organ systems or body regions.\textsuperscript{22} This may improve the usefulness of a grading system for surgical indications.

Despite the limitations of our study the presented data may not sufficiently describe the impact of trauma imaging scores on the workflow and patient management. Due to this, prospective studies should evaluate the immediate effect of trauma scores on the routine procedure in emergency department. It is conceivable that the design of integrated clinical and radiological injury checklists may improve emergency department routine work and follow-up monitoring.

In conclusion, a structured approach to abdominal trauma using an imaging checklist does not lead to a significantly higher detection rate, but reduces the rate of over-diagnoses and may be more precise in grading severity grade, especially concerning the cut-off-margins of nonoperative and surgical management. Moreover, it may streamline the emergency CT procedure.

REFERENCES


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News

Chinese Journal of Traumatology won the financial aid from “Global Influence Promotion Project for Chinese Scientific and Technical Journals”

The assessment result of the “Global Influence Promotion Project for Chinese Scientific and Technical Journals” was announced recently and our journal (Chinese Journal of Traumatology, CJT) won the financial aid, which implies that CJT will receive from our nation an annual amount of up to 1,000,000 yuan for three consecutive years since 2014.

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