Blunt abdominal trauma: changing patterns in diagnostic and treatment strategies
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The failure rate of nonoperative management in children with splenic or liver injury with contrast blush on computed tomography: a systematic review

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ABSTRACT

Introduction: Nonoperative management (NOM) is the treatment of choice for hemodynamically stable pediatric patients with spleen or liver trauma. The aim of this study was to assess the failure rate of NOM in children with blunt liver and/or splenic injury when a contrast blush is present on a CT scan.

Methods: A systematic review of the literature published between 1985 and 2009 was performed by searching the EMBASE and MEDLINE database for English and German articles. Articles were eligible if they reported the failure rate of NOM with or without angio-embolization (AE) in pediatric patients with splenic and/or liver injuries with a contrast blush on CT and included two or more trauma patients. Two reviewers independently assessed the eligibility and the quality of the articles and performed the data extraction. Interrater differences were resolved by discussion.

Results: Nine studies were included describing 117 pediatric patients. The median sample size was five (range 2-44). Seven studies (including 71 patients) reported a total of 16 patients with failure after NOM without AE. Failure rates across these studies ranged from 4.5 to 100%; the pooled percentage was 28.2% (95% CI: 8.9-61.3%). The failure percentages after NOM with or without AE ranged from 0 to 100%; the pooled percentage was 21% (95% CI: 7.5-46.8%). Two studies (including 46 patients) reported a total of 3 patients with failure after NOM with primary AE: a percentage of 6.5%.

Conclusion: Despite the current low level of evidence on failure rate of NOM when a contrast blush is present on CT we emphasize that there is a significant number of patients in whom NOM fails. We therefore recommend that the management of splenic and hepatic injury in children should not only be based on the physiological response, but should include consideration of the presence of a contrast blush.
INTRODUCTION

Blunt abdominal trauma is an important cause of death in children older than one year of age.\(^1\) The spleen and liver are the most commonly injured intraabdominal organs, accounting for up to 70% of all visceral injuries.\(^1\) The best method to diagnose liver and splenic injuries is an intravenous contrast-enhanced Computed Tomography (CT). CT has the ability to provide accurate information about the severity of sustained injuries and also gives information about the presence and location of active bleeding sites.

Reported success rates for nonoperative management (NOM) of blunt liver and splenic injuries are 90% or higher for pediatric patients. Due to this high success rate NOM is considered the standard of care in hemodynamically stable children.\(^2-4\) In the literature there are no reliable indicators other than hemodynamic instability that predict the failure of NOM in pediatric trauma patients.\(^5\) Several recent studies in adults suggest that the presence of a contrast blush on CT is associated with an increased failure rate of NOM of blunt splenic and/or liver injury.\(^6-8\) However, the clinical implication of a contrast blush on CT with liver and/or splenic injury in the pediatric population has not yet been assessed.

The primary aim of this systematic review was to assess the failure rate of NOM without AE (observational management) in children with blunt liver and/or splenic injury in the presence of a contrast blush on CT scan. The second goal was to determine the failure rate after NOM with angio-embolization (AE).

METHODS

A systematic search of the literature was conducted to identify studies assessing the significance of a contrast blush on CT and the failure of NOM (with or without AE) in children with liver and/or splenic injuries.

Data sources and search strategy

We searched the MEDLINE and EMBASE databases for English and German articles published between 1985 and 2009. The medical subject heading terms, title words and free text were searched for the following terms: (injury OR injuries OR trauma OR rupture OR rupture*) AND (child OR childr* OR childh* OR paediatric OR pediatric OR pediatric OR paediatric OR biliary OR hepatic OR spleen OR splenic* OR viscera* OR intestinal OR intestine* OR abdominal OR abdomen) AND (angiography OR angiography* OR embolization OR embolization* OR embolization OR angioembolization* OR angioembolization* OR (((extravasation* OR extravasation)) OR ((blush OR leak*)) AND contrast)). Additionally, the reference list of each eligible article was screened for other relevant
publications (cross-reference search) to identify studies not found in the computerized search. Furthermore, a manual search of the following journals was performed (CHV, TPS) that reported most frequently about the topic of interest: Journal of pediatric surgery, Pediatric Surgery International, European Journal of Pediatric Surgery, Journal of Trauma, Annals of Emergency Medicine, Injury, Journal of Emergency Medicine, Radiology, Emergency Radiology, American Journal of Roentgenology. For the manual search we used the same publication year restriction. The last search was performed in May 2009 and was conducted with the help of a clinical librarian.

Study selection

The selection procedure was performed by two independent reviewers (CHV and TPS). The inclusion criteria were: (1) pediatric trauma patients (age < 18 year); (2) English or German language; (3) original data (no review or editorials) (4) randomized clinical trials (RCT's), prospective or historical studies including at least two trauma patients; (5) clinical data concerning splenic and/or liver injuries with a contrast blush on CT; (6) the primary treatment was nonoperative; (7) the aim of the selected studies was to assess the failure rate of NOM with or without AE. Meeting abstracts, unpublished data, and theses were excluded. Trauma was defined as a physical injury or wound caused by an external force which may cause death or permanent disability. NOM was defined as treatment without operative interventions and included both clinical observation and/or AE. Failure of the initial treatment (NOM with or without AE) was defined as (1) the need for abdominal exploration, (2) the need for an (re-)AE after clinical observation or earlier AE for an ongoing bleeding or rebleeding, and (3) death due to uncontrollable hemorrhage.

Both reviewers independently assessed the titles of the literature search to determine whether they were potentially relevant. Subsequently, the abstracts were assessed and the eligible articles were retrieved. If abstract relevancy was questionable, the full text article was reviewed. The final step of inclusion was always based on the full text article. Interrater differences were resolved by discussion. During the selection process no concealment of authors and institutions was used.

Data Extraction

Data extraction was performed independently using a standardised checklist for the following characteristics: number of patients, mean age at time of trauma, mechanism of trauma, Injury Severity Score (ISS), Abbreviated Injury Score abdomen (AIS abd.), type of NOM (with or without AE) and organ specific failure of initial treatment. Interrater differences were resolved by discussion. All corresponding authors were contacted if the reported data was unclear or incomplete for data extraction.
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Methodological quality
The methodological quality of the studies was assessed using a scale that was based on a checklist of the Dutch Cochrane Centre for evaluating cohort studies (http://www.cochrane.org). The scoring system consisted of the following eight items: (1) description of demographic details of the investigated patient groups; (2) description of the selection criteria for treatment; (3) prospective study design; (4) consecutive inclusion of patients; (5) description of treatment; (6) definition of failure reported; (7) follow-up period > 30 days; (8) no selective loss to follow-up. If a study fulfilled the item, one point was awarded. If it was unclear whether the study fulfilled the item, no point was awarded. All items were assumed to be of equal importance and were not weighted. Studies with a score of 0–5 were classified as “poor quality” reports and those with a methodological score of 6–8 as “moderate to good”.

Statistical analysis
For each study, patient characteristics and failure rate were summarized using descriptive statistics. Pooled failure rates accounting for inter-study variation were analyzed using a nonlinear random effects model, implemented (proc nlmixed) in SAS version 9.1 (SAS Institute Inc., Cary, NC, USA). Statistical uncertainties were expressed in 95% confidence intervals (CI).

RESULTS

Search strategy and selection
The computerized literature search resulted in 447 titles from the EMBASE database and 957 titles from the MEDLINE database (Figure 1). After reviewing the titles and eliminating the duplicates from both databases 95 titles were selected for further evaluation. Based on the abstract 77 papers were excluded because they did not match the inclusion criteria resulting in 18 full text articles. The manual search and cross-reference search added two additional papers which made a total of 20 articles for full text review. In total, five authors were contacted for additional information on the data. After reviewing the full-length text, another 11 studies were excluded for various reasons leaving nine eligible studies.9-17 During quality assessment one study was rated poor quality and eight as moderate to good. No studies were excluded because of quality assessment.

Data extraction
All nine studies were observational studies, eight of them had retrospective data collection and one had a prospective design. All studies provided specific data about the failure rate of NOM with or without AE. The patient and injury characteristics, type of nonoperative treatment and failure rates of the nine included studies are shown in table 1. A total of 117 patients was included with a median
Chapter 3

**Figure 1.** Flowchart of the reviewing process

**Table 1.** Patients demographics and outcome

<table>
<thead>
<tr>
<th></th>
<th>Mayglothling</th>
<th>Fang</th>
<th>Eubanks</th>
<th>Lutz</th>
<th>Cloutier</th>
<th>Cox</th>
<th>Ohtsuka</th>
<th>Nwomeh</th>
<th>Taylor</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>44</td>
<td>5</td>
<td>22</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>27</td>
<td>4</td>
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<tr>
<td>age mean</td>
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<td>12.0</td>
<td>5.9</td>
<td>n.a.</td>
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<td>11.0</td>
<td>11.1</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>ISS mean</td>
<td>23.6</td>
<td>n.a.</td>
<td>25.8</td>
<td>24</td>
<td>n.a.</td>
<td>24</td>
<td>n.a.</td>
<td>20.7</td>
<td>n.a.</td>
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<td>organ injured</td>
<td>spleen</td>
<td>liver</td>
<td>liver</td>
<td>spleen</td>
<td>spleen</td>
<td>both</td>
<td>liver</td>
<td>spleen</td>
<td>both</td>
</tr>
<tr>
<td>AIS abd.</td>
<td>3.2</td>
<td>4.0</td>
<td>4.1</td>
<td>3.7</td>
<td>3.0</td>
<td>4.5</td>
<td>3.5</td>
<td>3.3</td>
<td>n.a.</td>
</tr>
<tr>
<td>NOM without AE</td>
<td>n=</td>
<td>n.a.</td>
<td>5</td>
<td>22</td>
<td>6</td>
<td>5</td>
<td>n.a.</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td>failure</td>
<td>n=</td>
<td>n.a.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>n.a.</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
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<td>40%</td>
<td>4.5%</td>
<td>16.7%</td>
<td>20%</td>
<td>100%</td>
<td>22%</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE=NOM with AE</td>
<td>n=</td>
<td>44</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>failure</td>
<td>n=</td>
<td>3</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
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</tr>
<tr>
<td>%</td>
<td>6.8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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</tr>
</tbody>
</table>

ISS = Injury Severity Score, AIS abd. = Abbreviated Injury Score abdomen, AE = AE angio-embolization
n.a. = no data available
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sample size of 5 (range 2–44). For the five studies specifically describing the age of their patient population, the median age was 11.0 years (range 5.9–12). All patients had sustained blunt trauma. Median Abbreviated Injury Score of the abdomen was 3.6 with a range from 3.0–4.5. Seven studies, including 71 patients, reported a total of 16 patients with failure after NOM without AE. The failure rates across the studies ranged from 4.5% to 100% with a pooled percentage of 28.2% (95% CI: 8.9–61.3%). Figure 2 shows the forest plot for these studies. The failure percentages after NOM with or without AE ranged from 0% to 100% with a pooled percentage of 21 (95% CI: 7.5–46.8%) (Figure 3) Two studies (46 patients) reported a total of 3 patients (6.5%) with failure after NOM with primary AE.

Figure 2. Forest plot showing the failure rate after NOM without AE

Figure 3. Forest plot showing the failure rate after NOM with and without AE
DISCUSSION

The primary aim of this systematic review was to assess the failure rate of NOM in children with blunt liver and/or splenic injury with a contrast blush on CT scan. Currently, hemodynamic stability is the main parameter decisive for the initiation of NOM in children with splenic and/or liver injuries.2-18-21 However, although the failure rates of NOM are assumed small, potential risk factors for failure in these children are unknown. Improved imaging techniques and the advances in interventional radiology have led to a better selection of adult patients who are eligible to NOM. Several recent studies in adults have suggested that vascular injuries including active bleeding (contrast blush) are associated with an increased failure rate of NOM of splenic and liver injury.22-25 For pediatric patients there is controversial evidence in the literature whether or not the presence of a contrast blush is associated with failure of NOM. Analysis of factors for failure of NOM in pediatric patients is relevant because children have a high ability for physiologic compensation. As a result, hypotension is usually a late sign signifying catastrophic hemorrhage and there is concern that delayed operations in unstable children may result in significant morbidity and mortality.26

Our analysis showed on average a failure rate of 28.2% after NOM without AE in pediatric patients with a contrast blush on CT scan. This suggests that almost one of the three children with liver or splenic injuries and a blush on CT scan required an intervention to treat the ongoing bleeding or rebleeding with all the potential adverse effects. However, it should be stressed that this aggregated point estimate is statically imprecise as most of the reviewed studies were retrospective nonrandomized studies of moderate quality with a large fluctuation of failure rates between the studies (from 4.5–100%). Moreover, the estimates were based on a small number of patients leading to wide confidence intervals.

Although no randomized controlled trials have been published, several studies of adult patients concluded that primary AE increased the success rate of NOM.27-32 However, the precise role of AE in children is still unclear. The combined data of all studies reporting on NOM with or without AE showed a failure rate to 21%. But here again, the differences in study populations and suboptimal study methods and quality hamper the interpretation of the results.

If only the two studies that reported on NOM supplemented with angio-embolization were analyzed we found a failure rate of 6.5%. This seems to suggest that the adjunction of AE leads to fewer failures. A critical note has to be made on this assumption because Mayglothling et al14 described 44 adolescent patients (aged 13–17 years) with splenic injuries in whom AE seemed to be a valuable and safe treatment. However, it is questionable if these results also apply to younger patients in their childhood and to children with liver injuries. In addition to this, AE is an invasive and time-consuming procedure in young children and carries the risk for complications. This increased risk is supposed to be due to the small size of the femoral artery which may be difficult to cannulate and the higher vaso-reactivity in children which makes accessing the
splenic artery or deploying the coil more difficult. However, these are all theoretical risks and the reviewed studies demonstrated no major complications and vascular injuries.\textsuperscript{14,16} Besides the small sample sizes and heterogeneity of the studies, our review has the limitation that it specifically focused on the presence of a contrast blush on the CT scan. The localisation (intraparenchymal, intraperitoneal) of the contrast extravasation, imaging evidence of the liver or splenic capsule and the presence and quantity of hemoperitoneum were not separately assessed. Studies in adult patients suggest that evidence of intraperitoneal bleeding and a large hemoperitoneum predict failure of observational management.\textsuperscript{12,18} Finally, as stressed before, the results of our systematic review should be interpreted with caution due to the wide variation in populations and study methods. As a result of the found low level of evidence the definitive answer about the optimal management strategy should come from a well-designed randomized clinical trial in which NOM without an NOM with primary AE should be compared for failure rate in hemodynamically stable children with liver or splenic injuries. Furthermore, all the above mentioned CT characteristics should be prospectively evaluated to assess if there are any CT findings that can predict failure of nonoperative management and when AE could be beneficial.

**CONCLUSION**

Despite the current low level of evidence on failure rate of NOM when a contrast blush is present on CT we emphasize that there is a significant number of patients in whom NOM fails. We therefore recommend that the management of splenic and hepatic injury in children should not only be based on the physiological response, but should include consideration of the presence of a contrast blush. AE could be a valuable adjunct to nonoperative management and its application should be assessed in future studies.
REFERENCES


