Pediatric abdominal Injury
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Chapter 8
Blunt Spleenic Trauma in Children:
Are We Too Careful?

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ABSTRACT

Introduction
There has been a shift from operative treatment (OT) to nonoperative treatment (NOT) of splenic injury. In this study we evaluate the outcomes of treatment of paediatric patients with blunt splenic trauma in our hospital with special attention to the outcomes of NOT.

Patients and Methods
Data of all patients <18 years with radiologically proven blunt splenic injury admitted to the UMCG between 1988 and 2007 were retrospectively analysed using a prospective trauma database. Mechanism of injury, type of treatment, ICU admission time, total admission time, morbidity and mortality were assessed. Patients were divided into two groups, those admitted before and after 2000. Patients suffering isolated splenic injuries were subsequently assessed separately.

Results
Sixty-four patients were identified: 49 males and 15 females with a mean age of 13 years (range 0-18). Three patients died shortly after admission to the emergency room due to severe neurologic injury and were excluded. In the remaining 61 patients concomitant injuries were present in 62%: fractures of long bones (36%), chest injuries (16%), abdominal injuries (33%) and head injuries (30%). Mechanisms of injury: car accidents (26%), motorcycle (20%), bicycle (19%), fall from height (17%) and pedestrians struck (8%). A change in treatment strategy is witnessed before 2000 compared to after 2000. Significantly more patients underwent NOT after 2000 in the isolated injured group 4/11 (36%) before vs. 10/11 (91%) after (p=0.009) and 15/19 (79%) before vs. 8/20 (40%) after 2000 (p=0.032) in the multitrauma group. There also is a shift to spleen preserving operations in the isolated injury group from 9/11 (82%) before vs. 11/11 (100%) after the year 2000 (p=0.069) and 10/19 (53%) before vs. 17/20 (85%) after the year 2000 (p=0.031) in the multitrauma group. All life-threatening complications occurred within 24 hours. The mortality for the entire cohort was 7% and all of these patients were treated operatively. When comparing the median ICU length of stay and length of stay in hospital before and after 2000 it increased significantly in the isolated injury group and remained statistically the same in the multitrauma group.

Conclusion
Splenic injury in children is associated with substantial mortality. This is due to concomitant (neurologic) injuries and not to the splenic injury itself. In the treatment of splenic injuries in hemodynamic stable children non-operative treatment is gaining preference above operative treatment. ICU length of stay and length of stay in hospital have, despite the
change from OT to NOT, remained the same. Complications in the NOT group are rare, suggesting that NOT is safe. It can be concluded that we are still observing children in hospital for a time period that is longer than necessary.'

INTRODUCTION

Blunt splenic injury in children is a potentially severe injury with a relatively high incidence. It is associated with high-energy trauma or violent compression of the abdominal or thoracic wall. Traffic related accidents account for the majority of blunt splenic injuries seen in children1,2,3.

The management of blunt splenic injury in children has changed over the past two decades. The most prominent change is the shift from operative treatment (OT) to non-operative treatment (NOT). Studies have proven the safety of this approach, specifically in children4,5, and this has led to a worldwide adaptation of non-operative treatment. In 2000 the American Paediatric Surgical Association (APSA) published evidence-based guidelines for the management of hemodynamically stable patients with isolated liver or spleen injuries2. These guidelines were set to create a benchmark for observation time in the Intensive Care Unit (ICU), the total length of stay (LOS) and indications for radiological imaging. All recommendations in the guidelines were related to the grade of injury as defined by the AAST organ injury scale. The degree of injury was assessed using computed tomography (CT) when possible.

This study was undertaken to audit the changes in treatment of splenic injury in the UMCG in Groningen, the Netherlands over the last two decades and assess our compliance to the APSA guidelines. The purpose of this study is therefore to analyse the treatment of splenic injury and particularly the observation times of children admitted to the UMCG. The cohorts before and after 2000 are compared as this is the year the APSA guidelines were published.

PATIENTS AND METHODS

The UMCG is a level 1 trauma centre. A retrospective analysis was performed and patients were identified using a comprehensive prospective trauma registry. The population for this study consists of all patients, aged 18 and younger, that were admitted to the UMCG with radiological (ultrasound and/or CT-scan) proven blunt traumatic splenic injury during the period of 1988-2007.
The data were analysed for age, sex, trauma mechanism, type of treatment, concomitant injuries, injury severity, mortality, complications during treatment, length of admission in the ICU (LOS-ICU) and in hospital (LOS-Hos).

To relate the different parameters to age, four different age groups were created: group I (0 – 5 years), group II (6 – 10 years), group III (11 – 15 years), and group IV (16 – 18 years). This particular division was based on a previous study from our institution regarding hepatic injuries in which these age groups delineated different trauma mechanisms.

The cohort was divided into two main groups; isolated splenic injury and multi trauma patients. To assess a possible shift in treatment and LOS, patients were subsequently divided in those treated before and those treated after 2000 (the publication year of the APSA guidelines).

Statistics
Statistical calculations were performed using the SPSS 16.0 statistical software package. Student t-test or Mann Whitney U test was used for continuous data as appropriate, while Chi square tests or Fisher Exact tests were used for categorical variables. P-values < 0.05 were considered statistically significant.

RESULTS

Patients
Sixty-four patients were identified: 49 male and 15 female with a mean age of 13 years (range 0-18). The injuries were induced by car accidents (26%), motorcycle accidents (20%), bicycle accidents (19%), falls from height (17%) and pedestrians struck (8%). Fall from height was the most important cause of injury in the 6-10 year group, bicycle injuries in the 11 to 15 year group and motorcycle accidents in the 16-18 year group as shown in Figure 1.

Three patients had sustained such severe neurological damage that treatment was ceased immediately after diagnosis of the neurological injuries. All died shortly after admission to the emergency room and were subsequently excluded from the analysis, leaving 61 cases for the present study.

Of the remaining 61 patients, 39 (62%) suffered concomitant injuries. Fractures of long bones (36%) were most frequent, followed by additional abdominal injuries (33%), head injuries (30%) and chest injuries (16%). Twenty-two patients (36%) suffered isolated splenic injuries.

Due to the fact that >50% of the patients were not subject to CT-scanning, the organ injury scale was not suited as a measure of injury severity. The Injury Severity Score (ISS) was used instead. The isolated splenic injury group had a median (range) ISS of 25 (4-25).
before 2000 and 25 (4-25) after (p=0.329). The multitrauma group had a median ISS of 29 (9-75) before 2000 and 34 (24-75) after (p=0.06).
The mortality for the entire cohort was 7% and all of these patients were operated on.

**Treatment and Length of stay**

*Isolated splenic injury patients*

Of the 22 patients that suffered isolated splenic trauma 8 (36%) underwent laparotomy. Two of them underwent total splenectomy, one a partial splenectomy, four received spleen salvaging operations such as splenic nets and one was not specifically documented on. The remaining 14 patients were treated conservatively.

Eleven patients were admitted before the year 2000 and eleven after. Before 2000, 4/11 (36%) received conservative treatment as opposed to 10/11 (91%) after 2000 (p=0.009). Before 2000, 9/11 (82%) patients received spleen-preserving treatment as opposed to 11/11 (100%) after the year 2000 (p=0.069).
Chapter 8

Table 1: ICU and hospital length of stay (LOS) in children with splenic injury before and after 2000.

<table>
<thead>
<tr>
<th></th>
<th>Before 2000</th>
<th>After 2000</th>
<th>P-value</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Median (range) days</td>
<td>Median (range) days</td>
<td></td>
</tr>
<tr>
<td>All patients (n=61)</td>
<td>n=19</td>
<td>N=20</td>
<td></td>
</tr>
<tr>
<td>ICU stay (days)</td>
<td>1 (0-23)</td>
<td>3 (0-24)</td>
<td>0.83</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>14 (0-58)</td>
<td>9.5 (0-54)</td>
<td>0.32</td>
</tr>
<tr>
<td>Isolated splenic injury (n=22)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICU stay (days)</td>
<td>0 (0-1)</td>
<td>2 (0-4)</td>
<td>0.02</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>7 (3-10)</td>
<td>12 (7-16)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

The median LOS-ICU and LOS-Hos before 2000 increased significantly after 2000 as described in Table 1.

**Multitrauma patients**

Of the 39 patients that suffered a multitrauma 23 patients (59%) underwent operative treatment of the splenic injury. Eleven of these underwent total splenectomy, one a partial splenectomy and eight received spleen-salvaging operations such as splenic nets. One patient received a total splenectomy with partial splenic reimplantation, one was treated using splenic packing and one patient was not specifically documented on. The remaining 16 patients were treated conservatively and in one of these patients the splenic artery was selectively embolised. Nineteen patients were admitted before the year 2000 and twenty after. Before 2000, 15/19 (79%) underwent laparotomy as opposed to 8/20 (40%) after 2000 (p=0.032). Before 2000, 10/19 (53%) patients received spleen preserving treatment as opposed to 17/20 (85%) after the year 2000 (p=0.031).

The median LOS-ICU and LOS-Hos before 2000 remained statistically the same before and after 2000 as described in Table 1.

**Treatment overview for entire cohort**

Of the 31 laparotomies performed, twenty-one (68%) were performed because the patient was hemodynamically unstable, as defined by the persistent necessity for fluid resuscitation as perceived by the attending trauma surgeon. Eight of these were patients with isolated injury. Other indications were suspicion of hollow-viscous perforation or severe hepatic injury with hemodynamic instability. The mode of treatment applied to patients admitted before and after 2000 is shown in Figure 2.

In a number of cases complications occurred. Two patients had to undergo a second laparotomy: one due to bleeding from the splenic artery six hours after the initial operation and the other due to iatrogenic diaphragm perforation caused by a chest tube.

Five patients developed pneumonia, one developed an infected splenic hematoma 10 days after the accident and one developed pulmonary embolism and a wound abscess.
All potential life-threatening complications occurred within the first 24 hours and all patients undergoing a second laparotomy were operated on within the first 24 hours. One patient with an initial indication for conservative treatment underwent a laparotomy within 24 hrs after the accident due to a concomitant hepatic tear. Therefore the success rate (defined as not having to undergo a laparotomy once non-operative treatment had been initiated) of NOT for splenic injury, was 29/30 (97%).

**DISCUSSION**

The current number one cause of death in children is trauma. Even in highly developed countries such as the Netherlands, traffic accidents account for the majority of deaths\(^3,7\) which is confirmed by this study.

After the year 2000, there was a significant shift towards non-operative treatment of splenic injury, with a total success rate of 97%. Complications in the NOT group were rare, and if life threatening, they occurred within 24 hours. Furthermore there was no mortality in this group. NOT thus provides a safe approach\(^6,8\).
The complications and deaths in the entire cohort all occurred during the first 24 hours of admission indicating that there is no benefit of prolonged stay for any of these patients in the ICU. The APSA guidelines, shown in Table 2, also support this statement.

The indication to perform OT in patients with blunt abdominal injuries is not always based on objective assessment. Literature reports varying degrees of familiarity with and use of clinical practice guidelines for pediatric splenic injury management in the general surgeon group. Limited pediatric experience and lack of pediatric hospital resources may limit more widespread adoption of nonoperative management.

Especially in multi-trauma patients hemodynamic (in-)stability is not the only criterium for laparotomy. Suspicion of hollow-viscous injury, injury to the diaphragm etc. might also prompt the surgeon to perform an exploration of the abdomen. In the present series 32% of the laparotomies were performed for other indications than “hemodynamic instability”. But also the term “hemodynamic instability” is rather subjective. The main challenge in the current management of the hemodynamically instable multitrauma patient with intra-abdominal injury is defining the cause for hemodynamic instability. In the present series, the definition of hemodynamic instability was subject to assessment by the attending surgeon. The response to fluid resuscitation might be a better guide for management than initial hemodynamic (in)stability. However, due to the lack of data and the retrospective nature of the study this could not be ascertained.

We realize that concomitant abdominal trauma can be an indication for laparotomy and thus lead to some form of spleen preserving treatment. In the present study, there were two patients who underwent laparotomy for indications other than splenic injuries. In both of these patients the spleen was preserved.

Even an arterial blush on the initial CT scan can be successfully treated non-operatively when using an established treatment protocol. The APSA protocol states that management should be based on physiological response rather than radiologic features of the injury. Fluid resuscitation alone is often sufficient to stabilise a paediatric patient hemodynamically (as opposed to adults). This offers further evidence that non-operative treatment is safe in the paediatric population, even in the presence of seemingly significant injuries. Literature shows that the success rate for NOT in high grade splenic injuries (IV and V) is very high if patient is hemodynamically stable. The only difference with lower grade injuries is that the LOS increases significantly.

### Table 2: Guidelines from the American Pediatric Surgical Association regarding ICU and Hospital length of stay (LOS) for hemodynamically stable children with isolated splenic/hepatic injury.

<table>
<thead>
<tr>
<th></th>
<th>Grade 1 injury</th>
<th>Grade 2 injury</th>
<th>Grade 3 injury</th>
<th>Grade 4 injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU LOS (days)</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>1</td>
</tr>
<tr>
<td>Hospital LOS (days)</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Activity restriction (weeks)</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>
We also observed an increase in spleen preserving operations. Spleen preservation induces a reduction in postoperative morbidity, hospital stays and blood products administration\textsuperscript{15}. Also from an immunological point of view spleen preserving treatment deserves preference as the immune system is not compromised and vaccination is therefore unnecessary. Total splenectomy should therefore be reserved for patients with persistent intra-abdominal blood loss\textsuperscript{16}.

Splenic artery embolization is an upcoming treatment modality. However, as only one patient underwent selective splenic artery embolization in the present series no comments can be made on success rates in treatment of splenic injury in children.

Remarkably the length of stay in the ICU and hospital between the groups before and after 2000 do not differ significantly despite the significant shift towards non-operative treatment. There even seems to be an increase in the length of stay in ICU and hospital of patients with isolated splenic injury, which cannot be attributed to an increase in injury severity. The most probable reason for these prolonged admission times is fear of splenic rebleeding, which disappears after splenectomy. Considering the few and minor complications after NOT, and the fact that all serious complications occur within 24 hours, one can state that the UMCG is still too careful with regard to its observation time. A decrease in the length of stay is beneficial for the paediatric patient, their parents and it reduces costs. We strongly suspect that UMCG is not the only hospital being too careful.

**CONCLUSION**

Splenic trauma in children is a severe type of injury with a substantial mortality. This is however due to the frequent occurrence of concomitant (neurological) injuries. In the treatment of splenic injuries in hemodynamic stable children non-operative treatment is gaining preference above operative treatment. However, the definition of hemodynamic (in) stability remains subjective, and other clinical factors may influence the decision to perform a laparotomy. In the present series, success rate of NOT is 97\%, and complications are rare. However, lengths of stay in the ICU and the hospital have not decreased, despite the change from OT to NOT. Given these facts it can be concluded that the UMCG is still observing children in hospital for a period that is longer than necessary and a strong suspicion exists that this is also the case in other hospitals.
REFERENCES