Chapter 7
Paediatric Blunt Liver Trauma in a Dutch Level 1 Trauma Center


ABSTRACT

Introduction: Paediatric blunt hepatic trauma treatment is changing from operative treatment (OT) to non-operative treatment (NOT). In 2000 the American Pediatric Surgical Association has published guidelines for NOT of these injuries. Little is known about the treatment of paediatric liver trauma in the Netherlands. Patients and methods: Data of all patients aged 18 years and younger admitted to our hospital for blunt hepatic trauma in the past 18 years were retrospectively analysed using a prospective trauma registry. The mechanism of injury, treatment, ICU admission time, total admission time, morbidity and mortality were assessed. Subsequently the group was divided into patients treated before and after 2000. Results: Eighty patients were identified: 52M, 28F with a mean age of 12 years (range 2 – 18).

Thirty patients sustained isolated liver injury. Concomitant injuries were fractures of long bones (28), abdominal (25), chest (24) and head injuries (18). Mean ISS score was 18 (range 4 – 57). Mortality was 8 %. Mechanisms of injury consisted of bicycle (25 %), car (20 %), and motorcycle accidents (15 %), pedestrian hit by vehicle (15 %), fall from height (14 %) and accidents associated with animals (11 %). Haemodynamically stable patients underwent NOT (55). 25 patients (31 %) underwent a laparotomy, which in 20 cases (80 %) was related to hepatic injury. Although the groups treated before and after 2000 did not differ haemodynamically on admission to hospital, a shift to NOT is evident: 24 / 37 (63 %) patients underwent NOT before 2000 versus 38 / 45 (84 %) after 2000 (p = 0.04). Complications following NOT were rare. Late onset bleeding did not occur. Two patients developed an infected biloma, requiring a laparotomy. Mean ICU stay before 2000 was 4.2 days (range 0 – 25 days) and 2.6 days (range 0 – 17 days) after 2000. Total hospital time did not decrease: 14 days (range 1 – 39 days) before 2000 and 14 days (range 1 – 60 days) after 2000. The overall mortality was 8 %. All deaths occurred in the operative group and were spread evenly over both periods.

Conclusion: In blunt paediatric liver trauma, the incidence and trauma mechanism seem age-related. A shift to NOT is found in the treatment of paediatric blunt hepatic trauma. NOT is the preferred treatment for the haemodynamically stable patient. Complications are rare and the success rate is 96%. The mean ICU stay has decreased but the total admission time could possibly be shortened.
INTRODUCTION

Blunt liver injury is associated with high energy trauma or violent compression of the abdominal or thoracic wall. Several studies have shown that the majority are caused by traffic accidents\(^\text{13,14}\). Little is known about the relation between mechanism of injury and severity of injury in the different age groups in the Dutch paediatric population.

Over the last decades the treatment of paediatric traumatic hepatic injury has shifted from operative treatment (OT) to non-operative treatment (NOT). In 2000, the American Pediatric Surgical Association (APSA) recommended evidence-based guidelines for the management of haemodynamically stable patients with isolated liver or spleen injuries\(^\text{7,4}\) (Tables 1, 2). These guidelines consisted of recommendations concerning observation time in the Intensive Care Unit, total admission time and the necessity of radiological imaging. All were related to the grade of injury as defined by computed tomography (CT) scanning. Subsequently, our unit gradually adapted to these guidelines, although the internal debate on admission time and obligatory bed rest continued.

The purpose of this study is to determine the demographic parameters of paediatric liver injury in our hospital and secondly to audit and possibly improve the current treatment of paediatric liver injury, taking the guidelines and literature into consideration.

Table 1: Treatment of liver injuries according to the APSA guidelines\(^3\)

<table>
<thead>
<tr>
<th>Grade I injury</th>
<th>Grade II injury</th>
<th>Grade III injury</th>
<th>Grade IV injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU stay</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Pre discharge imaging</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Post discharge imaging</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Activity restriction (weeks)</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 2: CT grading of liver injury

| Grade I: | Laceration(s) < 1 cm deep  
| Subcapsular haematoma < 1 cm diameter |
| Grade II: | Laceration(s) 1-3 cm deep  
| Subcapsular or central haematoma 1-3 cm diameter |
| Grade III: | Laceration(s) 3-10 cm deep  
| Subcapsular or central haematoma 3-10 cm diameter |
| Grade IV: | Laceration(s) > 10 cm deep  
| Subcapsular or central haematoma > 10 cm diameter  
| Lobar maceration or devascularization |
| Grade V: | Bilobar tissue maceration or devascularisation |
PATIENTS AND METHODS

The UMCG is a level 1 trauma centre in the northern part of the Netherlands. A retrospective analysis was performed of all patients aged 18 years and younger who were admitted to our hospital in the last 18 years (1990 – 2008) with blunt abdominal trauma causing hepatic injury as demonstrated on ultrasound and / or CT-scan. Patients were identified using a comprehensive prospective trauma registry, in which age, sex, trauma mechanism and sustained injuries are included.

To investigate the relation between age and the different mechanisms of injury, 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). Main outcome measures were: Injury Severity Score, trauma mechanism, length of stay in the ICU and in hospital, and the success of non-operative treatment. Injury severity was calculated using the Injury Severity Score (ISS) based on the Abbreviated Injury Scale (AIS) and assessing all associated injuries. Haemodynamic parameters on admission (blood pressure, pulse rate and haemoglobin levels) were retrieved from the charts.

The indication to perform a laparotomy was subjective, based on the attending surgeon’s assessment of haemodynamic stability. The treatment, including all surgical events, complications that occurred during admission, length of ICU stay, total hospital admission time and mortality were assessed. Subsequently the group was divided in two groups, those treated before and those treated after the publication of the APSA guidelines in the year 2000.

Statistical calculations were performed using the SPSS 14.0 statistical software package. For continuous variables Student’s t-test or Mann Whitney U-test was used as appropriate, for categorical variables the Chi square or Fisher’s exact tests were used. p-values < 0.05 were considered statistically significant.

RESULTS

Patient characteristics and injury mechanism Eighty children, 52 boys (65 %) and 28 (35 %) girls were admitted to our hospital with radiographically confirmed liver injury. The mean age was 12 years, ranging from 2 to 18 years. Isolated liver injury was found in 30 children (38 %) whereas 50 (62 %) had sustained associated injuries. 28 (35 %) children sustained fractures of long bones, additional abdominal or visceral injuries were found in 25 patients (31 %). Injuries to the chest occurred in 24 patients (30 %). Neurological or head trauma was found in 18 (23 %) children. All these injuries resulted in a mean ISS score of 18 with a range of 4 – 57.

Bicycle accidents accounted for most of the injuries (n = 20, 25 %), followed by car accidents (n = 16, 20 %). Pedestrians struck by vehicles and motorcycle accidents accounted
for injuries in 12 patients (15%). An overview of the different trauma mechanisms is provided in Fig. 1. Although there is a clear relation between age and the mechanism of injury, there is no significant difference between ISS scores in the different age groups.

**Operative treatment**

In 25 cases (31%) a laparotomy was performed due to clinical signs of circulatory instability. Patients undergoing a laparotomy had a significantly higher ISS compared with patients treated non-operatively (27 [range 4–57] versus 16 [range 4–50], p < 0.001).

In 19 of 25 cases the laparotomy was performed because of the liver injury, in 6 cases because of other visceral injuries. Packing of the liver was performed in 12 patients; topical haemostatic agents (including the use of sutures) were used in nine. One patient underwent a segmental resection in the acute phase. For the surgical group the mean ICU admission period was 7.2 days (range 0 – 25 days) and the mean total admission time was 19 days (range 1 – 46 days). Complications in the surgical group consisted of bile leakage (n = 2), abdominal compartment syndrome (n = 1), acute respiratory distress syndrome and / or multiorgan failure (n = 9). Rebleeding occurred in one patient. Eight patients underwent one or more re-laparotomies. One late bleeding occurred 10 days after admission: a child

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**Figure 1: Trauma mechanism in the age groups**

![Trauma mechanism in the age groups](image-url)
in the surgical group fell out of the hospital bed and had to undergo a relaparotomy for 
haemostasis because of rebleeding from the liver. 
Overall mortality was 8 %. All deaths occurred in the operative group. One patient exsan-
guinated in the operating room, two patients died of severe concomitant neuro-trauma, 
one patient developed irreversible pulmonary oedema and two patients succumbed to 
multi-organ failure. 

Non-operative treatment 
In total, 55 children (69 %) were considered haemodynamically stable enough by the at-
tending surgeon to undergo NOT. In the NOT group complications occurred in ten patients, 
including bowel obstruction (n = 1), pneumonia (n = 2), deep venous thrombosis (n = 1), 
syndrome of inappropriate antidiuretic hormone (n = 1) and urinary tract infection (n = 1). 
Late onset bleeding did not occur. Two patients required a laparotomy at seven and nine 
days after injury, respectively. Both patients developed an infected biloma which could 
not be managed by percutaneous drainage alone. In both patients, symptoms developed 
within the first 48 h of admission. Segmental resection was eventually unavoidable to halt 
the persistent bile leakage. In the NOT group the mean ICU admission was 2.0 days (range 
0 – 10 days) and the total admission time was 11.9 days (range 1 – 60 days). Overall, NOT 
was successful in 53 / 55 cases (96%). 
The percentage of patients who were given NOT was significantly higher in the period after 
the year 2000, compared to the period before 2000 (63% versus 84%; p = 0.04) There 
was no significant difference in haemodynamic parameters or mean ISS scores between 
patients treated before and after 2000, illustrating that, in similar patient groups, a differ-
ent treatment philosophy was chosen by the surgical team caring for the patient in favor 
of the NOT after 2000. 

Admission time before and after 2000 
The mean ICU stay of the group before 2000 was 4.2 days (range 0 – 25 days) and 2.6 days 
(range 0 – 17 days) after 2000. Total hospital time did not decrease: 14 days (range 1 – 39 
days) before 2000 and 14 days (range 1 – 60 days) after 2000 (see Table 3 ). 

| Table 3: Clinical parameters (Mean – range) parameters in the different periods. |
|-----------------------------------------------|-----------------|-----------------|
|                                 | Period < 2000   | Period > 2000   |
| Blood pressure (diast)             | 80 (35-95)      | 70 (40-92)      |
| Blood pressure (syst)              | 120 (90-170)    | 120 (80-145)    |
| Pulse                             | 100 (68-176)    | 90 (50-130)     |
| Age                               | 13.5 (4-18)     | 11.0 (2-18)     |
| ISS-score                         | 16.5 (4-57)     | 16.0 (4-41)     |
| Hb (mmol/l)                       | 7.3 (4.0-9.1)   | 7.2 (4.1-9.2)   |
DISCUSSION

Trauma is the number one cause of death in children worldwide, even in the relatively traffic safe countries of Western Europe\textsuperscript{1,9,14}. Internationally, most injuries are caused by traffic injuries. This was no different in the present study population. We observed different incidences in the mechanisms of injury for the different age groups. A few injury types remained stable throughout the age groups, for example the car accidents, falls or injuries caused by animals. The bicycle injuries mainly cause injury to children learning to ride their bikes and were therefore specifically represented in the group aged 6 – 10 years. This might be a typically Dutch phenomenon. One could also imagine that the significant increase in motorcycle accidents in the eldest group could be caused by reckless driving by young drivers, unaware of their vulnerability on the motorbike. In roughly two thirds of the present population, the liver injury was associated with substantial other injuries, making it a heterogeneous but also severely injured group of patients.

Fluid resuscitation alone is often sufficient to stabilise children haemodynamically, which is different from the adult patient with severe haemodynamic instability. Therefore NOT might be more beneficial in the paediatric population\textsuperscript{3,14}. Over time, the treatment of paediatric blunt hepatic injury changed from conservative treatment to aggressive operative treatment at the beginning of the last century, only to return to non-operative treatment where possible by the end of the century\textsuperscript{2}. To assess the impact of the APSA guidelines and audit the outcomes in our hospital, patients were divided into two groups, one group of patients admitted before 2000 and one group admitted after 2000.

We observed a significant shift from operative to non-operative treatment over time, whilst the patient characteristics for both groups did not differ in terms of haemodynamic parameters or injury severity. Since no rigid protocol regarding haemodynamic stability was used, the indication for operative treatment still depended on the attending surgeon’s (subjective) assessment of haemodynamic stability. The severity of injury as assessed by CT-scan is known to be associated with an increasing frequency of blood transfusion but does not correlate with the need for surgery\textsuperscript{2,6}. We endorse the theory that there is a poor correlation between grade of injury based on CT images and the success-rate of NOT. Hence the CT-scan was used as a diagnostic rather than a prognostic tool and treatment decisions were not made based on CT findings but on clinical grounds\textsuperscript{11}. In 19 / 25 patients the decision to perform a laparotomy was based on haemodynamic instability due to liver injury, while 6 patients underwent a laparotomy for other reasons. The APSA guidelines in combination with the emerging results for non-operative treatment in the adult population support a policy of watchful waiting. In our series this is confirmed by the increase in the number of patients managed non-operatively over time despite the fact that haemodynamic parameters on admission were similar.
Based on the present data, the non-operative treatment of haemodynamically stable paediatric patients with liver injury seems safe: complications are rare and in the present series, the success rate of NOT is 96 % which is in accordance with the literature\(^6,5,8,10,12,14,15\). Late-onset bleeding did not occur in our population. Both patients who required a laparotomy due to persistent bile leakage showed signs of deterioration within 48 h after admission. Our treatment philosophy has gradually shifted from early operation to non-operative treatment and watchful waiting. Although this basic change did decrease our ICU observation times, the total hospital time did not change. In our hospital patients with a proven injury to the parenchymatous organs were often hospitalized for at least ten days. Interestingly, this is not in accordance with the APSA guidelines. Possible explanations are the doubt concerning the predictive value of grading by CT images only and the fear of late onset rebleeding. Maybe the time has come to shorten the admission time in non-operatively treated patients, because surgical intervention appears not to be necessary when the first three days post trauma are uneventful\(^4,11\). This could lead to an even more profound change in the philosophy of the multidisciplinary team treating these patients.

**CONCLUSION**

In this retrospective study of paediatric blunt liver injury, the incidence and injury mechanism were found to be age-related. Most cases of liver injury were caused by traffic, with bicycle injuries especially prevalent in the patient group aged 6 – 10 years. A shift to non-operative treatment was found over time, paralleled by a decrease in the mean ICU stay. However the total admission has not decreased significantly. There were no severe late onset complications in the NOT group. As the incidence of complications is low and success rates are over 95 %, non-operative treatment is the preferred treatment for the haemodynamically stable patient. The total hospitalization time in our hospital could further be shortened, as late complications are rare.
REFERENCES
