

# Nonoperative Management of Blunt Hepatic and Splenic Injury in Children

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## Objective

The authors assessed the risks of nonoperative management of solid visceral injuries in children (age range, 4 months-14 years) who were consecutively admitted to a level I pediatric trauma center during a 6-year period ending in 1991.

## Method

One hundred seventy-nine children (5.0%) sustained injury to the liver or spleen. Nineteen children (11.2%) died. Of the 160 children who survived, 4 received emergency laparotomies; 156 underwent diagnostic computer tomography and were managed nonoperatively. The percentage of children who were successfully treated nonoperatively was 97.4%. Delayed diagnosis of enteric perforations occurred in two children. Fifty-three children (34.0%) received transfusions (mean volume 16.7 mL/kg); however, transfusion rates during the latter half of the study decreased from 50% to 19% in children with hepatic injuries, despite increasing grade of injury, and decreased from 57% to 23% in the splenic group with similar injury grade ( $p < 0.005$ , chi square test and Student's  $t$  test).

## Conclusion

Pediatric blunt hepatic and splenic trauma is associated with significant mortality. Nonoperative management based on physiologic parameters, rather than on computed tomography grading of organ injury, was highly successful, with few missed injuries and a low transfusion rate.

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It is common practice to forgo operative management of pediatric blunt hepatic and splenic injuries for more expectant therapy based on the physiologic status of the child rather than the anatomic nature of the injury. Previous reports have confirmed the efficacy of this approach,<sup>1-6</sup> but concerns remain about the ability of radiologic imaging to provide a diagnosis of all intraabdominal injuries. In addition, because of the growing

concern of transmitting diseases through the use of blood products, many question whether nonoperative management results in excessive transfusion rates. In an attempt to answer these questions and to examine the overall efficacy of treating blunt hepatic and splenic injuries in children nonoperatively, a review of our most recent experience was undertaken.

## PATIENTS AND METHODS

The Children's National Medical Center (CNMC) is a level I trauma center for the District of Columbia and adjacent counties in Maryland and Virginia. Our data

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were compiled from the CNMC Trauma Registry and were based on all patients aged 4 months to 14 years who were consecutively admitted to our center with blunt abdominal trauma between September 1985 and March 1991. These data included those who were declared dead on admission. Children were evaluated for urgent laparotomy or nonoperative management based on initial physiologic parameters and their response to advanced trauma life support management protocols established for the treatment of pediatric blunt trauma. If a child demonstrated hemodynamic instability on admission, Ringer's lactate solution was administered. If circulatory dysfunction persisted after administration of two 20-mL/kg boluses of crystalloid solution, blood transfusion at 10 mL/kg of body weight was initiated. If hemodynamic instability continued after transfusion of more than 40 mL/kg of packed erythrocytes, surgical hemostasis was undertaken. Children in stable condition who responded to resuscitative efforts underwent computed tomography (CT) examination, with 1-cm intervals from the diaphragm to the pubic symphysis. Intravenous contrast material was administered at 3 mL/kg of body weight. Oral contrast material was not used routinely. All children also underwent routine radiologic examination of the cervical spine, chest, and pelvis, with additional films obtained based on suspicion of injury. Hepatic injury was graded according to the organ injury scale adopted by the American Association for the Surgery of Trauma<sup>7</sup> (Table 1). Splenic injury was classified according to an assessment of the percentage of organ volume involved by laceration or hematoma—grade 1 injury (<25%), grade 2 (25%–50%) or grade 3 (>50%). The presence or absence of peritoneal fluid was noted in the perisplenic space, perihepatic space, left and right pericolic spaces, lateral paravesical fossae, and pouch of Douglas. Fluid found in only one of these spaces was classified as small, whereas fluid in two or more spaces was classified as moderate. If all spaces were distended with fluid, or if fluid in the pelvis extended anterior and superior to the bladder, the amount was classified as large.<sup>8</sup>

Children treated nonoperatively were placed on strict bed rest in a monitored setting with serial hemoglobin analyses. If the hemoglobin remained stable and the associated injuries permitted, the patient would be transferred to a regular ward bed for continued observation. Follow-up CT scans to verify complete solid organ healing were obtained at 3 months after mild injuries, 3 to 6 months after moderate injuries, and 9 months after severe injuries.<sup>9</sup> Because there was no evidence to verify that partial healing was adequate for the child to resume full activities, we waited for complete resolution of the injury on follow-up CT scans before return to unrestricted activity.

Demographic data were recorded at time of admis-

**Table 1. HEPATIC INJURY SCALE**

Grade*	Injury Description†
I	
Hematoma	Subcapsular, nonexpanding, <10% surface area
Laceration	Capsular tear, nonbleeding, <1 cm parenchymal depth
II	
Hematoma	Subcapsular, nonexpanding, 10–50% surface area intraparenchymal, nonexpanding, <2 cm in diameter
Laceration	Capsular tear, active bleeding, 1–3 cm parenchymal depth, <10 cm in length
III	
Hematoma	Subcapsular, >50% surface area or expanding; ruptured subcapsular hematoma >2 cm or expanding
Laceration	>3 cm parenchymal depth
IV	
Hematoma	Ruptured intraparenchymal hematoma with active bleeding
Laceration	Parenchymal disruption involving 25–50% of hepatic lobe
V	
Laceration	Parenchymal disruption involving >50% of hepatic lobe
Vascular	Juxtahepatic venous injuries; <i>i.e.</i> , retrohepatic vena cava/major hepatic veins
VI	
Vascular	Hepatic avulsion

\* Advance one grade for multiple injuries to the same organ.

† Based on most accurate assessment at autopsy, laparotomy, or radiologic study.

sion. Injury Severity Scores<sup>10,11</sup> and Revised Trauma Scores<sup>12,13</sup> were determined according to previous guidelines. The outcome of nonoperative management, transfusion requirements, and the frequency of missed injuries were tabulated. Statistical analysis (chi square test and Student's *t* test) was used to compare mean organ injury score and transfusion requirements between the first 3 years and the latter 3 years of the study.

## RESULTS

From September 1985 to March 1991, 3577 children (age range, 4 months–14 years) sustained blunt trauma necessitating admission to CNMC. More than 90% of their injuries resulted from motor vehicle accidents. The median age was 7 years. One hundred seventy-nine (5.0%) children sustained injury to the liver or spleen (94 liver; 77 spleen; 8 both). The mean Injury Severity Score was 15.3; the mean Revised Trauma Score was 13.7. Nineteen children died (11.2%). Nine deaths were central nervous system related, with one due to pulmonary failure. Six children were dead on admission. The exact cause of death was unclear, but a significant hemoperitoneum was present in all at autopsy.

Three children died of hemorrhagic shock despite operative attempt to control bleeding. Of 160 surviving

**Table 2. COMPUTED TOMOGRAPHY GRADING OF HEPATIC AND SPLENIC INJURY**

Hepatic		Splenic	
Injury Grade	No. of Patients	Injury Grade	No. of Patients
I	25	I	30
II	17	II	28
III	9	III	14
IV	21		
V	12		
Total	84		72

children, 4 were treated with emergency laparotomies (2 hepatorrhaphy, 1 splenorrhaphy, 1 splenectomy).

One hundred fifty-six children underwent diagnostic CT scans and were managed nonoperatively; 84 had hepatic injury, and 72 had splenic injury. Three children with injury to both liver and spleen were categorized by the organ with the higher injury severity score. One hundred fifty-two children (97.4%) were successfully treated nonoperatively. The CT scan grading of liver and splenic injury is shown in Table 2. The mean hepatic injury score was 2.73. Forty-eight children (57%) with hepatic injury had free intraperitoneal fluid (20 small, 15 moderate, and 13 large). The mean injury grade for splenic trauma was 1.77, with free fluid present on CT scan in 59.7% of splenic injuries (18 small, 12 moderate, and 13 large).

Nonoperative management failed in four children. Recurrent bleeding in a 3-year-old boy necessitated operative intervention on postinjury day 7, when a devitalized gallbladder was found adjacent to a bleeding site. In another boy 4 years of age, exploratory laparotomy for recurrent fever and abdominal pain resulted in resection of a necrotic right hepatic lobe. The other two failures were in the splenic injury group (children 5 and 14 years of age), in which delayed diagnosis of small intestinal perforation required laparotomy, intestinal resection, and primary anastomosis. There were no long-term sequelae from these delays in diagnosis and treatment.

Overall, 53 children (34.0%) received transfusions (mean volume 16.7 mL/kg). In 27 children, transfusion was limited to a single donor exposure. Transfusion rates since 1988 have been reduced to 21.3%, despite similar (spleen) or increasing (liver) mean organ injury scores (Table 3).

## DISCUSSION

Historically, operative therapy is the generally accepted method of treatment for pediatric blunt hepatic

**Table 3. TRANSFUSION RATES IN PEDIATRIC BLUNT HEPATIC AND SPLENIC INJURIES**

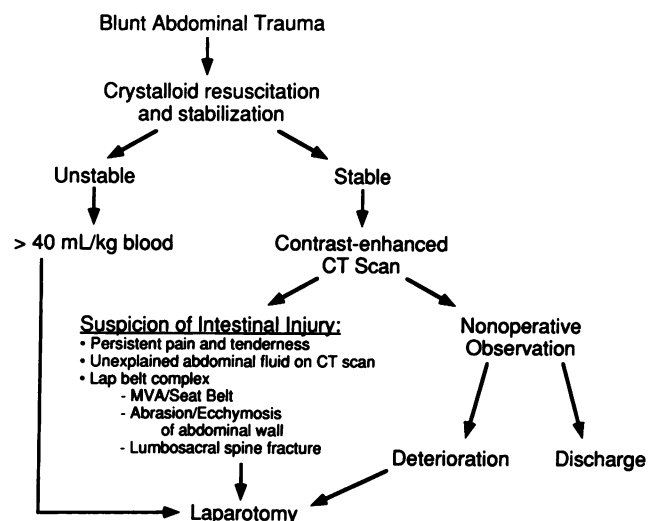
	Liver Injuries		Splenic Injuries	
	1985-1987	1988-1991	1985-1987	1988-1991
No. of patients	36	48	26	46
Mean organ injury score (OSS)	2.36	3.02*	1.88	1.71
No. (%) transfused	18 (50%)	9 (19%)†	15 (57%)	11 (23%)†

\* Mean OSS is significantly higher vs. 1985-1987 ( $p < 0.05$ ,  $t$  test).

† The 1988-1991 transfusion rate is significantly lower vs. 1985-1987 ( $p < 0.005$ , chi square test).

or splenic injury. The advantages are accurate assessment of solid and hollow visceral injury, coupled with prompt, expedient repair. However, between 20% and 67% of these injuries will stop bleeding spontaneously at the time of laparotomy.<sup>1</sup> This finding, coupled with reports of postsplenectomy sepsis,<sup>14,15</sup> led to the development of selective nonoperative management of splenic injuries in children. This approach is safe and effective, and lowers the incidence of splenectomy.<sup>5,6</sup> Subsequently, it was shown that blunt hepatic injuries can be treated nonoperatively with similar success.<sup>2-4</sup> An algorithm that describes our approach to blunt liver and spleen injuries is shown in Figure 1.

The data from this experience support the use of selective nonoperative management in the treatment of pediatric blunt hepatic and splenic injuries. The overall efficacy rate of 97.4% is consistent with other large studies of liver<sup>2-4</sup> and splenic trauma.<sup>5,6</sup>



**Figure 1.** Algorithm for pediatric blunt abdominal trauma.

Treatment failures were caused by continued hepatic bleeding, segmental liver necrosis, and missed diagnosis of bowel perforation. Serial examination in detecting these injuries is imperative. The initial examination can be misleading because of the patient's altered sensorium or from solid visceral pain masking a hollow viscus perforation. Also, CT scan will only show free air in one third of children with bowel perforation.<sup>16</sup> Free intraperitoneal fluid can assist in the diagnosis of intestinal perforation, but CT scan cannot differentiate succus entericus from blood extravasated from a hepatic or splenic injury. Fever, leukocytosis, abdominal tenderness remote from the known injury site, and subtle remote organ dysfunction suggest an occult injury. Peritoneal lavage may benefit children with equivocal findings. However, gross blood found on lavage is of little significance, as indicated in our series; 57% of the children with hepatic injury and 59% with splenic injury had free fluid evident on CT scan. These children would have had grossly positive peritoneal aspirations, yet only 4 children of 91 with free fluid on CT scan required operation. We do not routinely use oral contrast medium in our routine abdominal trauma scans. In a previous study<sup>17</sup> from this institution on lap belt injuries, the five children who were later found to have intestinal injury had their CT examinations repeated with oral contrast medium within 24 hours of their admission. The second examination did not provide any evidence to support a hollow viscous injury. We know of no data that conclusively indicate that intraluminal contrast enhances the CT diagnosis of intestinal injury.

A major concern with nonoperative management is the increased transmission of bloodborne diseases. In our series, 53 children (34.0%) received transfusions of blood. Since 1988, however, transfusion rates have decreased to 21.3% because of an increasing comfort level with nonoperative management of pediatric blunt hepatic and splenic injury, and greater awareness of the risks associated with blood product transfusion. This has been evident in the tolerance of lower hematocrit levels before considering transfusion therapy. Provided that the child remains physiologically stable, we tolerate hemoglobin levels of 7 g/dL without transfusion. In some instances, there is ample time to allow for donor-directed transfusion. We also try to limit the number of donor exposures because it correlates more closely with the risk of disease transmission than amount transfused. In this current series, approximately 50% of transfused children received blood from a single donor.

## CONCLUSION

During a 6-year period, 179 children were treated for blunt hepatic or splenic injury at CNMC. The overall

mortality rate was 11.2%. One hundred fifty-six children were selected for nonoperative management, with success in 97.4%. Delayed diagnosis of intestinal injury occurred in two children. Nonoperative management, coupled with increased awareness of transfusion-related disease, reduced our overall transfusion rate to 21.2% in the latter half of the study, despite increasing (hepatic) or similar (splenic) organ injury scores. Sequential physical examination continues to be essential in the selection of children for exploratory laparotomy.

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