Blunt Spleen and Liver Trauma

Brian G. A. Dalton[1] Jeff J. Dehmer[1] Katherine W. Gonzalez[1] Sohail R. Shah[1]

[1] Department of Surgery, Children's Mercy Hospital and Clinics, Kansas City, Missouri, United States

Address for correspondence Sohail R. Shah, MD, MSHA, Department of Surgery, Children's Mercy Hospital and Clinics, 2401 Gillham Road, Kansas City, MO 64108, United States (e-mail: sohailshahmd@gmail.com).

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Abstract

Blunt abdominal trauma is an important cause of pediatric morbidity and mortality. The spleen and liver are the most common abdominal organs injured. Trauma to either organ can result in life-threatening bleeding. Controversy exists regarding which patients should be imaged and the correct imaging modality depending on the level of clinical suspicion for injury. Nonoperative management of blunt abdominal trauma is the standard of care for hemodynamically stable patients. However, the optimal protocol to maximize patient safety while minimizing resource utilization is a matter of debate. Adjunctive therapies for pediatric spleen and liver trauma are also an area of ongoing research. A review of the current literature on the diagnosis, management, and follow-up of pediatric spleen and liver blunt trauma is presented.

Keywords

- blunt abdominal trauma
- spleen injury
- liver injury
- hepatic injury
- pediatric
- nonoperative management
- angioembolization

Introduction

Trauma is the leading cause of death in children older than 1 year of age and blunt trauma is the most common mechanism. The spleen and liver account for approximately 70% of all visceral injuries caused by blunt trauma, by far the most commonly injured intra-abdominal organs.[1] Injury severity of spleen and liver injury is graded by the American Association for the Surgery of Trauma injury scoring scale and is shown in ►**Tables 1** and **2**. The primary goals after blunt splenic or hepatic injury are patient stabilization and organ function preservation. Over the last 50 years, the standard of care for spleen and liver injuries has shifted to nonoperative management. Guidelines for management of the spleen and liver trauma have been proposed.[2] Modifications and challenges to this protocol have certainly been made. A review of current evidence is presented here to show current strategies for diagnosis and management of blunt hepatic and splenic trauma in the pediatric population.

Diagnosis

Abdominal computed tomography (CT) is highly sensitive, specific, and readily available for expedient diagnosis of hepatic and splenic injury.[3,4] CT is the best imaging modality to perform when suspicion for intra-abdominal injury exists. CT has a negative predictive value (NPV) near 100% for solid organ injury.[5] However, with the significant expense and exposure to radiation, there has been an effort to minimize the use of CT. Children are at especially high risk with regards to radiation-induced malignancies.[6] For this reason, algorithms have been designed to identify those patients at high and low risk for intra-abdominal injury thereby guiding abdominal CT usage while reducing unnecessary radiation exposure. In a recent series of 125 pediatric patients, after blunt trauma 97 patients underwent abdominal/pelvic CT. A total of 17 of these patients were found to have intra-abdominal injury. The model proposed (a group of parameters combining examination, vitals, X-ray findings, and laboratory values, see ►**Table 3**) would have predicted 16 of these injuries, only missing a grade I spleen injury.[3] Another series of 99 patients incorporated abdominal ultrasound along with examination, vitals and laboratory values and arrived at an NPV of 97% and a specificity of 84%.[7] This protocol was further validated in a subsequent study.[8] A large prospective trial that used only history and physical examination findings identified patients at very low risk for intra-abdominal injury, and therefore would not need an

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Table 1 Spleen injury scale

Grade	Injury type	Description of injury
I	Hematoma	Subcapsular, < 10% surface area
II	Laceration	Capsular tear, < 1 cm parenchymal depth
	Hematoma	Subcapsular, 10–50% surface area, intraparenchymal, < 5 cm in diameter
III	Laceration	Capsular tear, 1–3 cm parenchymal depth that does not involve a trabecular vessel
	Hematoma	Subcapsular, > 50% surface area or expanding; ruptured subcapsular or parenchymal hematoma, intraparenchymal hematoma ≥ 5 cm or expanding
IV	Laceration	> 3 cm parenchymal depth or involving a trabecular vessel
	Laceration	Laceration involving segmental or hilar vessels producing major devascularization (> 25%)
V	Laceration	Completely shattered spleen
	Vascular	Hilar vascular injury that devascularizes spleen

Table 2 Liver injury scale

Grade	Injury type	Description of injury
I	Hematoma	Subcapsular, < 10% surface area
	Laceration	Capsular tear, < 1 cm parenchymal depth
II	Hematoma	Subcapsular, 10–50% surface area, intraparenchymal, < 10 cm in diameter
III	Hematoma	Subcapsular, > 50% surface area or expanding; ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma ≥ 10 cm or expanding
	Laceration	> 3 cm parenchymal depth or involving a trabecular vessel
IV	Laceration	Parenchymal disruption involving 25–75% of hepatic lobe or 1–3 Couinaud segments in a single lobe
V	Laceration	Parenchymal disruption involving > 75% of hepatic lobe or > 3 Couinaud segments within a single lobe
	Vascular	Juxtahepatic venous injuries
VI	Vascular	Hepatic avulsion

abdominal CT.[9] While ultrasound and clinical examination are not quite as sensitive as CT using these algorithms, or other similar protocols, may help guide selective and efficient use of CT in suspected abdominal trauma.

Focused assessment sonography for trauma (FAST) has been used as an adjunct for diagnosis in both adult and pediatric trauma patients. A series of 107 pediatric trauma patients with suspected abdominal injury underwent FAST scan and a subsequent CT abdomen/pelvis for comparison. This study revealed 20 false negatives, but only 2 false positives.[10] A similar study performed in 359 adults resulted in a sensitivity of 42%, specificity of 98%, and an NPV of 93%.[11] Another series of 357 patients investigating FAST to determine clinically important free fluid in pediatric patients

Table 3 High-risk clinical variables for intra-abdominal injury

Hypotension for age
Abnormal abdominal examination (distention, tenderness to palpation, peritonitis, contusion)
Aspartate aminotransferase > 200 U/L
Amylase > 100 U/L
Microhematuria > 5 erythrocyte/high power field
Hematocrit < 30%
Abnormal chest radiograph (e.g., rib, clavicle, or scapular fracture)

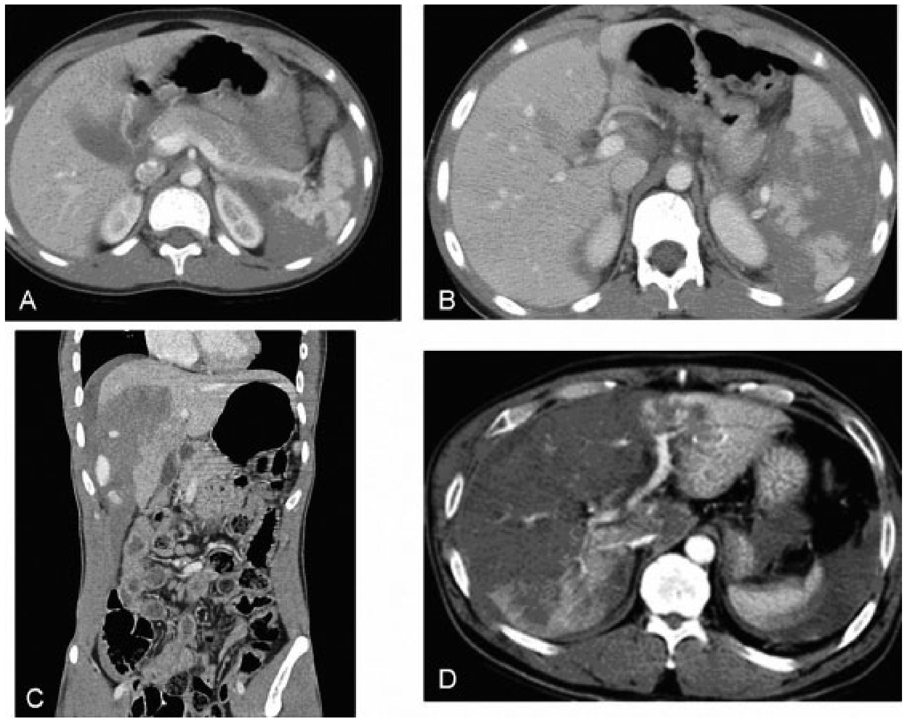

Fig. 1 Computed tomography representation of high-grade splenic and liver lacerations: (A) Grade IV splenic laceration, (B) grade V splenic laceration, (C) grade IV hepatic laceration, (D) grade V hepatic laceration.

resulted in a sensitivity of 52% and specificity of 96%.[12] A more recent series of 400 pediatric trauma patients combined FAST and measurement of liver transaminases resulted in a sensitivity of 50%, specificity of 98%, and an NPV of 96% for the detection of intra-abdominal injuries.[13] Given the low sensitivity of FAST its utility as a screening test has been called into question for hemodynamically stable pediatric patients.[10,11,14] Our current practice is to obtain a CT abdomen/pelvis on any patient with a high degree of suspicion for intra-abdominal injury given abnormal physical examination, abnormal laboratory values or other radiologic studies. We do not routinely utilize FAST as a screening tool.

Management

Nonoperative versus Operative Management

Nonoperative management of solid organ injury was first suggested in the early 1948 at the Hospital for Sick Children.[15] Initial concerns regarding this approach centered on the need for increased blood transfusion, but concerns for postsplenectomy sepsis ultimately outweighed these concerns.[16,17] Although it has taken almost 20 years since this initial report for surgeons to realize the benefits of solid organ preservation in the face of traumatic injury, nonoperative management of these injuries in children and adults has become universally accepted. Overall, nonoperative management has been successful in greater than 90% of patients, with splenic salvage rate of greater than 95%, decreased blood transfusions and a low complication rate of less than 4%.[18–21] Even high-grade injuries (grade $\geq$ 4, see ►**Fig. 1**) have been shown to be successfully managed by a nonoperative approach.[21,22] Operative management has been restricted to hemodynamically unstable patients not responsive to resuscitation efforts.

Guidelines have been proposed for the nonoperative management of blunt splenic and hepatic trauma in children by the American Pediatric Surgery Association (APSA) trauma committee. ►**Table 4** shows the proposed guidelines for resource utilization in pediatric spleen and liver trauma.[2] These guidelines serve as a common starting point for the management of pediatric solid organ injury, and have resulted in excellent results.[21] However, recent series have challenged certain aspects of these guidelines.[23–26] One prospective series of 110 patients examined an abbreviated bed rest protocol (ABRP) for spleen or liver injury. This protocol specifies one night of bed rest for grades I to II and two nights of bed rest for grade $\geq$ III. This study resulted in a mean length of stay (LOS) of 2.2 versus 3.6 days when the APSA guidelines were followed. Abdominal operations were performed in only three patients (2.3%) and the splenic salvage rate was 98.7%. After discharge from the hospital, the only activity restrictions were a 6 week omission from contact sports. No patients were readmitted for complications of solid organ injury.[25] A follow-up study to this prospective trial validated the results in 199 patients and again found no readmissions related to solid organ injury and no instances of bile leak or other splenic or hepatic-related complication.[26] Based on LOS data ABRP compared with APSA guidelines were theorized to potentially save over 9,000 hospital days/y and over $19 million annually if applied nationally.[27] We currently use the ABRP to guide length of bed rest orders, and recommend only restriction from contact sports for activity limitations.

Table 4 Proposed guidelines for resource utilization in children with isolated spleen or liver injury

Computed tomography grade	I	II	II	IV
Intensive care unit days	0	0	0	1
Hospital days	2	3	4	5
Predischarge imaging	None	None	None	None
Postdischarge imaging	None	None	None	None
Activity restriction (wk)	3	4	5	6

Intensive care unit (ICU) is recommended in the setting of grade ≥ IV injury by the APSA guidelines.[2] Other authors recommend ICU admission for patients with hemodynamic instability only, regardless of injury grade and have shown a reduction in ICU LOS without an increase in complications or operative intervention.[24,28] Our practice is to admit patients that are initially hemodynamically unstable, but responsive to resuscitation to the ICU.

Adjuncts to Nonoperative Management

Complications of blunt abdominal trauma, particularly hepatic trauma, deserve special mention. In adults, complications related to hepatic trauma have been described in 11 to 24% of patients. The most common complications are biloma, hematoma, and bile leak. The vast majority of these complications can be treated with nonoperative techniques.[29–31] In a series of 72 high-grade (IV–V) pediatric liver and spleen trauma patients, a mortality rate of 5.6% was found. All of these patients had liver injuries, but three of four had a severe head injury that was related to mortality. Only one patient (2.4%) with severe spleen injury developed a complication (pleural effusion). Five patients (17.9%) with liver injury developed complications, and all complications except one were treated with surgical adjuncts (e.g., endoscopic retrograde cholangiopancreatographic procedures, drains, transhepatic cholangiographic procedure).[32] Another review of 294 patients at a single institution found 11 patients with traumatic bile leak. All patients were treated with a combination of perihepatic drain placement and endoscopic retrograde cholangiopancreatography that resulted in resolution of bile leak within 2 weeks.[33] Another single-center pediatric study showed a correlation between elevated transaminase or alkaline phosphatase levels and development of complications.[18] This data emphasizes the need for vigilance to assess for complications in high-grade solid organ injury, especially hepatic trauma.

Angioembolization

The role for angioembolization (AE) as a treatment for arterial hemorrhage solid organ injury unresponsive to resuscitation has been well described in adults since the 1990s.[34] In adults the blush sign or contrast extravasation (CE), indicating ongoing arterial hemorrhage, has been shown to predict nonoperative failure and is an indication for angiography in many centers.[35] The role of AE in the pediatric population is less well defined. In a series of 86 pediatric abdominal CT available for review after blunt abdominal trauma, 6 were found to have CE associated with a splenic injury. Only one of six children required surgical intervention.[36] In another series of 123 pediatric patients with splenic injury, 8 were found to have CE on CT. None of these patients required intervention and patients with CE did not have a higher transfusion requirement or mortality.[37] In contrast to this, a meta-analysis of pediatric spleen and liver injury revealed a lower failure rate of nonoperative management when AE was used a treatment option.[38] In a recent single-center study of 259 pediatric patients with splenic trauma, 15 patients were treated with AE as the primary treatment and 8 patients were treated with AE after failure of observation. Only 1 patient of the 23 treated with AE subsequently underwent splenectomy and there were no deaths or other complications.[39] However, the main indication for AE as treatment was CE and as outlined above, this indication is of questionable importance in children. Primary hepatic AE has been reporting sparsely.[40–42] Although there is a small sample size, hepatic AE may act as an adjunct to nonoperative management.

More often AE is used to treat pseudoaneurysms that develop in a delayed fashion following blunt trauma. In a retrospective series of 362 children, the overall pseudoaneurysm rate after splenic injury was found to be 5.4 and 1.7% after hepatic injury. All were associated with grade III or IV injuries. The majority (7 of 10) of splenic artery pseudoaneurysms (SAP) closed spontaneously, but all three hepatic artery pseudoaneurysms (HAP) proceeded to embolization.[43] A review of SAP found an incidence of 2 to 27% of posttraumatic patients. These patients had a high rate of intervention (75%) but a low rate of symptoms 11%.[44] Currently, there are no prospective studies in children to direct management of posttraumatic SAP or HAP.

Follow-Up

Radiologic follow-up after spleen or liver trauma in a pediatric population originally was done to assess organ healing. These radiologic tests have been able to document healing of the affected organ but have failed to consistently demonstrate an ability to detect clinically relevant complications before symptoms. Therefore, the necessity of routine follow-up, especially radiologic has been called into question.[45–49] The APSA trauma guidelines do not recommend radiologic follow-up after a large number of patients in that series had no serious complications at follow-up.[2] A prospective series in adults found six HAP in 482 patients with hepatic trauma. All of these patients developed gastrointestinal bleed before diagnosis.[50] Without a large series with consistent follow-up, it is difficult to judge the exact incidence of SAP and HAP in the pediatric population. While a recent prospective trial of 199 pediatric found no complications at 10 week posthospital,[26] there have been reports of spontaneous rupture of SAP and HAP in the pediatric population.[43,44] We do not currently perform any routine in-hospital or postdischarge imaging in the absence of symptoms.

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