Blunt Spleen and Liver Trauma

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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

Keywords

► blunt abdominal trauma
► spleen injury
► liver injury
► hepatic injury
► pediatric
► nonoperative management
► angioembolization
abdominal CT. 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. A similar study performed in 359 adults resulted in a sensitivity of 42%, specificity of 98%, and an NPV of 93%. Another series of 357 patients investigating FAST to determine clinically important free fluid in pediatric patients

### Table 1 Spleen injury scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Injury type</th>
<th>Description of injury</th>
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<tbody>
<tr>
<td>I</td>
<td>Hematoma</td>
<td>Subcapsular, &lt; 10% surface area</td>
</tr>
<tr>
<td>II</td>
<td>Laceration</td>
<td>Capsular tear, &lt; 1 cm parenchymal depth</td>
</tr>
<tr>
<td></td>
<td>Hematoma</td>
<td>Subcapsular, 10–50% surface area, intraparenchymal, &lt; 5 cm in diameter</td>
</tr>
<tr>
<td>III</td>
<td>Laceration</td>
<td>Capsular tear, 1–3 cm parenchymal depth that does not involve a trabecular vessel</td>
</tr>
<tr>
<td></td>
<td>Hematoma</td>
<td>Subcapsular, &gt; 50% surface area or expanding; ruptured subcapsular or parenchymal hematoma, intraparenchymal hematoma ≥ 5 cm or expanding</td>
</tr>
<tr>
<td>IV</td>
<td>Laceration</td>
<td>&gt; 3 cm parenchymal depth or involving a trabecular vessel</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>Laceration involving segmental or hilar vessels producing major devascularization (&gt; 25%)</td>
</tr>
<tr>
<td>V</td>
<td>Laceration</td>
<td>Completely shattered spleen</td>
</tr>
<tr>
<td></td>
<td>Vascular</td>
<td>Hilar vascular injury that devascularizes spleen</td>
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### Table 2 Liver injury scale

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<th>Grade</th>
<th>Injury type</th>
<th>Description of injury</th>
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<tbody>
<tr>
<td>I</td>
<td>Hematoma</td>
<td>Subcapsular, &lt; 10% surface area</td>
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<tr>
<td></td>
<td>Laceration</td>
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<td>Subcapsular, 10–50% surface area, intraparenchymal, &lt; 10 cm in diameter</td>
</tr>
<tr>
<td>III</td>
<td>Hematoma</td>
<td>Subcapsular, &gt; 50% surface area or expanding; ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma ≥ 10 cm or expanding</td>
</tr>
<tr>
<td></td>
<td>Laceration</td>
<td>&gt; 3 cm parenchymal depth or involving a trabecular vessel</td>
</tr>
<tr>
<td>IV</td>
<td>Laceration</td>
<td>Parenchymal disruption involving 25–75% of hepatic lobe or 1–3 Couinaud segments in a single lobe</td>
</tr>
<tr>
<td>V</td>
<td>Laceration</td>
<td>Parenchymal disruption involving &gt; 75% of hepatic lobe or &gt; 3 Couinaud segments within a single lobe</td>
</tr>
<tr>
<td>VI</td>
<td>Vascular</td>
<td>Juxtahepatic venous injuries</td>
</tr>
<tr>
<td></td>
<td>Vascular</td>
<td>Hepatic avulsion</td>
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### Table 3 High-risk clinical variables for intra-abdominal injury

<table>
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<th>Variable</th>
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<tbody>
<tr>
<td>Hypotension for age</td>
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<tr>
<td>Abnormal abdominal examination (distention, tenderness to palpation, peritonitis, contusion)</td>
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<tr>
<td>Aspartate aminotransferase &gt; 200 U/L</td>
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<tr>
<td>Amylase &gt; 100 U/L</td>
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<tr>
<td>Microhematuria &gt; 5 erythrocyte/high power field</td>
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<tr>
<td>Hematocrit &lt; 30%</td>
</tr>
<tr>
<td>Abnormal chest radiograph (e.g., rib, clavicle, or scapular fracture)</td>
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resulted in a sensitivity of 52% and specificity of 96%. 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. Given the low sensitivity of FAST its utility as a screening test has been called into question for hemodynamically stable pediatric patients. 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. Initial concerns regarding this approach centered on the need for increased blood transfusion, but concerns for postsplenectomy sepsis ultimately outweighed these concerns. 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%. Even high-grade injuries (grade ≥ 4, see Fig. 1) have been shown to be successfully managed by a nonoperative approach. 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. These guidelines serve as a common starting point for the management of pediatric solid organ injury, and have resulted in excellent results. However, recent series have challenged certain aspects of these guidelines. 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 ≥ 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. 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. 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. We currently use the ABRP to guide length of bed rest orders, and recommend only restriction from contact sports for activity limitations.

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.
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

<table>
<thead>
<tr>
<th>Computed tomography grade</th>
<th>I</th>
<th>II</th>
<th>II</th>
<th>IV</th>
</tr>
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<tbody>
<tr>
<td>Intensive care unit days</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Hospital days</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Predischarge imaging</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Postdischarge imaging</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Activity restriction (wk)</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
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</table>
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 posthospi-
tal,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.

References
1 Tataria M, Nance ML, Holmes JH IV, et al. Pediatric blunt abdominal
injury: age is irrelevant and delayed operation is not detrimental.
J Trauma 2007;63(3):608–614
2 Stylianos S. The APSA Trauma Committee. Evidence-based guide-
lines for resource utilization in children with isolated spleen or liver
3 Streek CJ Jr, Jewett BM, Wahlquist AH, Gutierrez PS, Russell WS.
Evaluation for intra-abdominal injury in children after blunt torso
trauma: can we reduce unnecessary abdominal computed tomog-
raphy by utilizing a clinical prediction model? J Trauma Acute Care
4 Wegner S, Colletti JE, Van Wie D. Pediatric blunt abdominal
5 Richards JR, Derlet RW. Computed tomography for blunt abdomi-
16(4):338–342
6 Brenner DJ, Hall EJ. Computed tomography—an increasing source
7 Karam O, Sanchez O, Chardot C, La Scala G. Blunt abdominal
trauma in children: a score to predict the absence of organ injury.
8 de Jong WJ, Stoopker L, Nellenstein DR, Groen H, El Moumni M,
Huilscher JB. External validation of the Blunt Abdominal Trauma
In Children (BATIC) score: ruling out significant abdominal injury in
9 Holmes JF, Lillis K, Monroe D, et al; Pediatric Emergency Care
Applied Research Network (PECARN). Identifying children at very
low risk of clinically important blunt abdominal injuries. Ann Emerg
10 Coley BD, Mutabagani KH, Martin IC, et al. Focused abdominal
sonography for trauma (FAST) in children with blunt abdominal
11 Miller MT, Pasquale MD, Bromberg WJ, Wasser TE, Cox J. Not so
12 Fox JC, Boysen M, Gharabaghi L, et al. Test characteristics of
focused assessment of sonography for trauma for clinically signif-
icant abdominal free fluid in pediatric blunt abdominal trauma.
Acad Emerg Med 2011;18(5):477–482
13 Sola JE, Cheung MC, Yang R, et al. Pediatric FAST and elevated liver
transaminases: An effective screening tool in blunt abdominal
14 Scaife ER, Rollins MD, Barnhart DC, et al. The role of focused
abdominal sonography for trauma (FAST) in pediatric trauma
15 Upadhyaya P, Simpson JS. Splenic trauma in children. Surg Gyneco-
lost 1968;126(4):781–790
16 Ein SH, Shandling B, Simpson JS, et al. The morbidity and mortality
17 Balfanz JR, Nesbit ME Jr, Jarvis C, Krivit W. Overwhelming sepsis
18 Giss SR, Dobrilovic N, Brown RL, Garcia VF. Complications of
nonoperative management of pediatric blunt hepatic injury:
Diagnosis, management, and outcomes. J Trauma 2006;61(2):
334–339
19 Davies DA, Pearl RH, Ein SH, Langer JC, Wales PW. Management of
blunt splenic injury in children: evolution of the nonoperative
20 Partrick DA, Bensard DD, Moore EE, Karrer FM. Nonoperative
management of solid organ injuries in children results in de-
21 Stylianos S. Outcomes from pediatric solid organ injury: role of
23 Mehall JR, Ennis JS, Saltzman DA, et al. Prospective results of a
standardized algorithm based on hemodynamic status for man-
347–353
24 McVay MR, Kokoska ER, Jackson RJ, Smith SD. Throwing out the
“grade” book: management of isolated spleen and liver injury
1072–1076
25 St Peter SD, Sharp SW, Snyder CL, et al. Prospective validation of an
abbreviated bedrest protocol in the management of blunt spleen
26 St Peter SD, Aguayo P, Jiang D, et al. Follow up of prospective
validation of an abbreviated bedrest protocol in the manage-
2013;48(12):2437–2441
27 Dodgion CM, Gosain A, Rogers A, St Peter SD, Nichol PF, Ostlie DJ.
National trends in pediatric blunt spleen and liver injury manage-
ment and potential benefits of an abbreviated bed rest protocol.
28 Fremgen HE, Bratton SL, Metzger RR, Barnhart DC. Pediatric liver
lacerations and intensive care: evaluation of ICU triage strategies.
29 Carrillo EH, Spain DA, Wohltmann CD, et al. Interventional tech-
niques are useful adjuncts in nonoperative management of hepatic
30 Christmas AB, Wilson AK, Manning B, et al. Selective manage-
ment of blunt hepatic injuries including nonoperative manage-
ment is safe and effective strategy. Surgery 2005;138(4):606–610, dis-
cussion 610–611
31 Gourgiotis S, Vougas V, Germanos S, et al. Operative and nonoper-
ative management of blunt hepatic trauma in adults: a single-
32 Yang JC, Sharp SW, Ostlie DJ, Holcomb GW III, St Peter SD. Natural
history of nonoperative management for grade 4 and 5 liver and
33 Kulaylat AN, Stokes AL, Engbrecht BW, McIntyre JS, Rzucidlo SE,
Cilley RE. Traumatic bile leaks from blunt liver injury in children: a
multidisciplinary and minimally invasive approach to manage-
nonoperative management rate can be achieved with selective embolization.
J Trauma 2004;56(5):1067–1072
35 Olthoff DC, Joosse P, van der Vlies CH, de Haan RJ, Goslings JC.
Prognostic factors for failure of nonoperative management in
adults with blunt splenic injury: a systematic review. J Trauma
Acute Care Surg 2013;74(2):546–557
36 Lutz N, Mahboubi S, Nance ML, Stafford PW. The significance of
contrast blush on computed tomography in children with splenic
37 Davies DA, Ein SH, Pearl R, et al. What is the significance of contrast
45(5):916–920
38 van der Vlies CH, Saltzberg TP, Wilde JC, van Delden OM, de Haan
RJ, Goslings JC. The failure rate of nonoperative management in
children with splenic or liver injury with contrast blush on
40 Kiankhooy A, Sartorelli KH, Vane DW, Bhave AD. Angiographic embolization is safe and effective therapy for blunt abdominal solid organ injury in children. J Trauma 2010;68(3):526–531
49 Rovin JD, Alford BA, McIlhenny TJ, Burns RC, Rodgers BM, McGahren ED. Follow-up abdominal computed tomography after splenic trauma in children may not be necessary. Am Surg 2001;67(2):127–130