Pediatric Blunt Abdominal Trauma

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Despite increased awareness and prevention efforts, trauma remains the number one cause of childhood death and disability \cite{1}. According to the national pediatric trauma registry, each year approximately 1.5 million children are injured, resulting in 500,000 pediatric hospitalizations, 120,000 children with permanent disability, and 20,000 deaths. Although abdominal trauma is less common than isolated head injury, it is still a leading cause of morbidity and mortality in children. In certain scenarios, particularly in preverbal children or children with a decreased level of consciousness, identification of an abdominal injury can be challenging, and failure to detect these injuries initially can lead to preventable complications. Nationwide, injured children are cared for not only at dedicated pediatric trauma centers but also in emergency departments and clinics that may not routinely evaluate children for these injuries. All clinicians who care for children with potential blunt abdominal injuries should be aware of current concepts related to the diagnosis and treatment of pediatric blunt abdominal trauma.

In this article we discuss key issues to help clinicians efficiently and successfully evaluate and manage blunt pediatric abdominal trauma. We also briefly review select organ trauma, including trauma that involves liver, spleen, intestines, pancreas, and kidneys. Finally, we discuss some of the disposition issues,
including length of hospitalization and return to activity recommendations for children with intra-abdominal injuries (IAI).

**Mechanism of injury**

Consideration of the cause of blunt pediatric abdominal trauma has been a major decision point for pediatric trauma system activation and deciding how to evaluate a child for potential IAI. Motor vehicle collisions (without proper restraint and ejection from a vehicle), automobile versus pedestrian accidents, and falls are associated with the greatest increased risk of IAI \[2–4\]. Other mechanisms of concern that should prompt close evaluation for IAI include children in a motor vehicle collision wearing only lap belt restraints, automobile versus bicycle accident, all-terrain vehicle accidents, handlebar injuries from bicycles, and sports or nonaccidental trauma resulting in direct blows to the abdomen \[2,5,6\]. There is a case series involving two 5-year-old children who played “superman” (the children attempted to fly off a top dresser to a crib and instead of landing in the crib struck the railing of the crib with their abdomens), which resulted in IAI \[6\].

Several studies have outlined that abdomen-to-handlebar collisions are associated with a high risk of small bowel and pancreatic trauma \[7,8\]. This trauma can occur after seemingly harmless incidents, and direct impact on the handlebars may result in more severe injuries than flipping over them \[8\]. Childhood sports and recreational activities, although generally safe, can produce IAI. In a study of adolescents in western New York, Wan and colleagues \[9\] found that injuries occurred in 0.73% of sports participants; the organs injured in descending frequency were kidney, spleen, and liver. Of note, the authors found that sledding and snowboarding resulted in injuries more often than football. This finding was echoed by a Canadian report that found that snowboarding resulted in IAI six times more frequently than skiers \[10\].

**Past medical history**

Obtaining as much information as possible about a child’s past medical history is always worthwhile even in the abbreviated trauma history and examination. Medical conditions that affect children’s neurologic or developmental baseline are important to obtain from any sources available to the provider. A few examples that may make evaluation of a child more difficult include autism, cerebral palsy, or other medical conditions that result in mental or physical handicaps. Hemophilia is also of particular concern, and careful evaluation and management of children with this disease are warranted. Several reports in the literature cite the risk of delayed splenic rupture and massive bleeding from minor abdominal
trauma in children who have hemophilia [11,12]. In addition to inherited bleeding disorders, any pediatric patient who is being anticoagulated or receiving antiplatelet therapy (eg, for acquired or congenital heart defects) should be considered to be at higher risk for bleeding and significant IAI. It is important to inquire about recent or concurrent Epstein-Barr virus infection (secondary to the risk of splenic injury from even minor abdominal trauma in children with splenomegaly from Epstein-Barr virus).

Physical examination

When discussing the importance of physical examination findings in a child with a potentially serious IAI, certain key concepts should be emphasized. First, an abdominal examination abnormality should be considered an indicator of IAI. Second, in addition to the abdominal examination, other associated comorbid injuries or factors predict abdominal injury. Third, despite the helpfulness of the first two factors, a negative examination and absence of comorbid injuries do not totally rule out an IAI.

Holmes and colleagues [2] performed a prospective observational study of 1095 children and determined abdominal tenderness to be predictive of IAI (odds ratio [OR] 5.8). The authors did not calculate positive predictive value or negative predictive value in the study, but the article’s data indicate that they were 17%, and 93%, respectively. Cotton and colleagues [5] identified abdominal tenderness, ecchymosis, and abrasions as positive predictors of IAI (ORs were 40.7, 15.8 and 16.8, respectively). Isaacman et al [13] performed a retrospective review of 285 pediatric trauma patients classified as moderately injured (14 of the 285 were identified to have a significant IAI) and found that an abnormal physical examination plus an abnormal urinalysis (UA) to be a highly sensitive screen for IAI (sensitivity, specificity, positive predictive value, and negative predictive value were 100%, 64%, 13%, and 100%, respectively). Another study in 1997 looked specifically at small bowel injury and found that 94% of the time there was exam pathology and of the 13 CT scans that were performed on the patients with small bowel injury, only one was positive [14]. This evidence suggests that imaging is indicated in children with abnormal abdominal examinations.

Although this statement seems obvious, the more frequently encountered clinical scenario that may challenge the provider is when CT imaging should be obtained on children who have benign abdominal examinations but have a concerning medical history or mechanism. The first clue is to look at comorbid findings in a child with potential IAI, and the second is to look at select laboratory values.

Associated comorbid findings/injuries can help predict which children have abdominal injury. Two of these findings came from the 2004 Holmes study, the first of which was the presence of a femur fracture (OR 1.3) [2]. Although this
finding only has a mild increased risk for IAI, given the seriousness of a missed
IAI, the provider should consider strongly using the presence of a femur fracture
in a child as a reason to obtain further diagnostic imaging. The second finding
that can help predict IAI from the Holmes study is low systolic blood pressure
with an OR for IAI of 4.8 [2]. This is not necessarily a surprise and does not have
strong sensitive or specificity, but it does indicate another finding that, when
present, may lead a clinician to consider abdominal CT imaging.

Another factor that has been correlated with IAI (or at least may mask a
reliable physical examination that would make a clinician suspect IAI) is a
decrease in mental status. The Holmes investigation identified a Glasgow Coma
Score of less than 13 as a mild indicator of IAI with an OR of 1.7. This finding
was enough for the authors to recommend obtaining CT imaging in patients with
a Glasgow Coma Score less than 13 [2]. Another prospective study by Beaver
and colleagues [15] revealed that in patients with a Glasgow Coma Score less
than 10, 23% had significant IAI. A final point of consideration is that there is
much concern about the reliability of abdominal examination in preverbal
children. Although this age group is included in studies that addressed pediatric
blunt abdominal trauma, preverbal children are underrepresented and not spe-
cifically substratified. The provider must consider the mechanism of trauma in
assessing risk of injury. Because the risk of IAI varies greatly with each given
mechanism of trauma in the preverbal age group, the provider should err on
the side of caution in considering whether to obtain further laboratory testing or
radiographic imaging.

**Laboratory testing**

After the history and physical examination, the next step in evaluating pe-
diatric patients with potential IAI is what laboratory test should be obtained. In
a hypotensive child who is unresponsive to isotonic fluid boluses, the type and
cross is the most important test to order. Most children with abdominal injuries
are not hypotensive, however, and there are two reasons for performing labo-
rary testing. The first reason is to treat a potentially unstable patient im-
mediately. The second reason is to screen stable children for a possible IAI. When
considering which laboratory tests to order, it is important that the clinician avoid
routine “trauma panel” testing in pediatric trauma patients. One example to
support this practice can be demonstrated in a retrospective review by Keller and
colleagues [16], in which 77% of patients in their trauma center had a type and
cross performed, yet only 3.8% of the patients actually received blood.

The second reason to order laboratory tests is to help predict which children
may have IAI. The most useful laboratory tests for this purpose include the
complete blood count (CBC), liver function tests (LFTs), and UA. Also studied in
the literature are amylase, lipase, coagulation studies, and general chemistries.
Often these tests are part of standard trauma panels but not all are useful.
The CBC is a ubiquitous test drawn in almost every clinical situation [16]. The use of this test in pediatric trauma is mainly relegated to looking at the hemoglobin/hematocrit of patients. Initial serum values vary widely. In the study by Holmes and colleagues [2], an initial hematocrit of less than 30 had an OR of 2.6 for IAI. In 1993, however, Isaacman and colleagues [13] found that serial hematocrit used to detect IAI was a poor test. The greatest use for the hemoglobin and hematocrit is to follow serial values in known solid organ injuries. An initial hemoglobin and hematocrit are recommended in the evaluation of patients with pediatric abdominal trauma, but they should not be used to decide whether to perform an additional imaging study.

Coagulation studies (eg, prothrombin time, international normalized ratio, partial thromboplastin time) are sometimes drawn. It is well documented in the literature that a closed head injury leads to coagulation abnormalities [16,17]. When caring for pediatric patients who have blunt abdominal trauma without concomitant head injury or other premorbid conditions, no studies show that routine coagulation studies are beneficial.

Another routine trauma panel test often ordered is liver transaminases. The rationale is that liver enzyme release (alanine aminotransferase [AST] or aspartate aminotransferase [ALT]) is a marker for liver or other solid organ injury. Isaacman and colleagues [13] combined physical examination with a positive transaminase screen (AST or ALT >130) and claimed a 100% sensitive with 100% negative predictive value. Keller and colleagues [16,17] obtained a panel of laboratory tests (CBC, chemistry, coagulation panel, and UA) on 240 injured children younger than age 16. The authors concluded that routine laboratory data are of limited value in the management of injured children [16,18,19]. Puranik and colleagues [20] performed a chart review in 44 hemodynamically stable children with blunt abdominal trauma who had undergone abdominal CT. The authors compared AST and ALT levels in children with and without CT evidence of liver injury. They found an association between AST and ALT levels and CT evidence of liver injury. (Sensitivity and specificity of elevated liver enzyme levels were 92.2% and 100%, respectively, for predicting liver injury.) The authors concluded that an abdominal CT is indicated in pediatric blunt abdominal trauma when the AST is >400 or ALT >250. There was no significant evidence that LFTs were able to predict injuries that required an intervention, however [20].

In 2004, Cotton and colleagues [5] reported in a retrospective review that an elevated AST >131 plus abdominal findings had a sensitivity of 100% for detecting IAI. They also noted in patients without any abdominal tenderness that an ALT >101 had a sensitivity of 100% for detecting IAI [5]. A prospective observation series by Holmes and colleagues [2] enrolled 1095 children (107 had IAI) younger than age 16 who sustained blunt trauma. The authors identified six findings associated with an IAI (low systolic blood pressure, abdominal tenderness, femur fracture, elevated LFTs, UA with >5 red blood cells per high-powered field [hpf], initial hematocrit <30%). An ALT >125 or an AST >200 was determined to have an OR of 17.4; 95% CI 9.4 to 32.1 (54% of patients with elevated...
liver transaminases had an IAI) [2]. They concluded that laboratory testing contributes significantly to the identification of children with IAI after blunt trauma. Based on the evidence, it is reasonable to include an AST and ALT as part of an evaluation in a child with history of blunt abdominal trauma and an equivocal examination.

The UA is often routinely obtained in children with abdominal trauma. Microscopic hematuria has been defined differently by different authors as more than 5 red blood cells (RBC)/hpf, more than 20 RBC/hpf, or more than 50 RBC/hpf [2,13,21,22]. Gross hematuria is defined as hematuria visible to the clinician [2]. Gross and microscopic hematuria has been associated with the presence of an IAI in the blunt trauma pediatric patient [2,23]. The use of microscopic hematuria in evaluation of pediatric blunt abdominal is controversial, however [2,13,22–24].

Stein and colleagues [23] retrospectively evaluated the abdominal CT scans of 412 children, 48 of whom had CT documented renal injuries (25 of the 48 had significant renal injuries). All of the children with significant renal injuries presented with hematuria. Sixty-eight percent (17 of 25) had microscopic hematuria, and 32% (8 of 25) had gross hematuria. The authors concluded that any child who presents with blunt abdominal trauma and any evidence of hematuria should undergo abdominal and pelvic CT.

Stalker and colleagues [22] performed a retrospective chart review of 256 children with blunt abdominal trauma. One hundred six children presented with hematuria, and 35 had a renal injury diagnosed by abdominal CT. The authors commented that normotensive children with less than 50 RBC/hpf were not found to have a significant renal injury.

Taylor and colleagues [24] evaluated 378 children with blunt trauma. Hematuria was present in 256 children, of whom 168 had microscopic hematuria ≥10 RBC/hpf. In cases of asymptomatic hematuria, the risk of abdominal injury was negligible (0 of 41 patients). The authors concluded that asymptomatic hematuria is a low-yield indication for obtaining an abdominal CT in the pediatric patient who has blunt abdominal trauma.

Holmes and colleagues [2] performed a prospective analysis of laboratory testing in pediatric blunt abdominal trauma in which they considered microscopic hematuria to be >5 RBC/hpf. The authors concluded that hematuria more than 5 RBC/hpf is an important predictor of IAI in pediatric blunt trauma patients (OR of 4.8). In their recursive portioning analysis it was a more proximal node than abdominal tenderness. This is also echoed by an earlier investigation by Isaacman and colleagues [13] in which a negative UA and a normal physical examination had a negative predictive value of 100%. An investigation by Cotton and colleagues [5] with a similar statistical analysis of a smaller number of patients failed to discover a use for UA in pediatric blunt trauma patients. This debate still flourishes, especially in patients who are otherwise healthy without tenderness. Providers are cautioned in an area in which there is no definitive study to categorize patients according to mechanism of injury in conjunction with physical examination.
<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients</th>
<th>Type</th>
<th>UA</th>
<th>AST/ALT</th>
<th>CBC</th>
<th>COAGS</th>
</tr>
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<tbody>
<tr>
<td>Holmes [2]</td>
<td>1095</td>
<td>Prospective</td>
<td>OR 4.8 Microscopic UA + for IAI</td>
<td>ALT &gt;125 or AST &gt;200 OR 17.8</td>
<td>Hematocrit &lt;30, OR 2.6</td>
<td>Not studied</td>
</tr>
<tr>
<td>Cotton [5]</td>
<td>240</td>
<td>Retrospective</td>
<td>No difference in UA for IAI</td>
<td>AST &gt;131 (+PE) or ALT &gt;101 alone had 100% sensitivity</td>
<td>No difference in pops</td>
<td>Not studied</td>
</tr>
<tr>
<td>Keller [16]</td>
<td>240</td>
<td>Retrospective</td>
<td>Only 8% with a negative UA had IAI</td>
<td>Positive in 29% of patients with IAI</td>
<td>Only rare abnormal</td>
<td>No abnormalities in isolated abdominal injuries; 43% abnormal in head injuries</td>
</tr>
<tr>
<td>Isaacman [13]</td>
<td>285</td>
<td>Retrospective</td>
<td>Normal UA + normal PE 100% negative predictive value</td>
<td>Normal PE + LFT &lt;130: 100% negative predictive value</td>
<td>H/H abnormal in 8%</td>
<td>Not studied</td>
</tr>
</tbody>
</table>

Abbreviations: Coags, coagulation profile; H/H, hemoglobin/hematocrit; PE, physical exam; Pops, either population.
Finally, there is also some literature to consider regarding pancreatic enzymes predicting pancreatic or small bowel injuries. In the review by Keller and colleagues [16], only 2% of the patients had elevated amylase and none had pancreatic injuries. In a larger study conducted by Adamson and colleagues in 2003 [25], they looked at 293 patients with torso injuries with 11% IAI in which they identified 8 patients with pancreatic injuries [20]. Only 6 of 8 patients had amylase studies performed, but 5 of those 6 had abnormal amylase levels. All of the patients who underwent CT imaging had another indication for performing CT, however (most notably abdominal pain). The authors concluded that although serial enzymes may be useful, the initial set did not help to predict injury.

When considering laboratory testing, providers should resist the temptation to order a standard panel on every patient. If the physical examination is normal and the history is still concerning, based on the previously mentioned evidence, obtaining LFTs, a CBC, and UA may help clinicians determine which child should undergo further diagnostic imaging as part of trauma evaluation. Table 1 provides a concise summary of the major studies to date and their findings.

Select organ trauma

Classic teaching has been that the spleen is the most commonly injured abdominal organ after blunt trauma in children and that the liver is the second most commonly injured organ [22]. More recently, however, in a large prospective series of 1095 patients, the liver was the most commonly injured intra-abdominal organ, followed by the spleen [2]. In either case, both organs are commonly injured from blunt trauma to the abdomen in children and deserve a review of their individual injury grading systems and management. This article also discusses injuries to the intestinal tract, pancreas, and kidney.

Hepatic trauma

The diagnosis and management of liver injuries in children are important because blunt liver trauma is thought to be responsible for the greatest number of fatalities in which abdominal trauma is the primary cause of death [24]. The most common mechanisms of injury reported to result in liver injury were pedestrian struck by automobile (39%), motor vehicle collision (34%), falls or discrete blows to the abdomen (13%), bicycle injuries (5%), and nonaccidental trauma (5%) [25].

Abdominal CT scanning, particularly intravenous contrast-enhanced CT, is accurate in localizing the site and extent of liver injuries and providing vital information for treatment in patients. Trauma to the liver may result in subcapsular or intrahepatic hematoma, contusion, vascular injury, or biliary disrup-
tion. Criteria for staging liver trauma based on the American Association for the Surgery of Trauma (AAST) liver injury scale include the following:

Grade 1: Subcapsular hematoma less than 1 cm in maximal thickness, capsular avulsion, superficial parenchymal laceration less than 1 cm deep, and isolated periportal blood tracking
Grade 2: Parenchymal laceration 1–3 cm deep and parenchymal/subcapsular hematomas 1–3 cm thick
Grade 3: Parenchymal laceration more than 3 cm deep and parenchymal or subcapsular hematoma more than 3 cm in diameter
Grade 4: Parenchymal/subcapsular hematoma more than 10 cm in diameter, lobar destruction, or devascularization
Grade 5: Global destruction or devascularization of the liver
Grade 6: Hepatic avulsion [21] (CT scan grade not AAST grade)

Although it is useful to review the CT and AAST criteria for staging liver trauma, it is important to note that the hemodynamic status of a child is the primary indicator of the type of initial management required for hepatic injuries [26]. Patients with massive disruption and intractable bleeding despite aggressive fluid and blood transfusion resuscitation need emergent evaluation by a surgeon and possible exploratory laparotomy if hemodynamically unstable. As long as a child with hepatic injury remains hemodynamically stable, no emergent surgical intervention is necessary. These patients require careful management of fluid volume, however, and often require transfusion of blood. Despite careful therapy and monitoring, a percentage of initially stable children with hepatic injury are at risk of sudden exsanguination and as such should be managed under surgical supervision with bed rest, repeat serial abdominal examinations, and serial hemoglobin monitoring. The success rate of nonoperative management of pediatric liver injuries ranges from 85% to 90% [25–27]. Length and level of hospitalization and return to activity recommendations are made later in this article.

**Splenic trauma**

The spleen is a commonly injured abdominal organ in children who sustain blunt abdominal trauma, and splenic trauma should be suspected in children with left upper quadrant tenderness to palpation, left lower rib fractures, or evidence of left lower chest/abdominal contusion. Criteria for staging splenic trauma based on the AAST splenic injury scale include the following:

Grade 1: Subcapsular hematoma of less than 10% of surface area or capsular tear of less than 1 cm in depth
Grade 2: Subcapsular hematoma of 10%–50% of surface area, intraparenchymal hematoma of less than 5 cm in diameter, or laceration of 1–3 cm in depth and not involving trabecular vessels
Grade 3: Subcapsular hematoma of more than 50% of surface area or expanding and ruptured subcapsular or parenchymal hematoma, intraparenchymal hematoma of more than 5 cm or expanding, or laceration of more than 3 cm in depth or involving trabecular vessels
Grade 4: Laceration involving segmental or hilar vessels with devascularization of more than 25% of the spleen
Grade 5: Shattered spleen or hilar vascular injury

Because many of these injuries are self-limited in children, the management of splenic trauma has evolved to a point at which stable children are managed with bed rest, frequent examinations, serial hemoglobin monitoring, and close surgical supervision. Splenic preservation is the preferred modality to decrease the risk of postsplenectomy infection. The only absolute indication for performing a splenectomy in children is massive disruption and hemodynamic instability [26]. Conservative preservation management of splenic injuries in children has shown full recovery in 90% to 98% of patients [26,28,29].

Several reports have been cited in the literature of splenic rupture in patients with Epstein-Barr virus infection. This subset of children should be considered high risk when presenting after even minor abdominal trauma. Splenic rupture occurs in 0.1% to 0.2% of patients with infectious mononucleosis. Rupture is most likely to occur during the second and third weeks of clinical symptoms, and although it can happen spontaneously, it often has a history of recent abdominal trauma. Because bradycardia is usual in infectious mononucleosis, tachycardia is an important sign indicating possible shock in these children. Unlike most other pediatric splenic injuries, rupture of the spleen after mononucleosis usually requires surgical intervention; however, recently published data have suggested that concurrent infectious mononucleosis does not preclude the successful nonoperative management of blunt splenic injury [23].

Intestinal trauma

Fortunately, because of the inherent difficulties of establishing the diagnosis, injuries to the small intestines or colon are less common than solid organ injuries in children with blunt abdominal trauma. Holmes and colleagues [2] performed a prospective analysis of 1095 children who presented to a trauma center in which only 2% had gastrointestinal injuries identified. Injuries to the intestines include perforation, intestinal hematomas, and mesenteric tears with bleeding. They often occur as a result of deceleration trauma commonly associated with lap belt injuries. Any child in whom a “seatbelt sign” of abdominal wall contusion is present should be evaluated carefully for a minimum of 24 hours for the development of evidence of peritonitis. Many patients with a gastrointestinal injury initially have normal laboratory studies and CT scans. If a CT scan of the abdomen demonstrates pneumoperitoneum or extravasation of contrast, then this diagnosis is not difficult. More often, however, the CT scan only shows subtle signs, such as bowel wall edema. A high index of suspicion must be maintained.
for any child with a suspicious mechanism or examination. Abdominal pain that worsens or persists and persistent emesis must be investigated with serial examinations, judicious use of repeat abdominal CT imaging, and—at the discretion of the surgeon—exploratory laparotomy.

Pancreatic trauma

Pancreatic injuries are rare compared with other solid organ injury in children; however, injuries from falls onto the handlebar of a bicycle that result in a crush force applied to the upper abdomen are mechanisms that must induce a high index of suspicion. In one retrospective review over 14 years at a pediatric trauma center, only 26 cases of pancreatic injuries were identified, but 11 of the 26 cases were from falls onto the handlebars of a bicycle [7]. The diagnosis of pancreatic injury may be challenging. Often the laboratory and CT findings of injury to the pancreas may lag behind the clinical picture, so persistent tenderness should indicate further investigation to the clinician. The overall prognosis for pancreatic trauma is good, because several series have shown that conservative nonoperative management of pancreatic injuries without ductal disruption can result in low morbidity.

Renal trauma

If one includes the posterior abdomen and retroperitoneum in the definition of blunt abdominal trauma, then the kidney is a commonly injured solid organ in pediatric blunt abdominal trauma. The most likely cause of this type of injury is a motor vehicle collision. Like hepatic and splenic injuries, most renal traumatic injuries heal without surgical intervention; however, the combination of significant flank/abdominal trauma and hematuria (even microscopic) is indication for a CT scan to assess for renal injury. (Refer to the earlier discussion for controversies concerning screening urinanalysis in this area.)

Management and disposition

Disposition often begins with the initial medical system activation for a child suspected of having an IAI. In most states there are protocols for trauma team alert activation and triage from the field. In pediatrics this is less prominent because only 15 states specifically designate adult and pediatric trauma centers [30]. If a pediatric patient with a possible IAI does present to a hospital without any specific trauma designation, the patient should be evaluated adequately, provided stabilizing treatment as needed, and managed in accordance with advanced trauma life support (ATLS) and pediatric advanced life support (PALS) principles. Persistent vital sign instability (particularly tachycardia) is a worrisome sign and should be treated aggressively [31].
Unstable children require immediate crystalloid fluid resuscitation (20 mL/kg of normal saline or Ringer’s lactate solution), and in isolated blunt abdominal trauma the following should be rapidly ordered: type and cross, CBC, LFTs, and UA [32]. Continued hemodynamic instability after two fluid boluses should be treated with transfusion of 10 mL/kg of packed red blood cells, and surgical consultation should be obtained for likely emergent laparotomy. Surgical stabilization may be necessary before a possible transfer to a referral center.

For hemodynamically stable children with a concerning mechanism of injury or abdominal examination abnormality, we recommend obtaining UA, LFTs, and a CBC [33,34]. In preverbal children if all laboratory test results are normal and the children remain hemodynamically stable, then there is no consensus on whether to perform abdominal CT imaging. Regardless of mechanism, if verbal children are alert, have normal laboratory data (eg, UA, LFTs, and CBC) without concomitant injury, or lack abdominal examination abnormality, they can be discharged safely without imaging of the abdomen. In the presence of laboratory abnormalities children should undergo CT scanning to assess for IAI.

If CT scanning is not available, the provider should transfer stable children with persistent pain or vomiting, concerning examination, or laboratory findings to a facility that can perform the needed study [35]. The provider should remember that persistent tenderness on examination or persistent emesis (even with a normal abdominal CT scan) should be taken seriously and children should be admitted to a facility with a surgeon who feels comfortable managing intestinal tract injuries in children.

**Length of hospitalization and return to activity**

According to consensus guidelines concerning resource use, Stylianos and colleagues [36] suggested a standardized approach to isolated spleen or liver injury and made the following recommendations. For each grade level of injury, they mandated specific days in the intensive care unit, hospital stay, imaging, and discharge activity level (normal childhood level not necessarily contact sports). For either liver or spleen grades I to III they recommended no intensive care unit stays and a total hospitalization equaling 1 day plus the level of injury. A child with a grade III spleen laceration would be hospitalized for 4 days. For grade IV


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<p>| Table 2: Hospital stay and activity restriction guidelines for solid organ injury |
|-----------------------------------------------|---------------------------------|-----------------------------|</p>
<table>
<thead>
<tr>
<th>Spleen or liver injury grade</th>
<th>Hospital stay</th>
<th>Activity restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I–III</td>
<td>Injury grade + 1 day</td>
<td>Injury grade + 2 weeks</td>
</tr>
<tr>
<td>Grade IV</td>
<td>1 day intensive care unit + injury grade (for hospital day)</td>
<td>Injury grade + 2 weeks</td>
</tr>
</tbody>
</table>

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injuries they recommended 1 day of intensive care unit monitoring and retaining the formula for overall hospital stay. The authors recommended no re-imaging studies regardless of injury grade, and the return to a normal age-appropriate activity level was the organ laceration grade plus 2 weeks. A child with a grade III spleen injury would be on restricted activity for 5 weeks. Their prospective validation revealed increasing compliance with this protocol and, more significantly, no adverse events when following the protocol. Only 1.9% of patients needed readmission when following these guidelines. The authors did not state the reason for readmissions in their study; however, they stated that none required an operation. Table 2 summarizes these recommendations.

Summary

Blunt pediatric trauma remains a major threat to the health and well-being of children. Management of this disease entity does not only occur in major centers—nationwide many practitioners care for children who face this issue. In this article we attempted to elucidate some key principles related to the evaluation and management of these children.

References