

Review

Pediatric Trauma: Updates and Innovations in Triage, Management, and Interventions for Solid Organ Injuries

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Abstract

Pediatric trauma accounts for 10–20% of all emergency department visits annually in the United States, and both intentional and unintentional injuries contribute significantly to the overall morbidity and mortality associated with trauma in children. Solid organ injuries are often identified, particularly in relation to blunt injury mechanisms, and can lead to serious adverse events if not diagnosed and treated expeditiously. Advancements in diagnostic tools and intervention strategies have improved outcomes for injured children. This review identifies common mechanisms for pediatric solid organ injuries, discusses advances in triage and diagnostic capabilities, and explores treatment options along with intervention innovations for these types of traumatic injuries in the pediatric population.

Keywords: pediatric trauma; solid organ injury; trauma assessment; damage control surgery; laparoscopy in trauma

1. Introduction

Traumatic injury represents a major global health burden and remains one of the leading causes of death and disability among children and adolescents worldwide [1]. Although the global burden of injury has declined over recent decades, injuries continue to account for substantial mortality and disability-adjusted life years among pediatric populations [1]. Road traffic collisions, falls, and interpersonal violence are among the most significant contributors to injury-related morbidity and mortality globally, with children in low-resource settings experiencing disproportionately worse outcomes [1]. These findings highlight the continued importance of timely recognition and effective management of pediatric traumatic injuries [1].

In the United States, approximately 30 million children are seen annually in emergency departments (EDs) for injury or illness [2]. Pediatric trauma from intentional or unintentional injury accounts for approximately 10–20% of these hospital visits and remains the leading cause of pediatric mortality [3–5]. Although penetrating injuries are on the rise, there is still a predominance of blunt-related mechanisms such as falls and motor vehicle collisions (MVCs) [4,6]. In the setting of blunt trauma, particularly with high-energy mechanisms, healthcare providers must be concerned about solid organ injuries, which can cause life-threatening bleeding and lead to severe complications if not managed expeditiously.



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To identify and treat these injuries, a number of advances have been made in recent decades to improve the speed and efficacy of injury diagnosis. Contemporary approaches increasingly emphasize hemodynamic status, clinical response to resuscitation, selective imaging, and minimally invasive interventions when appropriate rather than injury-grade-driven management. These innovations allow for various management strategies to be implemented based on the type, location, and severity of solid organ injury. This review summarizes contemporary approaches to the evaluation, triage, and management of pediatric abdominal solid organ injuries, including liver, splenic, renal, pancreatic, and adrenal trauma (Figure 1). The discussion encompasses the full spectrum of injury severity, from isolated low-grade injuries managed non-operatively to high-grade injuries requiring interventional radiology or operative management.

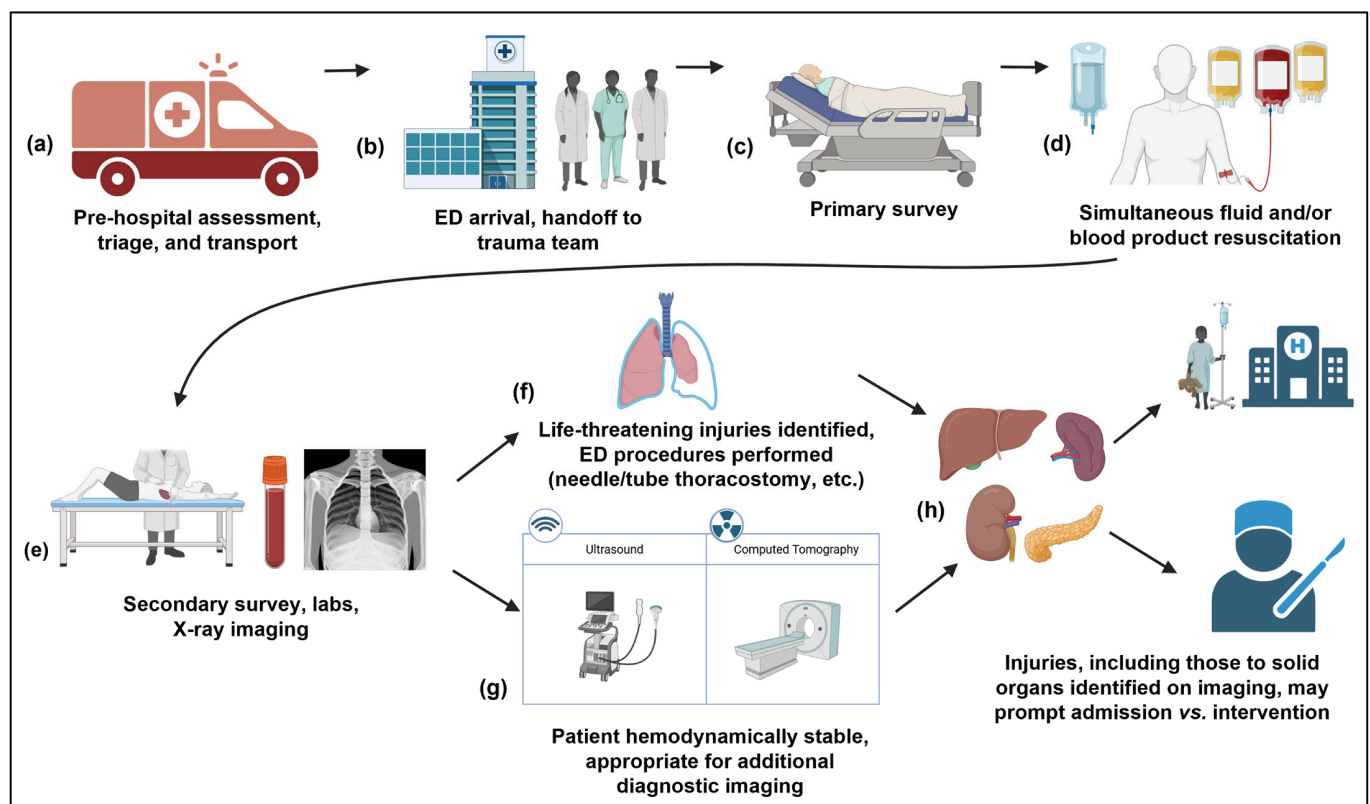


Figure 1. *Pediatric trauma workflow.* (a) Pre-hospital assessment and triage by EMS personnel, with transport to an appropriate center based on patient injury severity; (b) Patient arrives at emergency department and care is handed off to awaiting trauma team for additional triage and assessment; (c) Patient undergoes primary survey, following the “xABCDE” algorithm based on Advanced Trauma Life Support (ATLS) guidelines; (d) Simultaneous fluid resuscitation occurs and, when necessary, balanced 1:1:1 blood product administration with red blood cells, platelets, and plasma; (e) Once primary survey is complete, secondary survey is performed with head-to-toe examination, medical history, laboratory studies, and initial screening radiographs including chest and abdomen/pelvis X-rays; (f) If life-threatening injuries identified on secondary survey (pneumothorax, hemothorax, etc.), interventions can be performed in the ED such as needle/tube thoracostomy; (g) If patient is hemodynamically stable, additional imaging studies can be performed for better characterization of internal injuries; (h) Injuries likely to be identified on additional imaging include those to the solid organs, and may require intervention *vs.* hospital admission. Created in BioRender. Wayne, C. (2026). <https://BioRender.com/mw79ndq>.

2. Background

2.1. Epidemiology and Patient Demographics

Pediatric injuries remain a significant contributor to overall mortality in children in the United States and contribute substantially to the economic costs related to health-care utilization. According to the US Centers for Disease Control and Prevention's Web-based Injury Statistics Query and Reporting System (WISQARS), the costs for pediatric injuries (patients 1–17 years old) from 2014 to 2023 totaled over \$425.19 billion, with \$163.92 billion from fatalities alone [5]. Although relatively low at 11.37 per 100,000 patients, the overall death rate in this time period was 79,240 children, with 27.0% of deaths related to unintentional injuries secondary to motor vehicle collisions [5]. These data and other studies have consistently shown MVCs, firearms, and drowning to be significant contributors to overall pediatric injury and mortality [4–6]. Studies have also identified key characteristics of pediatric trauma deaths in the United States, demonstrating that patients were more likely to be male, American Indian or Alaskan Native, and in their teenage years [5,7].

When assessing emergency department visits and hospital admissions for non-fatal pediatric injuries, trends similar to those of fatalities were identified. MVCs remained the primary cause of medical evaluation in an emergency department for all age groups, with the most common injuries including traumatic brain injury (ranging from minor concussion symptoms to significant brain bleeds) and hip or long bone fractures [8]. Using the Pediatric Health Information Systems (PHIS) database, a national database of 55 tertiary care pediatric hospitals in the US, another study found that for all trauma-related visits from 2010 to 2019, the majority of pediatric trauma patients were White (52.6%), had public health insurance (54.5%), and were discharged home from the ED without an inpatient admission (92.2%) [3]. Additionally, the highest proportion of patients were between 1 and 4 years old (32.3%), closely followed by those between 5 and 9 years old (26.4%) [3].

2.2. Common Mechanism for Solid Organ Injury

The Centers for Disease Control (CDC) stratifies injuries into unintentional or intentional/violence-related, which can be further subdivided into homicide/assault, legal intervention, or suicide/self-harm [5]. Additional characterization classifies injuries into blunt or penetrating mechanisms. Numerous studies have reported that the most common injury mechanism for blunt solid organ injury in children remains MVCs [9–11]. This is true when also considering polytrauma, encompassing thoracic and abdominal injuries, bone fractures, and head injuries [12]. Falls, bicycle accidents, and sports-related contact injuries follow MVCs as the next most frequent events associated with pediatric abdominal injuries [11,13].

Interestingly, there are anatomic considerations that predispose pediatric patients to incur higher rates of solid organ injuries from blunt abdominal trauma compared to adults [14]. Specifically, children have proportionally larger intra-abdominal solid organs, less pronounced and therefore less protective abdominal musculature, and a thinner layer of subcutaneous fat compared to adults [11]. In one recent study by Chaudhari et al., the investigators examined abdominal injuries in children across the United States who presented to tertiary care children's hospitals from 2010 to 2019 [15]. Across 33 hospitals, 9265 children presented with intra-abdominal injuries, and of the organ injuries identified, 38.6% involved the liver, followed closely by those involving the spleen at 32.1% [15]. These findings support existing data suggesting that children have larger areas of surface exposure for intra-abdominal organs such as the liver, which may lead to increased injuries to these structures in pediatric patients [11].

3. Evaluation, Triage, and Assessment in Pediatric Trauma

3.1. Pre-Hospital Management

The key to effective and robust trauma care is the development of systematic and coordinated management guidelines across each phase of patient care. This involves streamlining pre-hospital care, emergency department assessment and management, and definitive hospital care in order to address a wide breadth of clinical situations effectively. In trauma, the time to appropriate management can be the difference between life and death. According to the Advanced Trauma Life Support (ATLS) program, evaluation and management should begin in the pre-hospital setting, followed by effective triage, preparation of receiving healthcare facilities, and systematic performance of the primary survey at the time of hospital arrival [16]. Therefore, pre-hospital management and triage are crucial for directing patients to an optimal trajectory for appropriate medical and surgical care.

To optimize pre-hospital care, protocolization and training of pre-hospital personnel in coordination with local healthcare centers and trauma facilities are key [16]. Education and training for pre-hospital providers include programs like the Prehospital Trauma Life Support Course created by the National Association of Emergency Medical Technicians, in conjunction with the American College of Surgeons (ACS). While pre-hospital care is available in many parts of the United States, pre-hospital triage decision algorithms are highly variable [17]. The triage process determines how severe the patient's condition is and what level of care and resources are needed in each patient clinical scenario. This helps healthcare workers determine whether the patient needs to be taken to an institution with pediatric trauma certification or whether a standard hospital emergency department is sufficient. Moreover, this process helps in determining whether travel needs to be expedited, such as by helicopter transport. Additionally, if a pediatric-trauma-certified institution is indicated, the pre-hospital team triage report can aid in the stratification of the trauma activation at the receiving hospital [16]. Activation levels at trauma institutions may have variation and nuance among institutions, with trauma activations commonly stratified into high-level alerts, which are reserved for patients with severe, possibly life-threatening, injuries, and lower-level alerts, in which patients have less severe, non-life-threatening injuries.

3.2. Pre-Hospital Triage Methods

Multiple studies have demonstrated poor performance in pre-hospital triage of pediatric patients and the need for improvement [18–20]. In 2019, the Pediatric Trauma Society (PTS) Research Committee performed a systematic review of 38 articles evaluating pre-hospital and emergency department triage practices in the United States [21]. They found that criteria for different levels of activation varied by institution and that, overall, pediatric triage criteria and scoring systems did not accurately predict or reduce mortality and were overall ineffective. Moreover, they specifically found that triage practices that were based on mechanisms of action performed particularly poorly, while those based on physiological parameters performed better. Therefore, there has been a push to move away from mechanism-of-injury-based triage criteria towards physiologic parameters and scoring instead [17].

To this end, scoring systems like the Glasgow Coma Score motor (GCSm), the pediatric age-adjusted shock index (SIPA), and the combination of the reverse Shock Index and GCS (rSIG) are being utilized [17]. Studies have demonstrated that the motor portion of the Glasgow Coma Scale (GCS) alone is accurate in the triage of pediatric patients, not only in predicting survival and the need for craniotomy in patients with severe head injuries [22] but in the assessment of all severely injured patients with regard to their overall need for

transfer to a trauma center [23]. Moreover, this simplifies the evaluation of patients for pre-hospital providers, streamlining the decision-making process [17]. SIPA leverages the ratio of heart rate over systolic blood pressure to create a physiologically based predictive score for the determination of severely injured patients [24,25]. This score is then compared to normal age-appropriate physiologic parameters and has been shown to be accurate in identifying pediatric patients who are severely injured, have intra-abdominal injuries requiring blood transfusion, and are at highest risk for mortality [25–27]. Most recently, a physiologic scoring system combining the inverse shock index (also known as the reverse shock index, rSI) multiplied by the GCS score (rSIG) has been shown to have significant promise in pediatric trauma triage [17]. It has also been shown to more accurately predict the need for early interventions (like blood transfusion, intracranial pressure monitoring, and intubation) than SIPA [28]. Additionally, it outperforms SIPA in identifying patients with the highest risk for mortality [29].

Although physiology-based scoring systems have demonstrated strong predictive capabilities, there is still much discrepancy in methods and criteria of pre-hospital assessment algorithms in the United States. In 2021, the ACS Committee on Trauma (COT) worked in conjunction with the National Highway Traffic Safety Administration, the Health Resources and Services Administration's Maternal and Child Health Bureau, and the Emergency Medical Services for Children program to develop the 2021 National Guidelines for Field Triage [16,30]. Despite the literature promoting physiologic parameters for triage, these guidelines utilize a combination of physiologic parameters and mechanisms of injury in patient triage. The group broke the guidelines into criteria for "high risk for serious injury", or "Red criteria", and criteria for "moderate risk for serious injury", or "Yellow criteria" [16,30]. If a patient meets any of the high-risk criteria, the patient should be taken to the highest-level trauma center within the region, whereas if a patient meets moderate-risk criteria, the patient can be taken to a trauma center of any level within the region. To date, there are no universally accepted and implemented triage guidelines in the US.

3.3. Pre-Arrival Hospital Preparation

While the patient is en route, communication about the patient and their condition should be relayed to the receiving trauma institution [16]. With this information, the trauma team can prepare for patient arrival. Team members ensure that all necessary equipment is available at the bedside. Additionally, team members don personal protective equipment and assign team roles (team leader, primary evaluator, vascular access team member, head assessment and airway management leader, and primary record keeper) [16]. A pre-arrival huddle occurs to ensure that everyone understands the situation and is prepared to work in an efficient and coordinated fashion once the patient arrives. On arrival, a concise but thorough handoff is performed between the trauma team and the pre-hospital providers. These handoffs should ideally include the mechanism of injury or primary complaint, injuries and information related to the injury, clinical assessment, GCS, vital sign trends, and any treatments provided [16]. Once this has been completed, a primary assessment should immediately commence.

3.4. Primary and Secondary Surveys

The primary survey progresses using the "xABCDE" algorithm, which evaluates exsanguinating hemorrhage, airway, breathing, circulation, disability, and exposure/environment, as outlined according to ATLS guidelines [16]. In this process the provider performing the primary assessment should begin by evaluating for uncontrolled external bleeding and perform measures to control and temporize this bleeding. The provider then ensures that the patient has an intact and protected airway. If there are con-

cerns that the airway is or may become compromised, then a definitive airway should be obtained. Following airway assessment, breathing is assessed to ensure proper aeration of both lungs. If there is concern for pneumothorax or hemothorax, a needle or tube thoracostomy should be performed to allow for proper lung expansion. Next is circulation—at this step, the patient should be evaluated for signs of shock. This includes palpation of extremity pulses and evaluation of capillary refill to ensure adequate tissue perfusion. Blood pressure and heart rate should also be assessed, as the pattern of derangements can help to determine etiology (i.e., hypovolemic, cardiogenic, neurogenic, septic, anaphylactic) and severity (i.e., stage 1–4 hypovolemic shock) of shock. The disability survey then assesses the patient's neurologic status through evaluation of their level of consciousness, their GCS score, and their motor and sensory functions in all four extremities. Finally, exposure/environment involves exposing the entire patient to ensure that there are no occult injuries that may have been missed and to ensure that any harmful environmental or chemical agents are removed from the body. Care should be taken to ensure that privacy is maintained and that the patient does not become hypothermic, as this can exacerbate conditions including coagulopathy. Upon conclusion of the primary survey, any life-threatening injuries should be either ruled out or controlled so that the patient is out of immediate mortal harm. At this stage, the secondary survey should commence, which includes obtaining a thorough history, performing a comprehensive physical exam and review of systems, and conducting necessary laboratory and imaging studies [16]. The goal of the secondary survey is to thoroughly identify all injuries to determine further steps of care.

3.5. Pediatric Considerations in Trauma Care

In the pediatric population, unique considerations exist when performing the primary and secondary surveys [14]. Children have a lower body mass-to-surface area ratio compared to adult patients [16]. Therefore, less energy is attenuated by body mass, and a greater proportion is transmitted to internal organs. With the increased surface area, there is a greater risk of heat loss, leading to hypothermia. The skeletal system of a child is also more pliable, as there is incomplete calcification. Thus, while a patient may not sustain bony injuries, they may still sustain significant internal injuries, necessitating a higher index of suspicion. Communication with pediatric patients can also present challenges due to either limited verbal skills in younger patients or the overwhelming psychological stress of a traumatic situation. The pediatric airway also presents multiple challenges for providers and makes poor oxygenation a high-risk etiology for rapid clinical decompensation. In infants and younger children, tonsillar hypertrophy, relatively larger tongues, a more anterior and cephalad larynx, a larger occiput leading to significant neck flexion when supine, a shorter trachea, and a larger mobile epiglottis are relevant obstacles when considering pediatric airway management [16]. Another significant challenge in pediatric trauma is the broad range of patient physiologic parameters and patient size. Providers must adjust what is considered normal physiology, what size of equipment can be utilized, what resuscitation strategies should be utilized, and what pharmacologic dosing is indicated based on each patient, realizing that the management of the newborn is drastically different to that of an adolescent. Tools like the Broselow Pediatric Emergency Tape help providers navigate the wide patient variability [16]. This tool provides recommendations based on patient height and weight for determining the appropriate size for equipment (including endotracheal tubes, chest tubes, nasogastric tubes, intravenous lines) and drug dosing.

3.6. Pediatric Abdominal Trauma

With specific regard to abdominal trauma, physical examination of the abdomen can be limited due to the patient's age or mental status. Additionally, if patients are distressed, the act of performing the exam may cause further fear and anxiety, prompting patients to tense their abdominal muscles or perform voluntary guarding, confounding pertinent exam findings. To have a high-yield abdominal examination, the provider should take the time to attempt to calm the patient, build rapport with the child, and then gently perform the abdominal exam while avoiding sudden and deep palpation. In addition to abdominal wall tenderness, visual cues of abdominal trauma, including an abdominal seatbelt sign, are concerning findings and should prompt further investigation [16,31,32]. Simultaneously, laboratory testing should be performed to supplement the abdominal examination. Initial laboratory tests include a complete blood count and basic metabolic panel to evaluate for anemia related to occult bleeding and for electrolyte derangements of concern for end-organ dysfunction [31–33]. Moreover, serum liver function tests, pancreatic enzyme levels, and urinalysis should be performed to assess for solid organ injury and can help guide imaging studies [31,33].

3.7. Imaging Studies

3.7.1. X-Ray and CT Scan

In addition to a well-performed physical exam and laboratory testing, diagnostic imaging is a useful adjunct in pediatric trauma assessment to identify solid organ injuries. Importantly, patients must be assessed for clinical stability before transport to imaging studies, and those with hemodynamic instability or those with ongoing life-threatening injuries should undergo immediate resuscitation and stabilization before advanced diagnostic imaging [16]. An abdominal X-ray is a fast and easy radiographic imaging study that can quickly identify a hollow viscus injury via the presence of intra-abdominal free air [32]. However, it is important to remember that the absence of free air does not exclude a bowel injury and must be factored into the overall clinical picture. Fractures of ribs and the pelvis are usually easily seen on X-ray images and can heighten clinical suspicion of intra-abdominal injury. Displacement of the bowel towards the center of the abdomen can be a sign of intra-abdominal fluid collection. Overall, plain film radiographs provide a quick picture of major injuries but have limited utility for definitive diagnosis of hollow viscus and solid organ injuries. The gold standard for diagnostic imaging in a hemodynamically stable patient is a contrast-enhanced computed tomography (CT) scan with intravenous (IV) contrast [32,34]. Contrast-enhanced CT scans provide highly sensitive and specific evaluations of intra-abdominal pathology [32,34]. These high-resolution images provide detailed assessments of intra-abdominal injuries, allow for staging of solid organ injuries, and aid in surgical planning when necessary [34]. However, the improved visualization of the internal anatomy comes at a cost—delivering a high dose of radiation to the body—compared to other imaging modalities. In pediatric patients, high doses of radiation at a young age put patients at a greater lifetime risk of radiation-induced cancers [35–37]. To promote responsible and appropriate utilization in pediatric patients and minimize excess radiation doses, guidelines such as the “as low as reasonably achievable” (ALARA) and Pediatric Emergency Care Applied Research Network (PECARN) prediction rules for CT imaging have been developed to help guide decision making regarding CT use [36,38,39]. Additionally, guidelines for CT imaging based on examination findings and specific laboratory tests have proven useful in the CT imaging decision-making process. Specifically, CT scans may be indicated in pediatric patients with visible signs of abdominal trauma (seatbelt sign), abdominal pain and tenderness; in patients with equivocal or limited physical examination; or in hemodynamically stable patients with a positive Focused Assessment Sonography

in Trauma (FAST) exam [32]. Additionally, elevated serum liver function test values (AST > 200 IU/L or ALT > 125 IU/L), elevated amylase or lipase levels, gross or microscopic hematuria on urinalysis, and low, or down-trending, hematocrit are findings that should prompt consideration of CT imaging studies [31–33]. In patients with significant traumatic injury requiring urgent evaluation, pre-existing chronic kidney disease should not preclude contrast-enhanced CT studies when clinically indicated [40].

3.7.2. Ultrasound

Ultrasonography (US) is an imaging modality that can effectively identify intra-abdominal and solid organ injuries while simultaneously avoiding the use of radiation. The FAST exam has been shown to be an effective tool in the evaluation for intra-abdominal bleeding and cardiac tamponade [41]. The FAST exam evaluates four views: subxiphoid/cardiac, right upper quadrant (hepatorenal recess), left upper quadrant (splenorenal recess), and pelvis. An extended FAST, or eFAST, includes assessment of the lung pleura for the development of a pneumothorax and/or hemothorax. Study conclusions have been mixed regarding the utility of FAST in pediatric trauma. In a randomized clinical trial of 975 pediatric patients by Holmes et al., FAST was comparable to standard care for hemodynamically stable pediatric patients with blunt abdominal trauma with regard to clinical care, resource utilization, ED length of stay, missed intra-abdominal injuries, and overall hospital charges [42]. Other studies have found that the FAST exam is specific but not very sensitive; therefore, a positive FAST likely indicates an intra-abdominal injury, whereas a negative exam is not reliable and requires further investigation [41,43]. FAST exams therefore are useful in that they are quick assessments to identify life-threatening abdominal pathology but should not be utilized as definitive imaging to rule out all intra-abdominal injuries in pediatric patients. While conventional ultrasound is effective at identifying collections of fluid (intra-abdominal blood or succus), it does not perform as well in the identification of parenchymal solid organ injuries [16]. However, contrast-enhanced ultrasonography (CEUS) has been shown to be an effective imaging study in the identification of solid organ injury, with sensitivity approaching that of CT scans [44–46]. For example, Armstrong et al. evaluated the performance of CEUS compared to traditional US, determining that CEUS had a sensitivity and specificity for solid organ injuries of 85.7% and 98.6%, compared to 45.2% and 96.4% for conventional ultrasound, respectively [44]. Lee et al. demonstrated that CEUS performed comparably to contrast-enhanced multidetector CT in the identification of vascular injuries of solid organs [45]. Finally, a systematic review by Pegoraro et al. evaluated seven studies examining the utility of CEUS in blunt abdominal trauma [46]. Their study identified a range of sensitivities and specificities of 85.7% to 100% and 89% to 100%, respectively, in identifying solid organ injuries [46]. The performance of CEUS in the assessment of intra-abdominal and solid organ injuries is close to that of contrast-enhanced CT scans and avoids unnecessary radiation, making it a promising alternative in the pediatric trauma population, although further studies and management guidelines incorporating the technique are needed to define its role in pediatric trauma evaluation.

4. Solid Organ Injuries and Management Options

Recent pediatric trauma guidelines have increasingly emphasized clinical status and hemodynamic stability over radiographic injury grade when guiding management decisions for solid organ injuries [47–49]. Clinical examinations, hemodynamic conditions, and laboratory evaluations can be utilized together to determine the need for more extensive radiological examination in the setting of blunt abdominal trauma. Based on an institution-specific algorithm for blunt torso trauma, one study found that their algorithm would have correctly identified 94% of patients with true intra-abdominal injuries, would

have missed only one patient with a low-grade non-operative splenic injury, and would have prevented unnecessary CT scans for 33% of patients seen in an 18-month period [33]. Guidelines initially published by the American Pediatric Surgical Association (APSA) Trauma Committee in 2000 noted a wide range of practices in non-operative management (NOM) of pediatric splenic and liver injuries and initially did not recommend pre- or post-discharge imaging regardless of the grade of injury [50]. A subsequent study noted decreased use of post-injury imaging as well as decreased lengths of intensive care unit (ICU) and hospital stays with adherence to these guidelines [51]. A more recent paper in 2019 from the APSA Outcomes and Evidence-Based Practice Committee recommended updated guidelines for the NOM of pediatric solid organ injuries. From this evaluation, it was determined that management strategies, including length of stay, return to activity, procedural intervention by interventional radiologists, and necessity for follow-up imaging, should be based upon the clinical picture and response rather than injury grade determined by imaging studies [47]. These recommendations were updated in 2023, with more extensive guidelines focused on blunt liver and spleen injuries. Management strategies were streamlined and simplified, with focused measures including blood transfusions only for hemoglobin < 7 g/dL or signs of ongoing hemorrhage, angioembolization or surgical intervention only in the setting of continued instability after resuscitation, and follow-up imaging required only for patients with persistent symptoms [48].

Studies have also determined that pediatric patients with trauma-related injuries tend to have better outcomes when treated at verified pediatric trauma centers compared to adult-focused or unverified children’s hospitals [52]. This is true for both operative management and NOM of pediatric solid organ injuries. The non-operative approach has been shown to be appropriate for patients with reassuring physical examinations and a small amount of isolated free intraperitoneal fluid seen on initial abdominal CT scans [9]. Many studies have also shown that for clinically stable patients with low-grade solid organ injuries on CT scan following blunt abdominal trauma, a period of observation in the emergency department with subsequent discharge home after careful discussion of return precautions is safe and could greatly reduce healthcare burden in treating these injuries [53–55]. In this section, this review will provide an overview of specific abdominal solid organ injuries and related management strategies with a focus on NOM (Table 1). Despite differences in specific recommendations, guidelines broadly support non-operative management for hemodynamically stable patients and emphasize clinical status over radiographic injury grade alone when guiding management decisions. Differences remain regarding follow-up imaging and post-injury activity restrictions.

Table 1. Major solid organ injuries with workup and management strategy summaries.

Injury-Specific Workup		Non-Operative Management Criteria	Procedural Intervention Criteria
Liver	CT with IV contrast remains the gold standard for diagnosis.	Hemodynamically stable OR responsive to resuscitation if initially hemodynamically unstable.	Consider angioembolization for those requiring ongoing resuscitation AND active bleeding; active bleeding alone is not an indication for intervention.
	Hemoglobin only as needed when admitted to the floor, OR with a change in clinical condition. Hemoglobin every 6 h in the ICU until stable [48,49].	No in-hospital activity restrictions for patients admitted to the floor. Transfusion for hemoglobin < 7 g/dL. ICU admission for initially hemodynamically unstable and those requiring ongoing resuscitation, keep NPO until stable [48,49].	Operative intervention for hemodynamic instability and active bleeding if unable to be managed by angioembolization or if angioembolization not available [48,56].

Table 1. Cont.

	Injury-Specific Workup	Non-Operative Management Criteria	Procedural Intervention Criteria
Spleen	The same as for liver injury—CT with IV contrast for diagnosis, hemoglobin as needed on the floor and every 6 h in the ICU [48,49].	The same as for liver injury—if hemodynamically stable OR responsive to resuscitation, no activity restrictions, transfusion for hemoglobin < 7 g/dL, ICU admission for unstable patients. Safe with concurrent traumatic brain injury [57].	The same as for liver injury—angioembolization vs. operative intervention for active bleeding and hemodynamic instability depending on resources. Aim for splenic salvage whenever possible. If the patient is rendered asplenic or hyposplenic via intervention, they should be vaccinated against encapsulated organisms 14 days post-intervention or before discharge [57].
Kidney	The same as for liver and spleen injuries—CT with IV contrast and delayed images for diagnosis, hemoglobin as needed on the floor and every 6 h in the ICU [47]. Urinalysis to examine for hematuria [47,58]. Can substitute contrast-enhanced or echo Doppler ultrasound in hemodynamically stable patients or those with only microscopic hematuria [58].	The same as for liver injury—if hemodynamically stable OR responsive to resuscitation, no activity restrictions, transfusion for hemoglobin < 7 g/dL, ICU admission for unstable patients [47]. If urinoma or urinary leak is present but asymptomatic, this can be monitored with NOM [59–62].	Selective angioembolization is the first line over operative intervention for ongoing or delayed bleeding in stable patients, even with high-grade injuries [63]. Urinomas should be drained first using percutaneous techniques, then apply an endoscopic urethral stent if ongoing high output through the drain [59–62].
Pancreas	Serum lipase and amylase to screen for possible injury [64,65]. Imaging for suspicious mechanism and elevated serum markers—MRI if available [66]. Consider ERCP for imaging and intervention if ductal injury suspected [66].	Hemodynamically stable OR responsive to resuscitation if hemodynamically unstable. Reasonable for low-grade injuries up to Grade 3 [67–70]. Peripancreatic fluid collections/pseudocysts can be observed but may require intervention [71–74].	ERCP may act as a diagnostic and therapeutic method in cases of high-grade pancreatic duct injury [67]. Hemodynamic instability or peritonitis indicates the need for operative intervention [75]. The need for resection vs. damage control surgery with wide drainage in high-grade injuries is under debate [68–70].

4.1. Blunt Liver Injury

NOM has been utilized in pediatric blunt liver injury since the 1960s, but with a wide range of other care provided to these patients, as well as variable conversions to operative management [50]. The American Association for the Surgery of Trauma (AAST) has developed grading scales for traumatic injury, including organ-specific scales. The grading for traumatic liver injury includes: Grade 1—subcapsular hematomas <10% of the area of the liver, parenchymal lacerations < 1 cm in depth, or capsular tears; Grade 2—subcapsular hematomas 10–50% of the surface area, intraparenchymal hematoma <10 cm in diameter, or parenchymal laceration 1–3 cm in depth and <10 cm in length; Grade 3—subcapsular hematomas > 50% in surface area, ruptured subcapsular or parenchymal hematomas, intact intraparenchymal hematomas >10 cm, lacerations >3 cm deep, or any liver vascular injury or active bleeding contained within the liver parenchyma; Grade 4—any parenchymal disruption involving 25–75% of a hepatic lobe or active bleeding extending beyond the liver parenchyma and extending into the peritoneum; and Grade 5—parenchymal disruption > 75% of a hepatic lobe or juxtahepatic venous injury including injury to the retrohepatic vena cava and central major hepatic veins [76]. The first APSA guidelines for solid organ injury published in 2000 recommended differences in management based on injury grade. ICU admission was recommended for patients with AAST Grade 4 injuries,

with hospital length of stay calculated in days as the grade of injury plus one, and duration of activity restrictions calculated as two weeks plus the grade of injury. However, they did not recommend any additional pre- or post-discharge imaging after initial diagnostic imaging, regardless of injury grade, in the absence of persistent symptoms or signs of clinical instability [50]. The Arizona-Texas-Oklahoma-Memphis-Arkansas Consortium, comprising Level I pediatric trauma centers across the United States, published guidelines in 2015 that provided recommendations based on evidence gathered over 15 years. They recommended that pediatric blunt liver injuries be managed based on hemodynamic status rather than AAST injury grade, and this included bedrest shortened to a one-day period for hemodynamically stable patients with unchanged hemoglobin levels, a transfusion threshold of hemoglobin of 7.0 g/dL for patients undergoing NOM, and consideration for surgery or urgent angioembolization in unstable patients if the hospital has the appropriate resources, otherwise recommending ongoing NOM [49].

The 2019 APSA guideline update reaffirmed their previous hospital stay and post-injury imaging recommendations but also discussed non-invasive management such as angioembolization, noting that this was only necessary in the setting of active bleeding with hemodynamic instability [47]. In 2023, APSA published specific liver injury updates and further specifications for inpatient management that were similar to the ATOMAC guidelines in their focus on clinical status [48]. This changed the ICU admission recommendation that previously was in place for all-grade IV injuries, stating that only patients who were hemodynamically unstable and not responsive to resuscitation required ICU admission. They further specified that during initial admission, ICU patients should be on bedrest until their vitals have normalized, should have their hemoglobin levels drawn every 6 h, and should be kept NPO until hemodynamically stable. Once on the regular inpatient floor, no activity restrictions or further hemoglobin levels were recommended, with labs only being drawn as needed for clinical changes and patients being provided with a regular diet. They did not recommend routine blood transfusions for patients admitted with blunt liver injuries, except for patients with a hemoglobin level of <7 g/dL with signs of ongoing bleeding or hemodynamic instability. Addressing the growing use of angioembolization, APSA recommended its use in patients with blunt liver injury with signs of ongoing hemorrhage and non-response to transfusion, but not for the presence of active extravasation on CT without hemodynamic instability. Only if these strategies fail would operative management be required. These updated guidelines also gave recommendations around discharge and follow-up, changing the recommendations for discharge date to be based on clinical condition rather than injury grade, confirming follow-up imaging only as needed for ongoing symptoms, and calculating the activity restriction period as AAST injury grade plus 2 weeks. These specific recommendations and emphasis on NOM gave pediatric trauma teams structured guidance to follow regarding blunt liver injury.

The World Society of Emergency Surgery (WSES) published slightly adjusted organ injury grades, correlating these to the AAST grading system, with minor or Class 1 WSES injury correlating to AAST Grades 1–2, moderate or Class 2 WSES injury correlating to AAST Grade 3, and severe or Class 3 WSES injury correlating to AAST Grades 4–5 for liver injuries [56]. Their recommendations are focused more on adult trauma patients but also include some pediatric-specific recommendations. Namely, they recommend NOM as the optimal management of blunt liver injury patients and consideration of the use of CEUS or CT scan in lieu of eFAST, which has a lower sensitivity in hemodynamically stable pediatric patients, and they note that angioembolization has been associated with an increased rate of failure of NOM in pediatric patients but that the presence of active extravasation in the absence of hemodynamic instability may be associated with higher rates of pseudoaneurysm formation. The majority of liver injuries can be managed non-operatively,

but approximately 3% require conversion to laparotomy, and WSES recommends that this occur for patients who exhibit hemodynamic instability and fail to respond to NOM and appropriate resuscitation [56,77]. Other organizations, such as the Eastern Association for the Surgery of Trauma (EAST), have guidelines regarding management of blunt liver injury and recommend NOM for hemodynamically stable patients but do not specifically give recommendations for the pediatric population [78].

4.2. Blunt Splenic Injury

Splenic injury has been managed using NOM in the pediatric setting for many years. Given the high mortality associated with overwhelming post-splenectomy infection (OPSI) in pediatric patients, pediatric surgeons pioneered NOM long before it was accepted in the management of adult trauma, and with positive outcomes [79]. As the rate of delayed splenic bleeding in pediatric patients is lower than in adults at approximately 0.2–0.3%, NOM is a much more reasonable option and has been proven safe over many years, with low rates of failure of only 3% [80,81]. Many of the guidelines for blunt splenic injury mirror those for blunt liver injury, including the AAST grades [76]. The APSA guidelines, including the most recent 2023 guidelines, group liver and spleen injuries together in their recommendations [48,50]. The ATOMAC guidelines similarly group both blunt splenic and liver injuries and maintain the same recommendations [49]. The EAST guidelines again do not offer pediatric-specific recommendations but do emphasize NOM for hemodynamically stable patients with CT as the initial evaluation modality [82].

The WSES guidelines again offer minor, moderate, and severe classifications of injuries, with a notable difference in grading from the liver guidelines in the severe category. The Class 4 or severe WSES splenic injury category includes AAST Grade 4–5 injuries or any injury with the presence of hemodynamic instability, essentially bypassing the grade of injury in the presence of clinical signs [57]. These guidelines also offer specific pediatric guidance including NOM as the first-line treatment for hemodynamically stable patients as long as a center has the appropriate capabilities for monitoring and rapid access to intervention if needed. The WSES guidelines also recommend that if adequate resources are not available or if the patient has a moderate to severe injury, they should be transferred to a dedicated pediatric trauma center. Additionally, they confirm that NOM is safe in patients with concurrent traumatic brain injury. They also remark on more specific management, including using US as the initial imaging modality (although CT remains the gold standard), the need for bedrest for 24 h in stable splenic injury patients, and agreement with other guidelines in that extravasation on imaging is not necessarily an indication for angioembolization if the patient is otherwise clinically stable without peritonitis. Additionally, there is agreement with a stated minimum of 6 weeks of activity restriction for those patients with moderate to severe injuries, slightly longer for certain injury grades than the APSA guidelines. Additionally, they offer guidelines for vaccine administration in patients who require splenectomy or angioembolization following injury, rendering them at risk of OPSI. They recommend vaccination against encapsulated organisms (*Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Neisseria meningitidis*) 14 days following intervention; however, if patients will be discharged before 15 days, then it is acceptable to administer vaccinations earlier. They additionally recommend antibiotic prophylaxis with amoxicillin–clavulanic acid for any unexplained fever, malaise, or chills, as well as an annual flu vaccine, and finally malaria prophylaxis when required for travel. Despite these recommendations, determining the optimal timing of intervention remains challenging in patients who initially respond to resuscitation but subsequently demonstrate progressive hemodynamic deterioration during non-operative management. One retrospective study found that earlier arterial embolization in selected pediatric patients

with ongoing hemorrhage was associated with shorter intensive care unit and hospital stays, reduced transfusion requirements, and lower hospital costs, although these findings require validation in larger multicenter studies [83].

4.3. Blunt Renal Injury

Management of renal injury, as with other blunt abdominal injury management, has trended toward NOM, even with high-grade injuries [59]. The AAST scale of kidney injury includes injury Grades 1–5: Grade 1—subcapsular hematoma < 3.5 cm without active bleeding and parenchymal contusion without laceration; Grade 2—parenchymal laceration < 2.5 cm or hematoma rim distance (HRD; the distance between the parenchyma and the hematoma edge) of <3.5 cm without active bleeding; Grade 3—parenchymal laceration > 2.5 cm, HRD > 3.5 cm without active bleeding, partial kidney infarction, vascular injury without active bleeding, and laceration extending into the urinary collecting system and/or urinary extravasation; Grade 4—active bleeding from the kidney, pararenal extension of a hematoma, complete or near complete kidney infarction without active bleeding, multi-fragmented kidney (MFK) without active bleeding, or complete or near complete ureteropelvic junction disruption; and Grade 5—main renal artery or vein laceration or transection with active bleeding, complete or near complete kidney infarction with active bleeding, or MFK with active bleeding [84]. Aside from the differences in this scale compared to that for liver and splenic injuries, there are additional clinical signs that may guide the need for imaging or intervention in these injuries that are not present in liver or splenic injury, namely, the presence of hematuria, be it micro- or macroscopic. The APSA 2019 guidelines for renal injury group it together with splenic and liver injuries, with similar management [47]. The EAST and Pediatric Trauma Society (PTS) joint guidelines published in 2019 specifically focus on blunt pediatric renal trauma, but their recommendations center on NOM for hemodynamically stable patients and recommend angioembolization over surgery for ongoing or delayed bleeding in stable patients with high-grade injuries (AAST 3–5) [63].

The joint WSES and AAST recommendations from 2019 contain recommendations regarding workup surrounding hematuria as well as pediatric-specific recommendations [58]. In pediatric patients with a high suspicion for kidney injury, either due to the mechanism or due to the presence of hematuria >50 RBCs/high-powered field (HPF), CT is recommended to evaluate for injury. It is also noted that US, including contrast-enhanced and echo Doppler US, can safely be utilized as an alternative to CT in pediatric patients who are stable or in those with mild symptoms, microhematuria (<50 RBCs/HPF), and no other indication for CT scan. They otherwise agree with the use of NOM in stable patients or patients who are responsive to resuscitation. These guidelines highlight the use of selective angiography and agree with the EAST/PTS guidelines on using angioembolization as the first-line treatment even in the setting of labile hemodynamics with ongoing bleeding.

A unique complication associated with renal injury is urinary leak and urinoma. The American Urological Association (AUA) 2020 Urotrauma guidelines do not have pediatric-specific recommendations but note that while urinary extravasation can initially be managed by NOM, if patients develop an enlarging urinoma or symptoms including fever, pain, ileus, fistula, or infection, they will require drainage [60]. In a pediatric-specific review of Grade 4 renal trauma, they note that urinomas can be drained using percutaneous techniques, endoscopic ureteral stent placement, or both [59]. They do recommend percutaneous drainage as the first step in pediatric patients given the need for anesthesia with removal of a urethral stent. If the percutaneous drainage continues to have high output, they then recommend urethral stent placement. The need for intervention with this complication varies from 9% to 45% [61,62].

4.4. Blunt Pancreatic Injury

Pancreatic injuries are relatively uncommon in pediatric trauma, with rates of injury of <1% [85,86]. Serum amylase and lipase may be used to screen for injuries and prompt the trauma team to obtain imaging; however, only a 3.6% risk of intra-abdominal injury occurs with abnormal results when identified, indicating a low predictive value for these laboratory studies [64]. Additionally, although serum amylase and lipase may be elevated in patients with pancreatic injury, they do not correlate with the degree of pancreatic injury [65]. The AAST scale for pancreatic injury ranges from Grades 1 to 5: Grade 1—minor contusion or superficial laceration; Grade 2—major contusion or laceration, both without ductal injury or tissue loss; Grade 3—distal transection or parenchymal injury with duct injury; Grade 4—proximal transection or parenchymal injury involving the ampulla; and Grade 5—massive disruption of the pancreatic head [87]. The WSES guidelines have some recommendations regarding pediatric-specific pancreatic injury, but otherwise, no pediatric-specific guidelines exist. The WSES guidelines recommend MRI for initial evaluation for pancreatic injury in pediatric patients if available and note that care of patients with duodenal–pancreatic injuries should only be managed at trauma centers [66]. They additionally recommend that endoscopic retrograde cholangiopancreatography (ERCP) be used as a diagnostic and treatment modality in hemodynamically stable patients. However, when compared to NOM, patients who undergo ERCP do not appear to have clinically significantly different outcomes [67,88].

For patients with higher-grade injuries (AAST Grade 3 and above), there is debate regarding whether to manage them non-operatively or with surgical intervention. For Grade 3 injuries, NOM is an option, but practice varies by institution [68]. The Western Trauma Association (WTA) 2023 guidelines recommend operative exploration for any patient with moderate to large peripancreatic fluid collections and evidence of ductal injury on initial presentation, as well as those patients who have other indications for operative exploration [75]. However, these guidelines are only specific to adults. The utility of distal pancreatectomy or other resection vs. wide drainage is still being investigated in adults [75]. However, in children, these higher-grade injuries have been treated with NOM without adverse outcomes [68]. Additionally, more conservative surgical management, such as damage control surgery with drain placement, may be effective in pediatric patients with high-grade injuries. In two recent studies, pediatric patients admitted with high-grade injuries were successfully treated with NOM or minimally invasive drainage procedures, with only two of 36 and two of 51 requiring surgical intervention to address their pancreatic injuries [69,70]. In pediatric patients with higher-grade injuries, ERCP for stenting across ductal injuries may also be an option, as demonstrated by Gong et al. [67].

There is a high rate of peripancreatic fluid collections and/or pseudocyst formation following injury, with one case series reporting an incidence of 83%, with 60% requiring surgical intervention [71]. At the same time, these fluid collections can resolve spontaneously [72]. Pediatric patients who have undergone observation for pancreatic fluid collections vs. drainage have no difference in hospital length of stay (LOS), time to regular diet, TPN use, or need for definitive drainage, according to one multi-institutional retrospective review [73]. Seventy percent of patients who underwent NOM experienced spontaneous resolution of fluid collections. Patients with larger collections of >7 cm had a longer LOS and time to regular diet but otherwise did not require further definitive interventions [73]. Results are mixed, with one multicenter study reporting patients with NOM being more likely to form pseudocysts and having increased length of stay, longer time to goal oral feeds, and increased time to resolution of the pseudocysts [74]. While the need for surgical intervention in pediatric patients with blunt pancreatic injuries is

not as well defined as other solid organ injuries, there is evidence of positive resolution of symptoms with NOM.

4.5. Blunt Adrenal Injury

Adrenal injuries are exceedingly rare, with reported rates as low as 0.2–4.95% [89–91]. No guidelines for management of adults or pediatric patients exist. The AAST grading scale for adrenal trauma ranges from Grade 1 to Grade 5: Grade 1—contusion; Grade 2—laceration only involving the cortex (<2 cm); Grade 3—lacerations extending into the medulla (>2 cm); Grade 4—>50% parenchymal destruction; and Grade 5—total parenchymal disruption and avulsion from blood supply with massive intraparenchymal hemorrhage [92]. In a review of 8064 pediatric patients with adrenal trauma in the National Trauma Data Bank, the presence of adrenal injury being associated with an adverse outcome was only seen with polytrauma [93]. A single-center review over 9 years noted that only 12% of patients had isolated adrenal injuries, with most having associated liver, head, and skeletal injuries [91]. None of these patients required adrenalectomy, adrenal exploration, or angioembolization. One patient presented with hemothorax, pelvic and long bone fractures, abdominal wall hematoma, and bilateral adrenal hematomas, and developed adrenal insufficiency. Overall, in adult and pediatric patients, hemodynamically stable patients can be treated with NOM, with advancement to angioembolization for active extravasation with hemodynamic instability and progression to surgery if hemostasis is unable to be achieved [94].

5. Laparoscopic vs. Open Surgery in Pediatric Trauma

With recent advancements and comforts of laparoscopic surgery, there is a growing trend to performing diagnostic laparoscopy as the initial intervention strategy in both blunt and penetrating trauma for hemodynamically stable patients [95–99]. In appropriate cases, diagnostic laparoscopy has been shown to be a safe and effective initial management tool when compared to exploratory laparotomy in both penetrating and blunt abdominal trauma [97,100]. Clinical indicators suggesting that laparoscopy will be a safe option include hemodynamic stability, appropriate physiological response to resuscitation, solid organ injuries with active extravasation not suitable for angioembolization, and failure of NOM in solid organ injuries [95,96].

When evaluating the benefits of laparoscopy versus laparotomy in hemodynamically stable adult trauma patients, Ietto et al. reinforced the well-accepted merits of laparoscopy, including shorter operative time, faster patient recovery, and decreased hospital length of stay [96]. This likely is due to a combination of factors, including reduced tissue damage during laparoscopy and decreased cell debris distribution, which in turn decreases the scale of the resulting immune response, as well as patient selection when laparoscopy is performed by experienced teams in trauma scenarios [96]. Another study in adult patients performed by Chestovich et al. compared matched cases in adult abdominal trauma, including penetrating injuries, where either exploratory laparotomy or diagnostic/therapeutic laparoscopy was chosen as the initial surgical strategy [97]. A total of 518 patients were matched 2:1 with laparotomy based on injury type and severity. There were significant differences in a number of outcomes between the two groups, with patients who received therapeutic laparoscopy experiencing fewer wound complications, fewer instances of post-operative ileus or small bowel obstruction, and shorter length of stay compared to the laparotomy group [97]. Importantly, there were no missed injuries in the laparoscopy group, reaffirming the safety and efficacy of laparoscopy for appropriately selected abdominal trauma patients.

It is important to note that similar studies have also been replicated in the pediatric trauma population. In one recent study by Mahmoud et al. in 2021, researchers investigated the efficacy of diagnostic laparoscopy for pediatric patients presenting with penetrating abdominal injuries [101]. In the setting of penetrating abdominal trauma and hemodynamic stability, 102 patients underwent laparoscopic evaluation, and only 13.2% of patients required conversion to open exploration. In this cohort, there were no missed injuries that required subsequent imaging or intervention [101]. Another study from 2020 by Butler et al. specifically focused on laparoscopy vs. laparotomy in pediatric blunt abdominal trauma [102]. Utilizing the National Trauma Data Bank, the authors identified 720 pediatric patients treated surgically for blunt abdominal injuries, of which 70.0% underwent primary laparotomy, and 30.0% underwent initial diagnostic laparoscopy. Of the 216 patients who underwent primary diagnostic laparoscopy, 38.9% required conversion to laparotomy for definitive injury management, while the remaining 132 patients were successfully managed with laparoscopy alone [102]. Importantly, the authors identified that use of laparoscopy alone helped to avoid 61 negative laparotomies and, if diagnostic laparoscopy had been implemented in all patients, 106 patients would have avoided negative laparotomies. Laparoscopy in their patient cohort was also associated with shorter length of stay and decreased rates of surgical site infections [102]. Finally, a meta-analysis was performed in 2022, analyzing nine different studies for both blunt and penetrating abdominal injuries in over 12,000 pediatric patients [103]. In this study, Park et al. found that laparoscopy for hemodynamically stable patients with traumatic intra-abdominal injuries was associated with younger patient age, shorter hospital and ICU lengths of stay, fewer complications, and lower mortality rates when compared to those undergoing exploratory laparotomy. Additionally, in all studies that included and assessed occurrence of missed injuries, there were no missed injuries in the laparoscopy groups [103]. Ongoing investigation is needed to further refine patient selection criteria and indications for laparoscopic vs. open operative intervention. Surgeon preferences and institutional resources may also affect operative selection.

Currently, laparoscopy has been well established in both adult and pediatric populations to be a safe and effective primary surgical modality in abdominal trauma, specifically for hemodynamically stable patients. Although multiple-port-site surgery is the current standard for diagnostic and therapeutic laparoscopy, there are some studies looking to decrease port sites, including single-site trocar, in trauma settings [104]. As medical advancements continue to be made and technological capabilities continue to progress, there may come a time when laparoscopy can also be utilized in unstable patients. However, exploratory laparotomy remains the primary assessment and management strategy, and damage control surgery remains the guiding principle for unstable patients with intra-abdominal injuries.

6. Conclusions

Pediatric trauma continues to be a leading cause of morbidity and mortality, with solid organ injuries being the most frequent injuries diagnosed. Diagnostic and interventional technologies have advanced significantly in recent decades and allow for rapid identification of solid organ injuries, providing opportunities for minimally invasive or non-operative management. Collectively, contemporary guidelines increasingly support management strategies guided by clinical status and physiologic response rather than radiographic injury grade alone. These tools, as well as open and laparoscopic surgical intervention strategies, allow pediatric surgeons to provide life-saving care and to improve outcomes for pediatric trauma patients across the United States.

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Abbreviations

The following abbreviations are used in this manuscript:

AAST	American Association for the Surgery of Trauma
ACS	American College of Surgeons
APSA	American Pediatric Surgical Association
ATLS	Advanced Trauma Life Support
CDC	Centers for Disease Control
CEUS	Contrast-enhanced ultrasonography
ED	Emergency department
FAST	Focused Assessment Sonography in Trauma
GCSm	Glasgow Coma Score motor
ICU	Intensive care unit
MVC	Motor vehicle collision
NOM	Non-operative management
PHIS	Pediatric Health Information Systems
PTS	Pediatric Trauma Society
SIPA	Pediatric age-adjusted shock index
US	Ultrasonography
WISQARS	Web-based Injury Statistics Query and Reporting System
WSES	World Society of Emergency Surgery

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