

## **NTRAP PEDIATRIC TRAUMA LITERATURE REVIEW**

### **ORIGINAL RESEARCH ARTICLES**

**01. Clinical trials for pediatric traumatic brain injury: definition of insanity?** J Neurosurg Pediatr. 2019 Jun 1;23(6):661-669. doi: 10.3171/2019.2.PEDS18384. Appavu B, et al.

PDF: [Read the PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/31153150>

Traumatic brain injury (TBI) is a leading cause of morbidity and mortality in children both in the United States and throughout the world. Despite valiant efforts and multiple clinical trials completed over the last few decades, there are no high-level recommendations for pediatric TBI available in current guidelines. In this review, the authors explore key findings from the major pediatric clinical trials in children with TBI that have shaped present-day recommendations and the insights gained from them. The authors also offer a perspective on potential efforts to improve the efficacy of future clinical trials in children following TBI.

**02. Recent Advances in Pediatric Concussion and Mild Traumatic Brain Injury.** Pediatr Clin North Am. 2018 Dec;65(6):1151-1166. doi: 10.1016/j.pcl.2018.07.006. Almeida AA, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30446054>

Concussions after a head injury among children continues to be a substantial public health concern. An increasing number of concussions are being managed initially by primary care physicians. The diagnosis of concussion remains a clinical diagnosis despite the availability of ancillary tests such as computerized neuropsychological testing, advanced imaging, and blood biomarkers. Clinically, overlooking other injuries and comorbidities may lead to prolonged recovery for the patient. Addressing concussions in a multidisciplinary approach may help in reducing recovery time for patients. Retirement from sport in the pediatric population remains a controversial issue lacking evidenced-based studies.

**03. Children With Severe Traumatic Brain Injury, Intracranial Pressure, Cerebral Perfusion Pressure, What Does it Mean? A Review of the Literature.** Pediatr Neurol. 2019 May;94:3-20. doi:

10.1016/j.pediatrneurol.2018.12.003. Epub 2019 Jan 11. Lovett ME, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30765136>

Severe traumatic brain injury is a leading cause of morbidity and mortality in children. In 2003 the Brain Trauma Foundation released guidelines that have since been updated (2010) and have helped standardize and improve care. One area of care that remains controversial is whether the placement of an intracranial pressure monitor is advantageous in the management of traumatic brain injury. Another aspect of care that is widely debated is whether management after traumatic brain injury should be based on intracranial pressure-directed therapy, cerebral perfusion pressure-directed therapy, or a combination of the two. The aim of this article was to provide an overview and review the current evidence regarding these questions.

**04. Pediatric Traumatic Brain Injury and Associated Topics: An Overview of Abusive Head Trauma, Nonaccidental Trauma, and Sports Concussions.** Anesthesiol Clin. 2019 Mar;37(1):119-134. doi:

10.1016/j.anclin.2018.10.002. Smith EB, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30711225>

Pediatric traumatic brain injury (TBI) uniquely affects the pediatric population. Abusive head trauma (AHT) is a subset of severe pediatric TBI usually affecting children in the first year of life. AHT is a form of nonaccidental trauma. Sports-related TBI resulting in concussion is a milder form of TBI affecting older children. Current recommended perioperative management of AHT and sports concussions relies on general pediatric TBI guidelines. Research into more specific pediatric TBI screening and management goals is ongoing. This article reviews the epidemiology, mechanisms, clinical signs, and management of AHT and sports-related concussions.

**05. Head and Cervical Spine Evaluation for the Pediatric Surgeon.** Surg Clin North Am. 2017 Feb;97(1):35-58. doi: 10.1016/j.suc.2016.08.003. Arbuthnot MK, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/27894431>

This article is designed to guide pediatric surgeons in the evaluation and stabilization of blunt head and cervical spine injuries in pediatric patients. Trauma remains the number one cause of morbidity and mortality among children, and the incidence of head injuries continues to rise. Cervical spine injuries, on the other hand, are unusual but can be devastating if missed. This article highlights the pathophysiology unique to pediatric head and cervical spine trauma as well as keys to clinical and diagnostic evaluation.

**06. Pediatric Cervical Spine Clearance: A Consensus Statement and Algorithm from the Pediatric Cervical Spine Clearance Working Group.** J Bone Joint Surg Am. 2019 Jan 2;101(1):e1. doi: 10.2106/JBJS.18.00217. Herman MJ, et al.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/30601421>

No abstract

**07. Pediatric thoracic trauma: Current trends.** Semin Pediatr Surg. 2017 Feb;26(1):36-42. doi: 10.1053/j.sempedsurg.2017.01.007. Epub 2017 Jan 11. Pearson EG, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28302283>

Pediatric thoracic trauma is relatively uncommon but results in disproportionately high levels of morbidity and mortality when compared with other traumatic injuries. These injuries are often more devastating due to differences in children's anatomy and physiology relative to adult patients. A high index of suspicion is of utmost importance at the time of presentation because many significant thoracic injuries will have no external signs of injury. With proper recognition and management of these injuries, there is an associated improved long-term outcome. This article reviews the current literature and discusses the initial evaluation, current management practices, and future directions in pediatric thoracic trauma.

**08. Pediatric Cardiac Trauma in the United States: A Systematic Review.** World J Pediatr Congenit Heart Surg. 2018 Mar;9(2):214-223. doi: 10.1177/2150135117747488. Mylonas KS, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/29544413>

Literature discussing cardiac injuries in children is limited. Systematic search of PubMed identified 21 studies enrolling 1,062 pediatric patients who experienced cardiac trauma in the United States during the period 1961 to 2012. The predominant type of injury was blunt cardiac contusion affecting 59.7% (n = 634/1,062) of the study population. Motor vehicle crashes (53.5%, n = 391/731) were the leading cause of blunt cardiac trauma, while gunshot wounds (50%, n = 150/300) accounted for most penetrating injuries. Overall mortality rate was 35.2% (n = 374/1,062).

**09. Operative Versus Nonoperative Management of Blunt Pancreatic Trauma in Children: A Systematic Review.** *Pancreas*. 2017 Oct;46(9):1091-1097. doi: 10.1097/MPA.0000000000000916. Koh EY, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28902777>

The aim of this study was to compare operative versus nonoperative management of blunt pancreatic trauma in children. A systematic literature search was performed. Studies including children with blunt pancreatic injuries classified according to the American Association for the Surgery of Trauma classification were included. The primary outcome was pseudocyst formation. After screening 526 studies, 23 studies with 928 patients were included. Sufficient data were available for 674 patients (73%). Of 309 patients with grade I or II injuries, 258 (83%) were initially managed nonoperatively with a 96% success rate. Of 365 patients with grade III, IV, or V injuries, nonoperative management was initially chosen for 167 patients (46%) with an 89% success rate. Pseudocysts occurred in 18% of patients managed nonoperatively versus 4% of patients managed operatively ( $P < 0.01$ ), of whom 65% were treated nonoperatively. Hospitalization was 20.5 days after nonoperative versus 15.1 days after operative management (nonparametric t test,  $P = 0.41$ ). Blunt pancreatic trauma in children can be managed nonoperatively in the majority of patients with grade I or II injuries and in about half of the patients with grade III to V injuries. Although pseudocysts are more common after nonoperative management, two thirds can be managed nonoperatively.

**10. Renal Trauma in Pediatrics: A Current Review.** *Urology*. 2018 Mar;113:171-178. doi: 10.1016/j.urology.2017.09.030. Epub 2017 Oct 13. Fernández-Ibieta M.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/29032236>

Children are at increased risk of renal injuries from blunt trauma. Four-phase computed tomography with intravenous contrast (noncontrast, arterial, nephrographic, and pyelographic phases) is the choice for initial imaging, although ultrasonography might also be used in children with minimal symptoms. The American Association for the Surgery of Trauma developed the known system for renal injury grading, which was modified in 2011. The management of pediatric renal injuries has largely shifted toward conservative means. However, as long as the child remains hemodynamically unstable, renal exploration might be necessary. There is a trend toward managing high-grade injuries with interventional radiography procedures.

**11. Management of pediatric blunt renal trauma: A systematic review.** *J Trauma Acute Care Surg*. 2016 Mar;80(3):519-28. doi: 10.1097/TA.0000000000000950. LeeVan E, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/26713980>

BACKGROUND:

Blunt trauma remains a significant cause of morbidity and mortality in the pediatric population. The use of conservative management for blunt renal trauma is widely accepted in adult trauma literature and is now increasingly accepted for use in the pediatric patient population. This study aimed to review current practices in pediatric blunt renal trauma management and to highlight current practices in conservative protocols, success rates of conservative management strategies, as well as short- and long-term outcomes of blunt renal trauma management.

METHODS:

This is a systematic review of PubMed, Ovid, and the Cochrane Library. The following search was performed in each of the three databases: (Renal or Kidney) AND (Pediatric or Children)

AND Trauma AND Management. Publications were limited to publish date after January 1, 2000. Inclusion criteria were (1) original research articles regarding management of pediatric blunt renal trauma, (2) involvement of cases of high-grade renal (Grades IV and V) trauma, and (3) more than one patient presented per study. Literature reviews and meta-analyses were excluded.

**RESULTS:**

Titles and abstracts (n = 308) were screened to identify scientific articles reporting original research findings. A total of 32 articles met the selection criteria and were included in the review.

**CONCLUSION:**

The literature supports application of conservative management protocols to high-grade blunt pediatric renal trauma. Criteria for early operative intervention are not well understood. At this time, emergent operative intervention only for hemodynamic instability is recommended. Minimally invasive interventions including angioembolization, stenting, and percutaneous drainage should be used when indicated. Short- and long-term outcomes are favorable when using conservative management approaches to Grade IV and V renal injuries. Further studies including prospective studies and randomized control trials are necessary. Cost analyses of current treatment protocols are also necessary to guide efficient management strategies.

**12. Child abuse and the pediatric surgeon: A position statement from the Trauma Committee, the Board of Governors and the Membership of the American Pediatric Surgical Association.** J Pediatr Surg. 2019 Jul;54(7):1277-1285. doi: 10.1016/j.jpedsurg.2019.03.009. Epub 2019 Mar 21. Escobar MA Jr, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30948199>

**BACKGROUND:**

The pediatric surgeon is in a unique position to assess, stabilize, and manage a victim of child physical abuse (formerly nonaccidental trauma [NAT]) in the setting of a formal trauma system.

**METHODS:**

The American Pediatric Surgical Association (APSA) endorses the concept of child physical abuse as a traumatic disease that justifies the resource utilization of a trauma system to appropriately evaluate and manage this patient population including evaluation by pediatric surgeons.

**RESULTS:**

APSA recommends the implementation of a standardized tool to screen for child physical abuse at all state designated trauma or ACS verified trauma and children's surgery hospitals. APSA encourages the admission of a suspected child abuse patient to a surgical trauma service because of the potential for polytrauma and increased severity of injury and to provide reliable coordination of services.

Nevertheless, APSA recognizes the need for pediatric surgeons to participate in a multidisciplinary team including child abuse pediatricians, social work, and Child Protective Services (CPS) to coordinate the screening, evaluation, and management of patients with suspected child physical abuse. Finally, APSA recognizes that if a pediatric surgeon suspects abuse, a report to CPS for further investigation is mandated by law.

**CONCLUSION:**

APSA supports data accrual on abuse screening and diagnosis into a trauma registry, the NTDB and the Pediatric ACS TQIP® for benchmarking purposes and quality improvement.

**13. Non-accidental trauma: A national survey on management.** Injury. 2018 May;49(5):921-926. doi: 10.1016/j.injury.2018.03.006. Epub 2018 Mar 10. Sola R Jr, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/29555082>

#### INTRODUCTION:

Non-accidental trauma (NAT) has significant societal and health care implications. Standardized care has been shown to improve outcomes. The purpose of our study was to survey trauma centers and elucidate the continued variable management of NAT.

#### METHODS:

After institutional review board approval, an email survey was sent to Level 1 and 2 ACS verified trauma centers along with general and pediatric surgery training programs. Trauma hospital characteristics and NAT management were analyzed.

#### RESULTS:

A total of 493 emails were sent and 91 responses (18%) were received. There were 74 (81%) pediatric surgeons who responded and 15(17%) adult general surgeons. The most common location of respondents were children's hospitals within academic/community hospitals (58%) followed by stand-alone children hospitals (42%), and adult only hospitals (9%). 51 (57%) providers reported using a screening tool; most commonly used by the emergency department (52%). 75% of providers reported utilizing management protocols in which 71% were initiated by trauma surgery. The most common consulting and admitting service for NAT was trauma surgery (86% and 84%). When comparing stand-alone and affiliated children hospitals, there was no difference in the use of a screening tool (54% vs. 59%;  $p = 0.84$ ), and management protocol (70% vs. 85%;  $p = 0.19$ ). However, those providers from pediatric trauma centers used a management protocol more often than providers from adult trauma centers (78% vs. 38%;  $p = 0.04$ ). No providers from adult trauma centers had intentions to initiate a management protocol in the future.

#### CONCLUSION:

Screening and management of non-accidental trauma continues to vary across the country. Future studies focusing on standardization and outreach/education to adult trauma centers is warranted.

**14. Firearm injuries and children: Position statement of the American Pediatric Surgical Association.** J Pediatr Surg. 2019 Jul;54(7):1269-1276. doi: 10.1016/j.jpedsurg.2019.03.001. Epub 2019 Apr 9. Petty JK, et al; APSA Board of Governors.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/31235607>

Firearm injuries are the second most common cause of death in children who come to a trauma center, and pediatric surgeons provide crucial care for these patients. The American Pediatric Surgical Association (APSA) is committed to comprehensive pediatric trauma readiness, including firearm injury prevention. APSA supports a public health approach to firearm injury, and it supports availability of quality mental health services. APSA endorses policies for universal background checks, restrictions on assault weapons and high capacity magazines, strong child access protection laws, and a minimum purchase age of 21 years. APSA opposes efforts to keep physicians from counseling children and families about firearms. APSA promotes research to address this problem, including increased federal research support and research into the second victim phenomenon. APSA supports school safety and readiness, including bleeding control training. While it may be daunting to try to reduce firearm deaths in children, the U.S. has seen success in reducing motor vehicle deaths through a multidimensional approach - prevention, design, policy, behavior, trauma care. APSA believes that a similar public health approach can succeed to save children from death and injury from firearms. APSA is committed to building partnerships to accomplish this. TYPE OF STUDY: APSA Position Statement. LEVEL OF EVIDENCE: Level V, Expert Opinion.

**15. Tourniquet usage in prehospital care and resuscitation of pediatric trauma patients- Pediatric Trauma Society position statement.** J Trauma Acute Care Surg. 2018 Oct;85(4):665-667. doi: 10.1097/TA.0000000000001839. Cunningham A, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/29462083>

**BACKGROUND:**

Recent mass casualty events in the United States have highlighted the need for public preparedness to prevent death from uncontrolled hemorrhage. The Pediatric Trauma Society (PTS) reviewed the literature regarding pediatric tourniquet usage with the aim to provide recommendations about the utility of this adjunct for hemorrhage control in children.

**METHODS:**

Search terms "pediatric" and "tourniquet" were used to query the US National Library of Medicine National Institutes of Health for pertinent literature. Exclusion criteria include not involving children, not involving the use of an extremity tourniquet, primary outcomes not related to hemorrhage control, tourniquet use to prevent snake envenomation, single case reports, and only foreign language formats available. Bibliographies of remaining studies reviewed to identify additional pertinent research. Four physician members of the PTS Guidelines Committee reviewed identified studies.

**RESULTS:**

One hundred thirty-four studies were identified. One hundred twenty-three studies were excluded. Seven additional studies were identified through bibliography review. Eighteen pertinent studies were reviewed. Seven articles evaluated physiologic response to tourniquet use in operating room settings. Six articles were generated from combat experience in conflicts in Afghanistan and Iraq. Four articles discussed technical details of tourniquet usage. One article evaluated the use of tourniquets during the Boston Marathon bombing in 2015.

**CONCLUSION:**

Despite limited data of limited quality regarding their use, the PTS supports the usage of tourniquets in the prehospital setting and during the resuscitation of children suffering from exsanguinating hemorrhage from severe extremity trauma. Expedited, definitive care must be sought, and tourniquet pressure and time should be limited to the least amount possible. The Society supports the ACS "Stop the Bleed" campaign and encourages further investigation of tourniquet use in children.

**16. Issues in Pediatric Craniofacial Trauma.** Facial Plast Surg Clin North Am. 2017 Nov;25(4):581-591. doi: 10.1016/j.fsc.2017.06.009. Chandra SR, Zemplenyi KS.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28941510>

Pediatric maxillofacial fractures are rare owing to anatomic differences between juvenile and adult skulls. Children's bone is less calcified, allowing for "greenstick fractures." The overall ratio of cranial to facial volume decreases with age. In children, tooth buds comprise the majority of mandibular volume. The most common pediatric craniomaxillofacial fractures for children ages 0 to 18 years old are mandible, nasal bone, and maxilla and zygoma. Growth potential must be considered when addressing pediatric trauma and often a less-is-more approach is best when considering open versus closed treatment. Regardless of treatment, pediatric trauma cases must be followed through skeletal maturity.

**17. Clinical considerations for blunt laryngotracheal trauma in children.** J Pediatr Surg. 2017 May;52(5):874-880. doi: 10.1016/j.jpedsurg.2016.12.019. Epub 2016 Dec 30. Cheng J, et al.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/28069269>

**OBJECTIVE:**

Systematic review of blunt pediatric laryngeal and tracheal trauma and development of proposed evaluation and management strategy.

**STUDY DESIGN:**

Systematic review and proposed clinical consideration algorithm.

**DATA SOURCES:**

PubMed, EMBASE, Web of Science, and Cochrane Central Register of Controlled Trials.

**REVIEW METHODS:**

A medical librarian was utilized.

**RESULTS:**

329 titles and abstracts were identified, and 50 reports were included. A total of 66 children were identified, with a majority of males (76.1%). Average age was 9.5±4.4years [range 2-17]. CT was employed in 66.7% of cases. False negative CT occurred in 29.5% of cases. Treatment consisted of observation (9.1%), endoscopy alone (31.8%), endoscopic repair (7.6%), and open neck exploration with repair/open reduction internal fixation (ORIF) (51.5%). Tracheotomy was utilized in 33.3% of the cases. Mortality was rare, with only one (1.5%) reported and occurred within one hour after presentation.

**CONCLUSIONS:**

Significant deviation and variation from recommended previously proposed management algorithms exists in reported cases. Awareness of the natural clinical history, potential for severe morbidity or mortality, and associated complications are extremely important. CT and fiberoptic, bedside laryngoscopy may not play a significant role but may add to clinical evaluation prior to operative intervention. If employed, care must be taken to not create an unstable clinical scenario. Operative endoscopy is recommended in cases with positive physical examination findings, and treatment tailored to extent of injury.

**18. Overview of current pediatric burn care.** Semin Pediatr Surg. 2015 Feb;24(1):47-9. doi: 10.1053/j.sempedsurg.2014.11.008. Epub 2014 Nov 7. Gonzalez R, Shanti CM.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/25639810>

Burn injuries affect approximately a million children in the United States on an annual basis. Moderate to severe burns require hospitalization, usually under the direction of a Pediatric Surgical service. Despite advancements in burn treatment, pediatric burn injuries account for approximately 2500 deaths annually. This article provides an overview of the initial evaluation and resuscitative measures for pediatric burn patients, most current wound care, indications for grafting, and the role of nutrition, including use of pharmacologic adjuncts. Use of colloid solutions, indications for use of skin substitutes, and transfer criteria will also be addressed.

**19. Pediatric Burn Care: Unique Considerations in Management.** Clin Plast Surg. 2017 Jul;44(3):603-610. doi: 10.1016/j.cps.2017.02.017. Shah AR, Liao LF.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28576249>

Severe pediatric burns require a multidisciplinary team approach at a specialized pediatric burn center. Special attention must be paid to estimations of total body surface area, fluid resuscitation and metabolic demands, and adequate analgesia and sedation. Long-term effects involve scar management and psychosocial support to the child and their family. Compassionate comprehensive burn care is accomplished by a multidisciplinary team offering healing in the acute setting and preparing the child and family for long-term treatment and care.

**20. Pediatric burn resuscitation: past, present, and future.** Burns Trauma. 2017 Sep 4;5:26. doi: 10.1186/s41038-017-0091-y. eCollection 2017. Romanowski KS, Palmieri TL.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28879205>

Burn injury is a leading cause of unintentional death and injury in children, with the majority being minor (less than 10%). However, a significant number of children sustain burns greater than 15% total body surface area (TBSA), leading to the initiation of the systemic inflammatory response syndrome. These patients require IV fluid resuscitation to prevent burn shock and death. Prompt resuscitation is critical in pediatric patients due to their small circulating blood volumes. Delays in resuscitation can result in increased complications and increased mortality. The basic principles of resuscitation are the same in adults and children, with several key differences. The unique physiologic needs of children must be adequately addressed during resuscitation to optimize outcomes. In this review, we will discuss the history of fluid resuscitation, current resuscitation practices, and future directions of resuscitation for the pediatric burn population.

**21. Early resuscitation and management of severe pediatric burns.** Semin Pediatr Surg. 2019 Feb;28(1):73-78. doi: 10.1053/j.sempedsurg.2019.01.013. Epub 2019 Jan 18. Arbuthnot MK, Garcia AV.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30824139>

Pediatric burns are a leading cause of injury and mortality in children in the United States. Prompt resuscitation and management is vital to survival in severe pediatric burns. Although management principles are similar to their adult counterparts, children have unique pathophysiologic responses to burn injury thus an understanding of the differences in fluid resuscitation requirements, airway management, burn and wound care is essential to optimize their outcomes.

**22. Pediatric trauma-related coagulopathy: Balanced resuscitation, goal-directed therapy and viscoelastic assays.** Semin Pediatr Surg. 2019 Feb;28(1):61-66. doi: 10.1053/j.sempedsurg.2019.01.011. Epub 2019 Jan 23. Drucker NA, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30824137>

The improved understanding of trauma-induced coagulopathy in adults has led to an evolution in the strategies of damage-control resuscitation. While its impact on the care of pediatric trauma patients is of tremendous interest, the evidence is sparse, and a great deal of research is still needed in this domain. Areas of particular interest include age-related differences in hemostasis and balanced resuscitation, advances in functional coagulation assays and effective adjunctive medications, such as tranexamic acid, for hemorrhage control. This review examines the available pediatric data, reviews applicable adult data, and introduces areas of investigation that will impact pediatric trauma care in the future.

**23. Pediatric Massive Transfusion: A Systematic Review.** Pediatr Emerg Care. 2018 Aug;34(8):594-598. doi: 10.1097/PEC.0000000000001570. Maw G, Furyk C.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30080793>

INTRODUCTION:

Balanced resuscitation of plasma, platelets, and red blood cells is now recognized as improving outcomes in traumatic bleeding in adults. The correct approach in children has yet to be determined.

METHODS:

We performed a systematic review of the literature into transfusion protocols in traumatic hemorrhage in children by conducting an article search of significant databases to identify relevant articles. Studies of interest included interventional trials with comparisons relating to the transfusion of blood including blood component therapy. The search identified 422 articles of interest, the abstracts of which were independently reviewed by 2 authors for inclusion in the trial. This revealed 35 articles, the full texts of which were reviewed. There were no randomized controlled trials and 4 nonrandomized trials with a further 21 articles that were deemed relevant. The data were insufficient for meta-analysis, and so a descriptive analysis was performed.

**RESULTS:**

There were 4 main trials. Two trials were small (approximately 100 patients) nonrandomized trials into pediatric hemorrhage managed as per a massive transfusion protocol or at physician discretion. One was a retrospective analysis of pediatric trauma patients who received red blood cell transfusion with differing platelet ratios, and one was a trauma database review of component ratios in hemorrhaging children. All 4 trials found increased ratios had no effect on mortality.

**DISCUSSION:**

As well as blood component therapy, adjunctive therapies used in the management of bleeding children are discussed. These include tranexamic acid, viscoelastic hemostatic assays, factor VIIa, and fibrinogen use.

**CONCLUSIONS:**

There is little evidence for improved outcomes using component-based transfusion in a rigid 1:1:1 strategy in children. A goal-directed approach using viscoelastic hemostatic assay-guided treatment with early institution of tranexamic acid and fibrinogen replacement is considered the way forward.

**24. Management Issues in Critically Ill Pediatric Patients with Trauma.** *Pediatr Clin North Am.* 2017 Oct;64(5):973-990. doi: 10.1016/j.pcl.2017.06.002. Ahmed OZ, Burd RS.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28941544>

The management of critically ill pediatric patients with trauma poses many challenges because of the infrequency and diversity of severe injuries and a paucity of high-level evidence to guide care for these uncommon events. This article discusses recent recommendations for early resuscitation and blood component therapy for hypovolemic pediatric patients with trauma. It also highlights the specific types of injuries that lead to severe injury in children and presents challenges related to their management.

**25. Controversies of enteral nutrition in select critically-ill surgical patients: Traumatic brain injury, extracorporeal life support, and sepsis.** *Semin Pediatr Surg.* 2019 Feb;28(1):47-52. doi:

10.1053/j.sempedsurg.2019.01.008. Epub 2019 Jan 18. Rice-Townsend SE, Aldrink JH.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30824134>

Adequate nutritional support for critically ill pediatric patients is an essential component of optimal care in the intensive care unit. For select patient populations in this setting, the enteral delivery of nutrients can bring unique challenges and potential risks. The focus of this paper is to provide a review of existing literature concerning the safety, efficacy and benefits of enteral nutrition in select surgical patient populations for whom these discussions are most controversial: patients with traumatic brain injury, patients receiving extracorporeal life support (ECLS), and patients receiving vasopressor therapy, such as in sepsis. Recommendations in the context of consensus or a call to investigate research gaps are provided based on a review of the evidence.

**26. Venous thromboembolism prophylaxis in the pediatric trauma patient.** Semin Pediatr Surg. 2017 Feb;26(1):14-20. doi: 10.1053/j.sempedsurg.2017.01.001. Epub 2017 Jan 5. Petty JK.

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Although venous thromboembolism (VTE) occurs in less than 1% of hospitalized pediatric trauma patients, care providers must make decisions about VTE prophylaxis on a daily basis. The consequences of VTE are significant; the risks of developing VTE are variable; and the effectiveness of prophylaxis against VTE is not conclusive in children. While the value of VTE prophylaxis is well defined in adult trauma care, it is unclear how this translates to the care of injured children. This review evaluates the incidence and risks of VTE in pediatric trauma and assesses the merits of prophylaxis in children. Pharmacologic prophylaxis against VTE is a reasonable strategy in critically injured adolescent trauma patients. Further study is needed to establish the risks and benefits of VTE prophylaxis across the spectrum of injured children.

**27. Non-operative management of solid organ injuries in children: An American Pediatric Surgical Association Outcomes and Evidence Based Practice Committee systematic review.** J Pediatr Surg. 2019 Aug;54(8):1519-1526. doi: 10.1016/j.jpedsurg.2019.01.012. Epub 2019 Jan 31. Gates RL, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30773395>

PURPOSE:

The American Pediatric Surgical Association (APSA) guidelines for the treatment of isolated solid organ injury (SOI) in children were published in 2000 and have been widely adopted. The aim of this systematic review by the APSA Outcomes and Evidence Based Practice Committee was to evaluate the published evidence regarding treatment of solid organ injuries in children.

METHODS:

A comprehensive search strategy was crafted and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were utilized to identify, review, and report salient articles. Four principal questions were examined based upon the previously published consensus APSA guidelines regarding length of stay (LOS), activity level, interventional radiologic procedures, and follow-up imaging. A literature search was performed including multiple databases from 1996 to 2016.

RESULTS:

LOS for children with isolated solid organ injuries should be based upon clinical findings and may not be related to grade of injury. Total LOS may be less than recommended by the previously published APSA guidelines. Restricting activity to grade of injury plus two weeks is safe but shorter periods of activity restriction have not been adequately studied. Prophylactic embolization of SOI in stable patients with image-confirmed arterial extravasation is not indicated and should be reserved for patients with evidence of ongoing bleeding. Routine follow-up imaging for asymptomatic, uncomplicated, low-grade injured children with abdominal blunt trauma is not warranted. Limited data are available to support the need for follow-up imaging for high grade injuries.

CONCLUSION:

Based upon review of the recent literature, we recommend an update to the current APSA guidelines that includes: hospital length of stay based on physiology, shorter activity restrictions may be safe, minimizing post-injury imaging for lower injury grades and embolization only in patients with evidence of ongoing hemorrhage.

**28. The Role of Minimally Invasive Surgery in Pediatric Trauma.** Surg Clin North Am. 2017 Feb;97(1):75-84. doi: 10.1016/j.suc.2016.08.005. Pearson EG, Clifton MS.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/27894433>

Minimally invasive surgery (MIS) in the management of blunt and penetrating pediatric trauma has evolved in the past 30 years. Laparoscopy and thoracoscopy possess high levels of diagnostic accuracy with low associated missed injury rates. Currently available data advocate limiting the use of MIS to blunt or penetrating injuries in the hemodynamically stable child. In the pediatric trauma population, MIS offers both diagnostic and therapeutic potential, as well as reduced postoperative pain, a decreased rate of postoperative complications, shortened hospital stay, and potentially reduced cost.

### **29. Implementing a Trauma-Informed Approach in Pediatric Health Care Networks. JAMA**

Pediatr. 2016 Jan;170(1):70-7. doi: 10.1001/jamapediatrics.2015.2206. Marsac ML, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/26571032>

Pediatric health care networks serve millions of children each year. Pediatric illness and injury are among the most common potentially emotionally traumatic experiences for children and their families. In addition, millions of children who present for medical care (including well visits) have been exposed to prior traumatic events, such as violence or natural disasters. Given the daily challenges of working in pediatric health care networks, medical professionals and support staff can experience trauma symptoms related to their work. The application of a trauma-informed approach to medical care has the potential to mitigate these negative consequences. Trauma-informed care minimizes the potential for medical care to become traumatic or trigger trauma reactions, addresses distress, provides emotional support for the entire family, encourages positive coping, and provides anticipatory guidance regarding the recovery process. When used in conjunction with family-centered practices, trauma-informed approaches enhance the quality of care for patients and their families and the well-being of medical professionals and support staff. Barriers to routine integration of trauma-informed approaches into pediatric medicine include a lack of available training and unclear best-practice guidelines. This article highlights the importance of implementing a trauma-informed approach and offers a framework for training pediatric health care networks in trauma-informed care practices.

### **30. Management and outcomes of peripancreatic fluid collections and pseudocysts following non-operative management of pancreatic injuries in children. Pediatr Surg Int. 2019 Aug;35(8):861-867. doi: 10.1007/s00383-019-04492-3. Epub 2019 Jun 3. Rosenfeld EH, et al.**

Pediatr Surg Int. 2019 Aug;35(8):861-867. doi: 10.1007/s00383-019-04492-3. Epub 2019 Jun 3. Rosenfeld EH, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/31161252>

#### **BACKGROUND:**

Peripancreatic fluid collection and pseudocyst development is a common sequela following non-operative management (NOM) of pancreatic injuries in children. Our purpose was to review management strategies and assess outcomes.

#### **METHODS:**

A multicenter, retrospective review was conducted of children treated with NOM following blunt pancreatic injury at 22 pediatric trauma centers between the years 2010 and 2015. Organized fluid collections were called "acute peripancreatic fluid collection" (APFC) if identified < 4 weeks and "pseudocyst" if > 4 weeks following injury. Data analysis included descriptive statistics Wilcoxon rank-sum, Kruskal-Wallis and t tests.

#### **RESULTS:**

One hundred patients with blunt pancreatic injury were identified. Median age was 8.5 years (range 1-16). Forty-two percent of patients (42/100) developed organized fluid collections: APFC 64% (27/42) and pseudocysts 36% (15/42). Median time to identification was 12 days (range 7-42). Most collections (64%, 27/42) were observed and 36% (15/42) underwent drainage: 67% (10/15) percutaneous drain, 7%

(1/15) needle aspiration, and 27% (4/15) endoscopic transpapillary stent. A definitive procedure (cystogastrostomy/pancreatectomy) was required in 26% (11/42). Patients with larger collections ( $\geq 7.1$  cm) had longer time to resolution. Comparison of outcomes in patients with observation vs drainage revealed no significant differences in TPN use (79% vs 75%,  $p = 1.00$ ), hospital length of stay (15 vs 25 median days,  $p = 0.11$ ), time to tolerate regular diet (12 vs 11 median days,  $p = 0.47$ ), or need for definitive procedure (failure rate 30% vs 20%,  $p = 0.75$ ).

#### CONCLUSIONS:

Following NOM of blunt pancreatic injuries in children, organized fluid collections commonly develop. If discovered early, most can be observed successfully, and drainage does not appear to improve clinical outcomes. Larger size predicts prolonged recovery.

**31. Contrast enhanced ultrasound for the evaluation of blunt pediatric abdominal trauma.** J Pediatr Surg. 2018 Mar;53(3):548-552. doi: 10.1016/j.jpedsurg.2017.03.042. Epub 2017 Mar 20. Armstrong LB, et al.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/28351519>

#### INTRODUCTION:

Blunt abdominal trauma is a common problem in children. Computed tomography (CT) is the gold standard for imaging in pediatric blunt abdominal trauma, however up to 50% of CTs are normal and CT carries a risk of radiation-induced cancer. Contrast enhanced ultrasound (CEUS) may allow accurate detection of abdominal organ injuries while eliminating exposure to ionizing radiation.

#### METHODS:

Children aged 7-18 years with a CT-diagnosed abdominal solid organ injury underwent grayscale/power Doppler ultrasound (conventional US) and CEUS within 48h of injury. Two blinded radiologists underwent a brief training in CEUS and then interpreted the CEUS images without patient interaction. Conventional US and CEUS images were compared to CT for the presence of injury and, if present, the injury grade. Patients were monitored for contrast-related adverse reactions.

#### RESULTS:

Twenty-one injured organs were identified by CT in eighteen children. Conventional US identified the injuries with a sensitivity of 45.2%, which increased to 85.7% using CEUS. The specificity of conventional US was 96.4% and increased to 98.6% using CEUS. The positive predictive value increased from 79.2% to 94.7% and the negative predictive value from 85.3% to 95.8%. Two patients had injuries that were missed by both radiologists on CEUS. In a 100kg, 17 year old female, a grade III liver injury was not seen by either radiologist on CEUS. Her accompanying grade I kidney injury was not seen by one of the radiologist on CEUS. The second patient, a 16 year old female, had a grade III splenic injury that was missed by both radiologists on CEUS. She also had an adjacent grade II kidney injury that was seen by both. Injuries, when noted, were graded within 1 grade of CT 33/35 times with CEUS. There were no adverse reactions to the contrast.

#### CONCLUSION:

CEUS is a promising imaging modality that can detect most abdominal solid organ injuries in children while eliminating exposure to ionizing radiation. A multicenter trial is warranted before widespread use can be recommended.

### **GUIDELINES**

#### **32. Management of Pediatric Trauma**

**Committee on Pediatric Emergency Medicine, Council on Injury and Violence, and Poison Prevention, Section on Critical Care, Section on Orthopaedics, Section on Surgery, Section on Transport Medicine, Pediatric Trauma Society, and Society of Trauma Nurses Pediatric Committee**

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URL: <https://pediatrics.aappublications.org/content/138/2/e20161569>

Injury is still the number 1 killer of children ages 1 to 18 years in the United States (<http://www.cdc.gov/nchs/fastats/children.htm>). Children who sustain injuries with resulting disabilities incur significant costs not only for their health care but also for productivity lost to the economy. The families of children who survive childhood injury with disability face years of emotional and financial hardship, along with a significant societal burden. The entire process of managing childhood injury is enormously complex and varies by region. Only the comprehensive cooperation of a broadly diverse trauma team will have a significant effect on improving the care of injured children.

### **33. EAST Landmark Papers in Trauma and Acute Care Surgery: Pediatric Trauma**

URL: <https://www.east.org/education/publications/landmark-papers-in-trauma-and-acute-care-surgery/pediatric-trauma>

### **34. Pediatric blunt renal trauma practice management guidelines: Collaboration between the Eastern Association for the Surgery of Trauma and the Pediatric Trauma Society.**

J Trauma Acute Care Surg. 2019 May;86(5):916-925. doi: 10.1097/TA.0000000000002209. Hagedorn JC, et al.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/30741880>

#### **BACKGROUND:**

Injury to the kidney from either blunt or penetrating trauma is the most common urinary tract injury. Children are at higher risk of renal injury from blunt trauma than adults, but no pediatric renal trauma guidelines have been established. The authors reviewed the literature to guide clinicians in the appropriate methods of management of pediatric renal trauma.

#### **METHODS:**

Grading of Recommendations Assessment, Development and Evaluation methodology was used to aid with the development of these evidence-based practice management guidelines. A systematic review of the literature including citations published between 1990 and 2016 was performed. Fifty-one articles were used to inform the statements presented in the guidelines. When possible, a meta-analysis with forest plots was created, and the evidence was graded.

#### **RESULTS:**

When comparing nonoperative management versus operative management in hemodynamically stable pediatric patient with blunt renal trauma, evidence suggests that there is a reduced rate of renal loss and blood transfusion in patients managed nonoperatively. We found that in pediatric patients with high-grade American Association for the Surgery of Trauma grade III-V (AAST III-V) renal injuries and ongoing bleeding or delayed bleeding, angioembolization has a decreased rate of renal loss compared with surgical intervention. We found the rate of posttraumatic renal hypertension to be 4.2%.

#### **CONCLUSION:**

Based on the completed meta-analyses and Grading of Recommendations Assessment, Development and Evaluation profile, we are making the following recommendations: (1) In pediatric patients with blunt renal trauma of all grades, we strongly recommend nonoperative management versus operative management in hemodynamically stable patients. (2) In hemodynamically stable pediatric patients with high-grade (AAST grade III-V) renal injuries, we strongly recommend angioembolization versus surgical intervention for ongoing or delayed bleeding. (3) In pediatric patients with renal trauma, we strongly recommend routine blood pressure checks to diagnose hypertension. This review of the literature reveals limitations and the need for additional research on diagnosis and management of pediatric renal trauma.

**35. Prophylaxis against venous thromboembolism in pediatric trauma: A practice management guideline from the Eastern Association for the Surgery of Trauma and the Pediatric Trauma Society.**

J Trauma Acute Care Surg. 2017 Mar;82(3):627-636. doi: 10.1097/TA.0000000000001359. Mahajerin A, et al.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28030503>

**BACKGROUND:**

Despite the increasing incidence of venous thromboembolism (VTE) in hospitalized children, the risks and benefits of VTE prophylaxis, particularly for those hospitalized after trauma, are unclear.

The Pediatric Trauma Society and the Eastern Association for the Surgery of Trauma convened a writing group to develop a practice management guideline on VTE prophylaxis for this cohort of children using the Grading of Recommendations Assessment, Development, and Evaluation framework.

**METHODS:**

A systematic review of MEDLINE using PubMed from January 1946 to July 2015 was performed. The search retrieved English-language articles on VTE prophylaxis in children 0 to 21 years old with trauma. Topics of investigation included pharmacologic and mechanical VTE prophylaxis, active radiologic surveillance for VTE, and risk factors for VTE.

**RESULTS:**

Forty-eight articles were identified and 14 were included in the development of the guideline. The quality of evidence was low to very low because of the observational study design and risks of bias.

**CONCLUSIONS:**

In children hospitalized after trauma who are at low risk of bleeding, we conditionally recommend pharmacologic prophylaxis be considered for children older than 15 years old and in younger postpubertal children with Injury Severity Score (ISS) greater than 25. For prepubertal children, even with ISS greater than 25, we conditionally recommend against routine pharmacologic prophylaxis. Second, in children hospitalized after trauma, we conditionally recommend mechanical prophylaxis be considered for children older than 15 years and in younger postpubertal children with ISS greater than 25 versus no prophylaxis or in addition to pharmacologic prophylaxis. Lastly, in children hospitalized after trauma, we conditionally recommend against active surveillance for VTE with ultrasound compared with routine daily physical examination alone for earlier detection of VTE. The limited pediatric data and paucity of high-quality evidence preclude providing more definitive recommendations and highlight the need for clinical trials of prophylaxis.

**LEVEL OF EVIDENCE:**

Systematic review/meta-analysis, level III.

**MILITARY PRIORITIES**

**36. The Top 10 Research and Development priorities for battlefield surgical care**

Martin, M. et al. 2019 Journal of Trauma and Acute Care Surgery

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/31246901>