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Pediatric thoracic trauma: Current trends

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ABSTRACT

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.

Introduction

Trauma remains the most common source of morbidity and mortality in the pediatric population,[1] and is the number one cause of death for children older than 1 year. Although thoracic injury only accounts for a relatively small proportion of trauma admissions (5–12%), it is associated with a significantly higher mortality rate than other types of injuries.[1,2] In isolation, thoracic trauma is associated with a 5% mortality rate.[1] However, when combined with an intra-abdominal injury and head trauma, the mortality rate is increased to 40%.[1,3]

The pediatric population has wide range of size differences, physiologic differences, and responses to injury. Thus, any evaluation of an injured child must take into account the child's age and size, their physiologic response, level of communication, ability to comprehend their injuries, and the potential to cooperate with the care team.[4]

Diagnosing thoracic trauma in children is also complex. Not only do vital signs vary by the age of the child, but also initial signs of thoracic trauma are often subtle or nonexistent on physical exam. A high index of suspicion is required at the time of presentation in order to correctly diagnose and treat an intra-thoracic injury. Furthermore, children with significant thoracic trauma will often require significant hemodynamic and respiratory support, making the timely diagnosis and treatment of these injuries of critical importance.[1,3]

Epidemiology

The 2015 Pediatric Report of the National Trauma Data Bank (NTDB) includes 143,996 injured children.[5] Of these admissions, 18,406 (12.78%) cases of thoracic trauma were reported with 1425 deaths. In relation to other classes of injuries, thoracic trauma had the highest fatality rate of 7.74%. While blunt trauma is the most frequent cause of thoracic trauma (92%), penetrating chest trauma is becoming more common as the use of firearms increases.[4]

Children with thoracic trauma also have higher trauma scores than those without chest involvement.[2] When comparing children with multiple injuries, those with thoracic involvement had an average trauma score (TS) of 11, and an injury severity score (ISS) of 27 comparatively those without thoracic trauma who had a Trauma Score of 15 and an injury severity score of 7. The most common cause of death in pediatric patients with thoracic trauma results from central nervous system injury followed by hemorrhagic shock.[3] Overall, the most common thoracic injuries are pulmonary contusion, rib fractures, and pneumothorax/hemothorax (Table).[4] More devastating injury complexes are far less common including injury to the heart, the diaphragm, the tracheobronchial tree, the esophagus, and the aorta. The vast majority of patients with thoracic trauma sustain concurrent injuries such as injuries of the central nervous system, musculoskeletal system, and the abdomen, with between 60% and 85% of children having thoracic injuries.[2,4]

Thoracic trauma: Relevant anatomy and physiology

Children have different anatomic and physiologic properties that influence the diagnosis and management of the child with

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Table
The most common pediatric thoracic injuries encountered.[4]

Injury	Percentage
Pulmonary contusion	53.3
Rib fractures	49.5
Pneumothorax	37.1
Hemothorax	13.3
Tracheobronchial tree	2.9
Diaphragm rupture	1.9
Aortic rupture	1.0
Flail chest	0.9

thoracic trauma. A child's chest wall anatomy is much more compliant and often has less muscle mass allowing for a greater transmission of energy to the underlying soft tissues during an blunt force injury.[6–8] In addition, because a child's body-wall thickness is less than that of an adult, a penetrating thoracic injury is more likely to injure an internal organ.[6–8] Children are also more likely to develop hypoxia as they have a lower functional residual capacity to total lung volume ratio, and a higher rate of tissue oxygen consumption. The mediastinum is more mobile in children allowing a pneumothorax to quickly develop into a tension pneumothorax and obstructive shock. Although this effect is similar to hypovolemic shock as seen in adults, it is more pronounced in children and can cause abrupt changes in vital signs.[1]

Clinical presentation of pediatric thoracic trauma

Children with thoracic trauma will arrive to the emergency department with a range of injuries including damage to the thoracic wall (rib fracture, intercostal hemorrhage, flail chest, and pneumothorax), the lung (contusion and laceration), the tracheobronchial tree, the heart, the diaphragmatic, and the esophagus. Thoracic trauma is the result of high kinetic energy transfer, most commonly from blunt trauma following motor vehicle accidents. In a retrospective review of 2086 children with blunt and penetrating trauma, 4.4% presented with a thoracic injury; 82% of these children had multisystem injury with an overall mortality rate of 26%, increasing to 39% in children with a combination of head, chest, and abdominal trauma.[2] Associated injuries are the greatest predictor of mortality in thoracic trauma underscoring the importance of a complete primary and secondary survey and systematic approach to management.[9]

The initial assessment of a child with thoracic trauma follows advanced trauma life support (ATLS) protocols beginning with the primary survey, specifically evaluating the safety of the child's airway. The pediatric airway and neck should be carefully and thoroughly evaluated as injuries to the thorax may impair the airway. The neck should be examined to confirm a midline trachea, to rule out the presence of subcutaneous emphysema and to inspect for a distended jugular venous pulse. A low index of suspicion is required in the evaluation of a pediatric trauma patient with chest trauma as subtle abnormalities in the head and neck exam will alert the physician to a worsening thoracic injury. Next, examination of the chest wall may reveal paradoxical movement concerning for flail chest, asymmetric movement typical of hemopneumothorax and/or obvious signs of injury including assymetry, and ecchymosis or entry/exit wounds. The pediatric thoracic wall is more compliant than the adult chest due to the thicker periosteum surrounding immature bone. This results in a tendency for ribs to bend rather than break, transferring a greater force to the lung and thoracic organs and vessels.[10] The rib-fracture rate in children sustaining trauma in general is 1–2%; however, it rises significantly in the context of major pediatric trauma up to an incidence of 60%.[11] As the number of rib fractures rises the incidence of multisystem injury also increases. As many as 70% of children with 2 or more rib fractures have multisystem injury compared to 12% with a single fractured rib.[11] In a study of the National Trauma Data Bank comparing injuries between children and adults, children were found to have a decreased incidence of rib fractures despite a higher injury severity score, and a greater incidence of associated injury, brain injury, hemothorax, pneumothorax, spleen, and liver injury.[12] Upper rib fractures have traditionally been associated with increased severity of injury following blunt thoracic trauma. Fractures of the upper 3 ribs, scapula, and clavicle signify high-energy trauma and are associated with a high incidence of vascular and cardiac injury.[11] Importantly, children who are victims of abuse have more rib fractures than accidentally injured children though they have fewer intrathoracic injuries. The typical force from violent squeezing of the chest cavity unfortunately seen too commonly in children victim to nonaccidental trauma can lead to multiple sequential rib fractures.

After identifying the presence or absence of breath sounds via auscultation and examining the chest for signs of injury, the ATLS protocols recommend a chest X-ray as the initial imaging modality to evaluate thoracic trauma.[13] It will rapidly confirm the presence of pneumothorax, hemothorax, and mediastinal pathology directing the clinician toward additional imaging or intervention. The indication of computed tomography scanning in pediatric thoracic trauma is poorly defined, yet it's use has been increasing as part of the “pan-scan” trauma evaluation.[14] In a retrospective review of 174 patients undergoing CT imaging, 33% had a chest CT that did not change patient management, but did add significantly to radiation exposure.[14] In a separate study of 425 patients with blunt thoracic trauma, 41% received a CT scan that did not change management.[10] They concluded that, chest CT should not be used in the setting of a normal chest X-ray in children sustaining blunt thoracic trauma. Finally, Golden et al. retrospectively reviewed 1035 patients with 139 patients who underwent a Chest CT and only 4 patients had a chest CT that changed clinical management. They concluded that a chest CT for only patients with an abnormal mediastinal on CXR would decrease CT scans by 80% while still identifying intrathoracic vascular injury.[13]

Pulmonary contusion represents the most common thoracic injury in children with blunt thoracic trauma, the incidence reaching greater than 50%, twice the incidence of adults.[11] This is largely due to the pliable pediatric chest wall that allows significant intrathoracic injury without bony injury. The contusion will develop over the hours following injury and will usually resolve without scarring within 7 days of the injury. Pulmonary contusions can be difficult to distinguish from pulmonary aspiration that evolves over 24–48 hours.[11] Pulmonary lacerations are unusual injuries in pediatric blunt thoracic trauma but may be found in children with penetrating injury to the chest by a foreign object, displaced rib fractures, or shearing forces of the lung.

Following pulmonary contusion, pneumothorax, and hemothorax are the second most common injuries in pediatric chest trauma with significant morbidity and mortality. While one-third of pneumothoraces occur in isolation in children, the majority have significant associated injuries.[11] Diagnosing a pneumothorax in the patient radiographed in the supine position, the clinician should look for specific imaging findings including[1] hyperlucency of the affected hemithorax,[2] a sharp heart border,[3] a deep costophrenic sulcus with sharp margins, and[4] a double diaphragm sign (Figure 1).[11] It should be noted that a tension pneumothorax is 3 times more common in children than adults due to the increased mobility of the mediastinum.[4] Hemothoraces in children, often caused by injury to the pulmonary parenchyma, intercostal