**Chapter 55
Pediatric trauma priorities**

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**Introduction**

Injury is the leading cause of death and disability in children, and adolescents, young adults, and pediatric patients constitute 25% of all injured patients in the United States. While overall mortality is one-third the rate of trauma deaths in adults, case fatality rates for children are higher [1]. In other words, for equivalent trauma severity, children are more likely than adults to die during transport and resuscitation. Although prehospital encounters with pediatric patients represent a small fraction of EMS transports, traumatic injury is the most common chief complaint for EMS response in the pediatric age range [2].

Most injuries in children fall into the category of minor trauma, such as contusions and lacerations, and typically require straightforward application of the basic tenets of wound care, splinting, and immobilization. However, being prepared to manage major multisystem pediatric trauma involves a thorough understanding of the unique anatomical and physiological characteristics of the pediatric patient, as well as a working appreciation of pediatric growth and development [3,4]. The effect that these factors can bring to bear upon injury presentation and patient assessment, and thus the establishment of resuscitation and treatment priorities, is significant.

The following discussion is organized around a system-based inventory of what makes children different and an analysis of how these differences can affect the approach to the pediatric trauma patient. The clinical implications of these unique attributes are highlighted in the context of the trauma survey. Also important is a basic appreciation of injury mechanisms in children, as they differ from those in older patients. The recognition of particular injury patterns can be important clues in the field assessment and management of the pediatric trauma patient.

**Anatomical and physiological considerations**

There are several key anatomical and physiological characteristics unique to the pediatric patient of which the prehospital professional needs to be aware when evaluating an injured child. These characteristics can affect the presentation of traumatic injuries, especially in young children, and require a heightened index of suspicion during the trauma survey for subtle signs and symptoms of occult injury.

**General**

Because of a child's smaller body size, traumatic forces can be distributed over a larger area, thus making multisystem trauma the rule rather than the exception with childhood injuries. Children often sustain internal injuries with little or no external evidence of trauma. Thus, as a general rule, internal injury cannot be ruled out in a child merely based on the absence of external signs of trauma. Children also have a large surface area to body mass ratio and are particularly vulnerable to thermoregulatory derangements from prolonged environmental exposure. Particularly in infants, the relatively large head can be a source of significant unrecognized heat loss in a trauma resuscitation situation. The simple placement of a cap on the head of an infant during transport and turning up the heat in the ambulance can help to obviate this problem.

**Head**

Head injury is the most common cause of serious trauma in children. The disproportionately large head in young children functions like a “lawn dart,” causing them to lead head-first during falls or rapid deceleration mechanisms, such as car crashes. More than 80% of multisystem pediatric trauma cases involve the head and nearly one-third of all childhood injury deaths result from head injury [1,4]. Among the highest priority early interventions in the management of multisystem pediatric trauma are those directed at limiting the severity of traumatic brain injury and preserving brain function.

**Airway**

The pediatric airway has several unique anatomical features with which the prehospital professional must be familiar to ensure successful airway management. These features are usually present until about 8 or 9 years of age when the airway assumes more of an adult configuration. Because of the relatively short neck, particularly in young children, the larynx is more cephalad and far more anterior than what would be visualized on direct laryngoscopy of an adult patient. In fact, the cricoid pressure provided by the Sellick maneuver is not only necessary to occlude the esophagus during endotracheal intubation, but is often required to actually bring the airway into view. The diameter of the pediatric airway is obviously much smaller than the adult airway and is far more vulnerable to compromise from relatively small amounts of obstructive material, blood, or edema. The tongue is a relatively larger structure within the mouth and is actually the most common cause of upper airway obstruction in the young child.

The epiglottis is a floppier, U-shaped structure that generally requires use of the straight Miller blade to control it directly and provide adequate visualization during intubation. The narrowest part of the pediatric airway is the subglottic region, below the vocal cords, as opposed to at the cords themselves. This “physiological cuff” obviates the need for cuff inflation or for cuffed endotracheal tubes altogether before 8 years of age. Children are obligatory abdominal breathers and depend on sufficient diaphragmatic excursions to ventilate properly. Swallowing air, or aerophagia, with subsequent gastric distension is common in the trauma resuscitation setting. Gastric decompression with an orogastric or nasogastric tube is required to prevent disruption of ventilatory mechanics [5,6].

**Spinal column**

Although vertebral injuries in children are uncommon, the cervical spine has a high injury risk potential due to the large head being supported by relatively weak neck muscles and elastic supporting ligaments. Through the age of 8, anatomically, the pediatric c-spine has a higher fulcrum (C1–C2) compared to adults upon extreme flexion-extension of the neck. Therefore disruption of innervation to the diaphragm (phrenic nerve) and accompanying ventilatory impairment must be a consideration in high-energy mechanisms in which neck injury with vertebral fracture is a possibility [7,8]. Compression fractures to the thoracolumbar vertebral bodies are a possibility in rapid deceleration from a motor vehicle crash when a child hyperflexes over a lap belt which is improperly positioned across the abdomen. This circumstance is typically the result of young children being prematurely advanced to adult restraint systems when they still require the use of belt-positioning booster seats [9].

**Cardiovascular**

The cardiovascular response to hemodynamic instability from bleeding in young children is one of rapid and accentuated vasoconstriction with limited stroke volume boosting capacity. The ability to increase cardiac output is almost entirely dependent on the capacity to increase heart rate because of the diminished compliance of the immature ventricular myocardium. Tachycardia is the earliest and most sensitive sign of impending hemorrhagic shock in children and must always be explained in the evaluation of any injured child. The prehospital professional must also appreciate that normal ranges for pediatric vital signs are age dependent, and that convenient access to a reference guide is prudent. The total circulating blood volume in a child is 70–80 cc/kg and children will maintain compensatory vasoconstrictive mechanisms in the face of hemorrhage until 25% blood volume loss, after which uncompensated shock rapidly ensues [3,10]. Particularly in young children, relatively small volumes of blood loss can precipitate hemorrhagic shock and it is incumbent upon the prehospital professional to note external evidence of blood loss on the scene and maintain a high index of suspicion for occult blood loss, especially in the face of tachycardia. Even an isolated laceration to the highly vascularized scalp of an infant can produce significant enough blood loss to warrant volume resuscitation.

**Musculoskeletal, chest, and abdomen**

The pediatric musculoskeletal system is generally more pliable and elastic than an adult's and, therefore, less likely to yield fractures in response to equivalent mechanical force. For example, significant blunt force trauma can be distributed to the intrathoracic cavity without evidence of rib fractures. Therefore, injuries like flail chest are uncommon in children, yet high-energy transfers can exert significant injury directly to the heart and lungs. The mediastinum in a child is hypermobile and can be significantly displaced, for instance, by a tension pneumothorax with concomitant kinking of the great vessels. Loss of pulses or other sudden change of vital signs should raise suspicion for this possibility.

The ribcage itself is more horizontally oriented than in adults, exposing the liver and spleen which themselves are poorly protected by underdeveloped abdominal muscles and by the absence of a fat pad. This same orientation is responsible for excursion of the diaphragm on full exhalation as high as the nipple line with concomitant presentation of underlying abdominal organs high in the thoracoabdominal cavity. The clinical implication is that injuries to abdominal organs can occur after chest trauma alone.

In the developing long bones, the ligamentous structures are actually stronger than the nearby growth plates, explaining why fractures at the epiphyseal-metaphyseal region, the weak cartilaginous areas, are more common in children.

**Injury patterns**

Children in the United States are far more likely to sustain blunt trauma than are adults; blunt force mechanisms represent nearly 90% of the pediatric injury burden. Motor vehicle occupant injuries remain the leading cause of death in the pediatric age group [1]. Although penetrating injury mechanisms are far more typical of adult patients, firearm injuries among children, especially unintentional, are a growing concern, as are intentional firearm injuries among adolescents for whom gun violence is the most common cause of penetrating trauma [11]. Children are typically injured as a function of their activity or location. Thus, being aware of common patterns of injury based on mechanism as part of the assessment of the pediatric trauma patient is important. Three examples are Waddell’s triad, handle bar injuries, and the lap belt complex.

* Waddell’s triad refers to the multisystem injury pattern seen when a child pedestrian is struck by a vehicle. This mechanism can produce lower extremity (femur) fractures from direct contact with the bumper, chest and abdominal trauma caused by being thrown onto the hood, and, finally, head injury when the child strikes the pavement, as described above, lawn dart style.
* Bicycle falls produce a range of injuries from minor abrasions and contusions to major head injury in unhelmeted riders. However, contact with the bicycle handle bars during a fall can cause intraabdominal trauma, such as a duodenal hematoma, which, clinically, may be very subtle and notoriously late-presenting. The prehospital professional must have a high index of suspicion for such injury when soliciting a history that reveals this mechanism.
* The lap belt complex refers to a constellation of signs and possibly symptoms associated with hyperflexion over the top of an abdominally positioned lap belt during rapid deceleration in a motor vehicle crash. The presence of an ecchymotic bruise across the abdomen can be an important clue to underlying intraabdominal (especially hollow viscus) injuries, as well as vertebral compression fractures to the thoracolumbar spine. These injuries can also have a delayed clinical presentation, thereby making recognition of the mechanism and associated injury pattern essential [9].

The prehospital professional may encounter traumatic injuries that seem inconsistent with the developmental motor capability of a young child to have sustained as a result of an unintentional mechanism. This circumstance should be a red flag for suspected intentional injury or child abuse. Child abuse is the most important cause of visceral injuries in children under the age of 3 [3,12].

**Pain management**

Due to the wide range of developmental and communication variability in assessing pain in children and unfounded concern about masking injury, pediatric trauma patients are frequently undertreated with analgesics. Recent national efforts to define an evidence-based approach to pain management in all injured patients strongly support weight-based opioid dosing, with either intravenous morphine sulfate, 0.1 mg/kg, or intranasal or intravenous fentanyl, 0.1 μg/kg. Redosing if pain persists upon 5-minute reassessment is also strongly recommended [13,14].

**Resuscitation and management priorities**

The approach to the trauma survey is basically the same as in adults. The sequencing of the steps in assessment of the injured child must be primarily attendant to the integrity of the airway and adequacy of ventilation, along with protection and immobilization of the cervical spine as necessary. Controlling bleeding, establishing vascular access, and supporting circulation are also primary management priorities. As the prehospital professional completes the trauma survey and head-to-toe secondary assessment, there are several pitfalls and caveats based on the aforementioned unique characteristics that must be kept in mind [3].

* Failure to recognize the subtle signs of early shock. Tachycardia is the most sensitive measure of compensated traumatic shock, usually hemorrhagic, in an injured child and should never be dismissed [10]. Also crucial is understanding that responsiveness inconsistent with expected developmental stage suggests a derangement in sensorium secondary to early shock and compromise of cerebral perfusion.
* Failure to suspect abdominal injury in multiple trauma. Small size, greater surface to mass ratio, poor protection of viscera by muscle or fat, and compliant musculoskeletal system all contribute to the widespread internal distribution of kinetic energy forces in multisystem trauma. The absence of external signs of injury should never rule out intrathoracic or intraabdominal injuries.
* Acute gastric dilation mimics visceral injury. Swallowed air with gastric distension can not only mimic injury but may interfere with diaphragmatic excursion and thus impair ventilation. Decompression with passage of an orogastric or nasogastric tube will ameliorate this preventable complication.
* Inadequate pain management. Oligoanalgesia, or underdosing of pain medications in the field, may be more common in pediatric patients due to communications challenges in the way that children manifest and express pain and/or in the way that providers may subjectively interpret it. Appropriate weight-based dosing of opioid analgesics (morphine or fentanyl) should always be offered in the management of moderate-to-severe pain associated with traumatic injury [13,14].

**Field triage**

The Centers for Disease Control and Prevention’s 2011 Guidelines for the Field Triage of Injured Patients introduced a modification to the Step 1 criteria that recognizes that patients requiring ventilatory support, independent of respiratory rate, require immediate transport to a trauma center. This revision is particularly appropriate for pediatric patients acknowledging that adults and children in need of ventilatory support, including both bag-mask ventilation and intubation, represent a high-risk group, whether or not their respiratory rate falls outside the specified ranges of <10 or >29 breaths per minute (<20 in infant aged <1 year) [15].

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