Chapter 17

Pediatric Trauma

Karla E.K. Wyatt

You are called to assist in the evaluation and care of a seven-year-old boy who will be arriving to your emergency department following a head-on motor vehicle collision. The child was an unrestrained passenger in the backseat of an automobile. The first responders report positive loss of consciousness at the scene, with two failed attempts at intubation. There is adequate bag-mask ventilation. There is no additional medical or surgical history available, as the child's parents were injured in the accident and taken to the nearest adult trauma center.

His current vital signs are: blood pressure 75/32 mmHg; heart rate 140/min; temperature 35.2°C; SpO_2 92% with bag-mask ventilation.

What Are the Demographics of Pediatric Trauma?

According to the Centers for Disease Control and Prevention, unintentional injury, suicide, and homicide comprise the top three causes of morbidity and mortality in children between the ages of 1–14 years. Unintentional injuries are the leading cause of childhood death, with motor vehicle collisions reported as the most common, followed by drowning, fires/burns, and accidental suffocation. Traumatic brain injury and thoracic trauma are the leading causes of death due to motor vehicle collisions in children.

Accidental suffocation is the leading cause of *injury-related* death in children under one year, while the overall leading cause of death in children under one year is secondary to congenital anomalies.

How Is Pediatric Trauma Care Organized?

In the United States, adult and pediatric trauma centers undergo a state and local designation as well as the American College of Surgeons (ACS) verification process. The ACS designates standardized criteria for hospital entities to ensure uniform resource capability. Pediatric trauma patients are typically routed to level I or level II trauma centers. A level I facility has the means to sustain the adult and/or pediatric patient, encompassing all aspects of injury-related care including but not limited to the vast emergency, perioperative, operative, intensive care, and rehabilitation settings. Both Level I and Level II pediatric centers require the presence of trauma and subspecialty surgeons, emergency medicine, radiology, anesthesiology, and critical care personnel (24-h *in-house* for level I and 24-h *immediately available* for level II).

What Is the Initial Evaluation and Classification of the Pediatric Trauma Patient?

Evaluating the pediatric trauma patient involves a stepwise continuum of information processing including the prehospital encounter, primary survey, resuscitation, secondary survey, resuscitation, re-evaluation, and anticipatory care. The Advanced Trauma Life Support guidelines recommend a primary and secondary survey be performed on all trauma patients.

What Are the Elements of the Primary Survey?

The primary survey is a systematic approach used to identify and treat life-threatening injuries. This evaluation often includes multiple medical personnel simultaneously assessing the trauma patient. The mnemonic *ABCDE* can be used to guide the primary survey.

A. Airway. The airway is evaluated for patency, obstruction, and secretions. In the pediatric population, careful inspection should be given to oral and facial anomalies that may alert the

https://doi.org/10.1017/9781108668736.018 Published online by Cambridge University Press

Table 17.1 Glasgow coma scale (GCS) in pediatric patients

	Adult and verbal children	Infants and nonverbal children	Score
Eye opening	Spontaneous	Spontaneous	4
	To speech	To speech	3
	To pain	To pain	2
	None	None	1
Verbal	Appropriate speech	Coos, babbles	5
	Confused speech	Irritable, cries but consolable	4
	Inappropriate words	Cries, inconsolable	3
	Incomprehensible words	Moans to pain, grunts	2
	None	None	1
Motor	Follows commands	Spontaneous movement	6
	Localizes pain	Withdraws to touch	5
	Withdraws to pain	Withdraws to pain	4
	Decorticate posture to pain	Decorticate posture to pain	3
	Decerebrate posture to pain	Decerebrate posture to pain	2
	None	None	1

provider to the potential difficult airway associated with an underlying syndrome. Providers should quickly determine the patient's level of consciousness and the ability to talk and/or protect the airway. Jaw-thrust, chin-lift, and airway adjuncts may assist in eliminating obstruction. Endotracheal intubation should be performed in those who cannot protect their airway. It is important to maintain cervical spine instability precautions with any head and neck manipulations during this assessment.

B. Breathing. Visual inspection of the oropharynx, neck, and chest for injuries and deviations, followed by an assessment of respiratory quality, auscultation, and palpation of the thorax should be accompanied with intervention if appropriate.
C. Circulation. During acute blood loss, children can compensate their blood pressure for a longer period of time when compared to adults. Tachycardia is often manifested as an initial sign of poor perfusion. Assessment of adequate perfusion in the pediatric patient should include palpation of the brachial and femoral pulses, capillary refill, and turgor. Two large bore intravenous catheters should be placed in the upper extremities if possible, to maintain resuscitation should the inferior vena cava be compromised. If intravenous access is difficult, pending no contraindications, intraosseous lines can also be placed. In children, hypotension becomes apparent when ~25% of the patients' blood volume is depleted. If there is evidence of poor perfusion, resuscitation with 20–30 mL/kg of a balanced salt solution should be administered. If obvious hemorrhage is occurring, direct pressure should be applied, and type O negative blood can be administered.
D. Disability. Assessment of the patients' neurological status includes the Glasgow coma scale (GCS) (Table 17.1). The pediatric modified GCS can be used in infants and nonverbal children. A GCS score $\leq$8 signals severe brain injury and endotracheal intubation with in-line stabilization is highly recommended. A GCS of 9–12 is classified as moderate, and a GCS $\geq$13 is considered minor brain injury. The next course of action in the management of a patient with a GCS in the mild to moderate range will depend on the nature of overall injury and the stability of their current clinical status.
E. Exposure. Removal of all patient clothing and accessories followed by careful inspection for further injury. During this evaluation, it is imperative to maintain patient normothermia.

What Are the Elements of the Secondary Survey?

Once the initial primary survey and resuscitation is complete and all life-threatening injuries have been

https://doi.org/10.1017/9781108668736.018 Published online by Cambridge University Press

addressed or ruled out, the secondary survey can take place. The secondary survey is a head-to-toe examination for any injuries that may have been overlooked during the primary survey. During this assessment radiologic, ultrasound, and laboratory data is gathered. When caregivers are available, this is the time to collect the patient's past medical history, allergies, medications, and any additional information pertinent to acute care. If clinical deterioration occurs during the secondary survey, the primary survey should promptly be re-evaluated.

What Are the Common Mechanisms of Injury?

Pediatric patients have a higher incidence of blunt traumatic injuries, with abdominal injuries occurring more often than thoracic injuries, likely secondary to the common causes of injury (i.e., falls, motor vehicle collisions, sports injuries). Adults are more likely to present with penetrating traumatic injuries, with many localized to the thorax. Thoracic trauma is the second leading cause of death due to trauma in children. However, due to the cartilaginous nature of a child's thorax, it is uncommon for them to sustain rib fractures. As a result, internal and mediastinal injury may not be immediately apparent. Furthermore, when tension and/or hemopneumothoraces occur in children, the shifting of structures within the mediastinum can lead to more pronounced hemodynamic instability. For these reasons, when such injury is suspected, consideration of needle decompression and/or chest tube placement is recommended prior to the initiation of positive pressure ventilation to avoid further hemodynamic compromise.

How Is the Traumatic Airway Assessed?

Significant respiratory distress; GCS $\leq$8; blunt and/or penetrating trauma to the face, neck, thorax, or abdomen; cardiovascular decompensation or direct injury; severe hemorrhage; and significant fire/burn trauma are all indicative of patients who will likely require intubation. Examination of the pediatric airway trauma should include assessment of mouth opening, consideration for restricted neck movement, debris/secretions/blood in the oropharynx, potential airway distortion, dysmorphic facies, congenital syndromes, the nature of any head and neck injuries, and consideration of the consequences of intubation with positive pressure ventilation with respect to thoracic and abdominal injury.

The approach to the airway will depend on the patient's overall clinical status. Fiberoptic airway management is ideal in the nonemergent trauma patient with a suspected difficult airway. All trauma patients should be considered to have a full stomach. Hence, there are aspiration risks associated with this approach, as it is rare for children to accommodate an awake fiberoptic technique. In emergent situations where there is no concern for a difficult airway or cervical spine instability, rapid sequence intubation with in-line stabilization of the cervical spine is preferred. Careful consideration of anesthetic induction agents that maintain hemodynamic stability and/or spontaneous ventilation is advised. In the event of a difficult airway the pediatric difficult airway algorithm should be employed.

Airway assessment should address:

- Patient cooperation
- Potential difficulty of mask ventilation
- Potential difficulty of supraglottic airway placement
- Difficulty of laryngoscopy
- Difficulty of intubation
- Difficulty of surgical airway
- Craniofacial trauma
- Head and neck trauma

What Is the Best Approach to Vascular Access?

Large bore intravenous access should be obtained as soon as possible to aid resuscitative measures. If abdominal injury is suspected, it is recommended to place lines above the diaphragm in the event that large vessels below the diaphragm are injured. Attempts should be made to avoid placing lines in injured extremities. If the head or neck has sustained a substantial injury, placement of access below the diaphragm will ensure delivery of fluids, products, and medications should there be significant vascular compromise above. It is imperative that peripheral access is obtained quickly to guide therapeutic intervention, as such large bore access should not be delayed for advanced access (central lines).

In children, intraosseous lines (IO) are often utilized when peripheral access cannot be obtained. Providers should quickly move to intraosseous line

https://doi.org/10.1017/9781108668736.018 Published online by Cambridge University Press

placement when peripheral IV attempts have failed to avoid undue delays in treatment and resuscitation. IO lines can aid fluid resuscitation until peripheral and or central lines can be placed. Typically, IO lines are placed in the proximal humerus or tibia. Detailed instruction and a video on placing IO lines is provided by the manufacturer (www.teleflex.com/en/usa/ezioeducation/index.html).

Contraindications to intraosseous access include fracture of the extremity, underlying bony disease, previous attempt at the same site, infection at the site, and the inability to identify landmarks. Central and arterial line placement is usually performed after the acute phase access and resuscitation has begun. The patient's clinical status and the location of their injuries often preclude initiation of early advanced monitoring.

Why Is Maintaining Normothermia Important in Trauma Patients?

Hypothermia contributes to altered mental status, left shift in the oxygen-hemoglobin dissociation curve with decreased oxygen delivery to the tissues, shivering with increased metabolic oxygen consumption, and platelet dysfunction leading to coagulopathy. These effects can lead to further deterioration of hemodynamically unstable trauma patients. Various techniques may be used to warm the patient, increasing ambient temperature, fluid warmers, forced air warming devices, and warming blankets.

In certain situations (cardiac arrest and neurotrauma), deliberate hypothermia may be employed for functional preservation. In patients returning to the operating room undergoing active cooling, decision to continue this therapy should be discussed with the critical care team. In many situations, the cooling is continued perioperatively understanding that it may result in coagulopathy.

What Are the Anesthetic Implications of Cervical Spine Injury?

Cervical spine injuries occur less commonly in children as compared to adults due to the cartilaginous nature of the spine and incomplete calcification of the vertebrae. However, pseudo-subluxation of the cervical spine, the anterior displacement of C2 on C3, is common in children. Differentiating pseudo-subluxation from a true spinal injury requires cervical manipulation and should not be attempted until potential spinal injury is discussed with a surgeon. When the mechanism of trauma involves acceleration, deceleration, or forceful impact, or neurologic deficits are present, the anesthesiologist should assume cervical instability and institute cervical immobilization with a backboard and cervical collar. A neurosurgical consultation should be obtained.

What Are the Intraoperative Anesthetic Implications of Intraoperative Management?

Intraoperative management of pediatric trauma patients is dynamic and involves all of the operating room personnel. The trauma operating room should be prepared with a warm ambient temperature, crystalloid fluids, airway adjuncts and devices, suction, fluid warmers, central venous and arterial monitoring capability, rapid transfusing devices, emergency vasoactive medications, access to an institution approved defibrillator, and commonly used anesthetic medications. If massive blood loss is anticipated, patient type specific or type O negative blood product should be readily available. This often involves close communication with blood bank personnel. Administration of red blood cells, fresh frozen plasma, and platelets in a 6:6:1 ratio has not been validated in the pediatric population. Calculation of the patient's estimated blood volume and maximal allowable blood loss, in conjunction with assessment of ongoing blood loss and laboratory data, will help guide therapy. Continuous analysis of vital signs, laboratory data, urine output, ventilator changes, and surgical interventions are variables that should be frequently reassessed.

What Are the Postoperative Anesthetic Implications?

Intensive care and enhanced monitored floor units are required postoperatively for many pediatric trauma patients. Maintaining normothermia, adequate oxygenation and ventilation, and cardiovascular stability is paramount as care transitions from the operating room to the intensive care unit. Children with large volume resuscitation are at increased risk for postoperative pulmonary edema, fluid overload, respiratory complications, hypothermia, infections, coagulopathy, and thrombosis. The decision to

https://doi.org/10.1017/9781108668736.018 Published online by Cambridge University Press

remain intubated should be based on the extent of the injury, degree of resuscitation, and the potential for ongoing hemodynamic instability and the need for continued resuscitation. Careful communication among anesthesia, surgery, nursing, and the receiving patient care team is paramount.

How Is Pain Managed in the Trauma Patient?

Pain is expected in trauma patients. Pain is managed using nurse or patient controlled analgesia of opioids or by continuous infusion. Understanding of the effects of narcotic medications on the patients' hemodynamic goals will help titrate pain control and maintain adequate perfusion. Pain requirements should be considered when deciding on extubation. Additionally, opioid side effects should be considered such as constipation and ileus with preventative strategies empirically started. It is prudent to avoid analgesic medications that can worsen renal function/injury and liver insult, and excessively sedate patients with fluctuating neurological status. Standardized pediatric pain scales for both verbal and nonverbal patients can be utilized for frequent assessment of pain and the adequacy of analgesia.

Is There a Role for Regional Anesthesia in the Pediatric Trauma Patient?

Prehospital and disaster medicine teams have reported the utilization of regional anesthesia for patients undergoing amputations and wound debridement during mass casualty and extreme conditions. Similar intervention has been reported in the adult military prehospital population. Epidural and peripheral nerve catheters have been used successfully with management of minor trauma in the pediatric population. However, the role for regional anesthesia has not yet been evaluated in a large-scale pediatric population. The decision to employ regional anesthesia in the polytrauma patient is often more complicated given the risk of coagulopathy, compartment syndrome, nerve injury, and labile hemodynamics. Ongoing research may enhance understanding of this in the future.

Suggested Reading

Apfelbaum JL, Hagberg CA, Caplan RA. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. *Anesthesiology*. 2013;118(2):251–70.

Avarello JT, Cantor RM. Pediatric major trauma: an approach to evaluation and management. *Emerg Med Clin North Am*. 2007;25 (3):803–36.

Densmore JC, Lim HJ, Oldham KT, et al. Outcomes and delivery of care in pediatric injury. *J Pediatr Surg*. 2006;41:92–8.

Myers SR, Branas CC, French B, Nance ML, Carr BG. A National Analysis of Pediatric Trauma Care Utilization and Outcomes in the United States. *Pediatric Emergency Care* 2019; 35(1):1–7.

Sperka J, Hanson S, Hoffmann R, Dasgupta M, Meyer MT. The effects of pediatric advanced life support guidelines on pediatric trauma airway management. *Pediatric Emergency Care*. 2016;32 (8):499–503.

https://doi.org/10.1017/9781108668736.018 Published online by Cambridge University Press