Using Advanced Trauma Life Support (ATLS) Principles for the Perioperative Management of Pediatric Trauma Patient AND How to Effectively Disclose a Medical Error to a Parent

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Stem Case and Key Questions Content
Your patient is a 6-year-old male who was involved in a motor vehicle accident. His mother was the driver of the vehicle and she was taken to another hospital. The motor vehicle was hit head-on at approximately 40 miles per hour; your patient was found unrestrained. The patient is reported to have a Glasgow Coma Scale (GCS) score of 6. Bag-mask-ventilation is being provided by the paramedics while en route to your facility. The paramedics have no additional information about this patient other than his name; his father has been notified of the accident by the police department.

Estimated time for arrival (ETA) is 4 minutes.

The paramedics placed a cervical collar and backboard on the patient. Intravenous access has been established utilizing an intraosseous line to the left leg.

You have been called to the Emergency Department (ED) for airway management. (This is standard practice in your institution for all pediatric trauma patients).

Upon arrival to the ED, you are initially the only physician available to care for this patient; the only ED physician is currently caring for another patient in critical condition.

1. Why do you think that the principles of Advanced Trauma Life Support (ATLS) are relevant and beneficial to all anesthesia providers that care for pediatric trauma patients?

2. How common are pediatric traumatic injuries? What types of traumatic injuries are more characteristic in the pediatric population?

3. Why do you think that tracheal intubation was not performed by the paramedics?
4. What would be your strategy for the initial evaluation and management of this pediatric trauma patient? Describe your plan for airway management including medication selection and any special techniques required.

5. Describe one approach to estimate the patient's weight to determine medication doses. Can the intraosseous (IO) line be utilized for medication delivery? If so, what adjustments to medication doses are required when using an IO line?

The patient has the following vital signs after placement of a tracheal tube:
Temperature (axillary) 35.1 degrees Celsius
Respirations 36 (positive pressure ventilation via self-inflating bag)
Heart rate 174; Blood pressure 69/38; Oxygen saturation 74% (FiO₂ 100%)
Positive carbon dioxide (CO₂) was confirmed after tracheal intubation.
Patient's estimated weight: 20 kilograms (kg).
Physical exam: absent breath sounds over the left chest.

6. What additional management would you recommend for this patient after the airway has been secured and verified? Would you perform needle decompression to the left chest? If so, what are the appropriate landmarks to perform needle decompression? How would you distinguish between a tension pneumothorax to the left chest and a right mainstem intubation?

The tracheal tube was pulled back 3 centimeters; bilateral breath sounds are now present.
The blood pressure remains at 69/38; heart rate 174, Oxygen saturation 93% (FiO₂ 100%).

7. If you think that the administration of volume expanders is indicated, how will you decide between administering crystalloid, colloid, or blood products? What type(s) and amounts of volume expanders will you select to administer? Are there any advantages to one particular product?

8. After administration of the first fluid bolus, no significant change has occurred to the vital signs. What is your next step in management? What will you do if this is ineffective?

9. Suppose the patient's vital signs have remained unchanged (69/38; heart rate 174) after 3 fluid boluses. What is your differential diagnosis for the patient’s refractory hypotension? What is your recommendation to the surgeon regarding management of the blood pressure?

Your subsequent plan results in improvement of the vital signs. Vital signs include blood pressure.
96/58, heart rate 136, \(\text{SpO}_2\) 97%

You have just completed a head to toe examination of the patient:

Obvious injuries include multiple contusions to the head, chest, and an open fracture to the right lower extremity.

10. Describe an effective strategy to evaluate the cervical spine in this patient. Suppose the CT (Computed tomography) scan of the cervical spine is negative. Is this information sufficient to clear the cervical spine? If not, what additional information would be required to clear the cervical spine? If the cervical spine is not cleared preoperatively, how would a Magnetic Resonance Imaging (MRI) study be useful in the postoperative evaluation of this patient’s cervical spine?

Diagnostic studies:
Chest x-ray: no acute disease; no pneumothorax or rib fractures, tracheal tube in good position
Focused Assessment with Sonography for Trauma (FAST) exam: no free fluid identified
Laboratory studies are all pending
CT scan of the brain and cervical spine: epidural hematoma with midline shift; diffuse cerebral hemorrhage; cervical spine grossly normal

The patient is now scheduled for an emergent decompressive craniectomy to evacuate the epidural hematoma.

You have no preoperative information on this patient. No previous medical records are found on this patient within your hospital’s electronic medical record. You have been informed that the father is currently unavailable by telephone but is on the way to the hospital.

The patient is emergently transported from the CT diagnostic imaging area to the operating room.

Vital signs upon arrival in the operating room:

Temperature (axillary) 35.3 degrees Celsius
Respirations 24 (positive pressure ventilation via self-inflating bag)
Heart rate 92
Blood pressure 122/76
Oxygen saturation 97% (\(\text{FiO}_2\) 100%)

A 22-gauge peripheral intravenous line has been placed.
11. What are your main intraoperative goals and priorities for the anesthetic management of this pediatric patient with a Traumatic Brain Injury (TBI)? The surgeon suspects the patient has increased intracranial pressure (ICP). What are your strategies to lower the ICP? Do you think corticosteroids or mannitol should be administered? What degree of hyperventilation is appropriate?

Approximately 15 minutes after arrival into the operating room, but before opening of the bone flap or dura, a sudden reduction to the end-tidal carbon dioxide (EtCO2) value was identified. This corresponded with a loss of the pulse oximetry and arterial line tracings. You quickly identified these findings, notified the surgeon, and promptly started resuscitation. Resuscitation continued for approximately 3 minutes and consisted of epinephrine and chest compressions. Based on the sequence of events just prior to the patient’s decompensation, you strongly suspect an embolic event as the sole cause for the cardiac arrest. During the resuscitation, it was discovered that all of the intravenous lines were not flushed with intravenous fluid; you think that the tubing was connected to intravenous fluids but not flushed with crystalloid solution. This intravenous line was then connected by you to an existing intravenous catheter when the patient was emergently brought to the operating room; this was followed by the administration of blood products via a pressure bag.

The resuscitation resulted in return of spontaneous circulation and stable vital signs. Based on the emergent condition of the patient, the surgical procedure was then completed. The patient is currently hemodynamically stable but requires an epinephrine infusion. The neurosurgeon believes that the patient has a very poor prognosis. The patient was brought to the Intensive Care Unit (ICU) in critical condition with the tracheal tube still present. You are about to go to the surgical waiting room to speak with the father.

12. What preparations should you make prior to speaking with the father regarding the child’s critical condition and recent medical error? What logistical issues do you think should be arranged?

13. Should you speak with anyone, such as the surgeon, prior to speaking with the father? If so, what is the purpose and what would you discuss?

14. In general, what do you think should be discussed with the father? Who should ideally be present during this conference with the father? What would you actually say to the father? Is it appropriate to say that you’re “sorry” or that “I made a mistake” even if you’re not certain of the cause for this cardiac arrest?
15. How would your discussion differ if no medical error occurred but a poor outcome was still expected?

Model Discussion Content

Traumatic injuries in children are the most common cause of death in the United States for children above one year of age; this will account for approximately 20,000 deaths this year alone. Most traumatic injuries in children are a result of one of the following: motor vehicle accidents, child abuse (also referred to as non-accidental trauma), drowning, thermal injury, or falls; motor vehicle accidents (from being within or being struck by a motor vehicle) are the leading causes of death for children above the age of one year. According to the Centers for Disease Control and Prevention (CDC), approximately 9 million children (ages 0-19) are treated for injuries in Emergency Departments (ED) every year with approximately 200,000 requiring hospitalization at an estimated cost of around $87 billion in medical and societal costs.

The principles of Advanced Trauma Life Support (ATLS) closely resemble traditional teaching philosophies of anesthesiology training in regards to the resuscitation of a critically ill patient. ATLS principles are widely accepted within hospital systems as well as required certification for most surgeons and emergency medicine physicians. Anesthesiologists should be familiar with the initial evaluation and management of pediatric traumatic injuries in order to continue this care effectively in the perioperative setting. The prioritizing of initial management of a trauma patient follows the common order of “ABC’s” which is utilized by most anesthesiologists for the initial evaluation of any critically ill patient. In addition, recognition of the ATLS guidelines currently being performed may guide system utilization more effectively. For example, an anesthesiologist recognizes that a patient has a positive Focused Abdominal Sonography for Trauma (FAST) exam; this finding will most likely result in transfer to the operating room. This increased situational awareness can result in more efficient and effective perioperative care.

Pediatric trauma patients develop unique injuries when compared with adults. Head injuries are the most common isolated, life-threatening injuries and the leading cause of death for pediatric patients; one explanation for this would be the disproportionately large head present in pediatric patients. Thoracic injuries are the second leading cause of death for pediatric trauma patients. Due to increased ribcage pliability, severe internal injury can occur in pediatric patients without external signs such as rib fractures. Blunt abdominal trauma in pediatric patients can frequently be treated with close observation and lack of operative intervention. Penetrating abdominal trauma in pediatric patients usually requires surgical exploration. Non-accidental trauma (NAT) is also seen at disproportionately increased amounts when compared to adults.

Tracheal intubation, in this case, was not performed in the prehospital setting due to multiple
reasons\(^2\). Unsuccessful prehospital airway management for pediatric patients has been proposed due to training, experience, equipment, and environmental issues. Many prehospital providers (e.g. paramedics) have minimal initial training in pediatric airway management skills (e.g. tracheal intubation) and do not typically have ongoing utilization of these skills. Recent guidelines have suggested that avoidance of airway instrumentation in the prehospital setting may be just as effective as securing the airway for pediatric patients. For example, the American Heart Association, Pediatric Advanced Life Support (PALS) guidelines state that, “Bag-mask ventilation can be as effective as ventilation through an endotracheal tube for short periods and may be safer.” The 2010 PALS guidelines also states that, “In the prehospital setting, ventilate and oxygenate infants and children with a bag-mask device, especially if transport time is short.” As a result, many emergency medical services (EMS) have policies containing a “scoop and run” philosophy for pediatric trauma patients that avoid definitive airway management if the transport time is short and effective bag-mask ventilation is able to be performed. In addition, many EMS policies contain provisions for the placement of supraglottic airway devices in lieu of tracheal intubation if mask ventilation is difficult or tracheal intubation was unsuccessful.

Based on the 9\(^{th}\) Edition of the Advanced Trauma Life Support (ATLS) guidelines\(^3\), which is the most recent edition and was released by the American College of Surgeons in 2012, the initial evaluation of the pediatric trauma patient is termed the Primary Survey. The sequence of the Primary Survey can be remembered as “ABCDE” and includes: A (Airway), B (Breathing), C (Circulation), D (Disability), and E (Exposure/Environment). The A (airway) should be evaluated for patency and opened using a jaw-thrust technique if obstructed. Immobilization of the cervical spine should be maintained. Suctioning of secretions from the oral and/or nasal cavities may also be required. The patient’s B (Breathing) and ventilation should be evaluated and immediate intervention should take place if not adequate. C (Circulation) is evaluated by blood pressure, sensorium, and skin turgor. Control of hemorrhage should also take place; this can typically be accomplished by the application of direct pressure to the area that is bleeding. D (Disability) is evaluated by looking for potential neurological injuries. The Glasgow Coma Scale (GCS) is the most commonly recognized scale to estimate the severity of neurological injury; a modified pediatric version is also available. A GCS score of 8 or less implies significant neurological injury and immediate tracheal intubation is strongly recommended. E (Exposure) of the entire patient should occur. The (Environment) E should consist of providing a heated treatment area to reduce hypothermia as well as evaluating for environment threats such as chemical contamination of the patient.

The patient in this clinical scenario requires emergent and definitive airway management initially due to severely depressed neurologic function\(^1,3\); it will later be determined that the patient would also require airway management for the decompressive craniectomy. Placement of a tracheal tube would be accomplished utilizing a Rapid Sequence Induction (RSI) technique unless a difficult airway was suspected\(^1,3\). Preoxygenation followed by administration of medications\(^1,3\) would occur as well as
avoidance of positive pressure ventilation; cervical spine immobilization would occur during airway management and all patient transfers. The use of cricoid pressure during a RSI technique has been recently questioned. A cuffed tracheal tube (size 5.0) would be appropriate for this patient. Medications acceptable for tracheal tube placement in this case includes most intravenous induction agents (excluding ketamine due to its direct increase in intracranial pressure), a neuromuscular blocking agent (e.g. rocuronium), intravenous lidocaine to blunt airway reflexes, and perhaps an opioid (e.g. fentanyl).

Medications and fluids (including blood products) can be administered at the same doses with an intraosseous (IO) line as a typical intravenous line. Drug doses can be determined even if the actual weight is unknown. If the patient’s age is known (or estimated), the weight can be estimated by using the following formula:

Estimated weight (kg) = 2 x (age in years + 4)

If the weight and age are not known, both of these values can also be estimated by use of the Broselow tape. The Broselow tape is a commercially available (Armstrong Medical Industries, Lincolnshire, IL) product that has a reference color range when placed lengthwise next to the patient. Each color range corresponds to a list of equipment sizes and medication doses to perform emergency resuscitation.

The establishment of a secure airway cannot be overemphasized\textsuperscript{3,4,5}. After airway management has occurred or if a patient arrives with a tracheal tube in place, verification of the tracheal tube should occur. Several approaches should be utilized to verify the correct placement of the tracheal tube including auscultation and carbon dioxide detection. If the placement of a tracheal tube is unclear, strong consideration should be given to verify the location of the tracheal tube by direct or indirect laryngoscopy\textsuperscript{22}. If a cuffed tracheal tube has been placed, palpation of the cuff can also be used to evaluate the location of the tracheal tube. A tracheal tube that is positioned too deep can result in a right mainstem intubation. Physical examination, if a right mainstem intubation is present, will commonly reveal decreased breath sounds over the left chest. The numerical value of the markings on the tracheal tube at the lip may suggest that the tube has been placed too deep. In contrast, a patient with a tension pneumothorax within the left chest may present with hypotension, tracheal deviation to the right, and distended neck veins. One approach to management if unsure of the etiology would be to withdraw the tracheal tube to the estimated appropriate length at the lips and reassess for bilateral breath sounds. If no improvement occurs or hemodynamic instability is present, strong consideration for needle decompression to the left chest should occur. Needle decompression would be performed by placement of a large gauge needle above the second rib at the mid-clavicular line.
Hypotension in pediatric trauma patients should be aggressively managed\(^1,3\). Two large bore intravenous lines that are appropriate for age should be placed. For hypotension, administer a fluid bolus of 20 milliliters/kilogram of isotonic crystalloid. If the blood pressure is refractory after two fluid boluses of isotonic crystalloid, strong consideration should be given to the administration of blood products. The typical initial dose for administration of packed red blood cells is 10 milliliters/kilogram\(^2,22\). Colloid has not been shown to be superior to the administration of crystalloid for the volume resuscitation of the pediatric trauma patient\(^7,8\). Hypertonic saline has also not been shown to have any beneficial effect when compared to standard crystalloid resuscitation. The strategy of administering blood products earlier in the resuscitation process has now been emphasized in the updated ATLS Guidelines\(^3\). However, no specific guidelines or ratios have been recommended for the use of specific blood products such as plasma or platelets\(^8\). If the patient’s blood pressure is not improving after multiple fluid boluses including blood products, strong consideration should occur for emergent transfer to the operating room or the angiography suite for control of hemorrhage\(^1,3,7\). The differential diagnosis for a patient with refractory hypotension despite aggressive therapy includes ongoing hemorrhage, tension pneumothorax, pericardial tamponade, cardiac contusion, neurogenic shock, and preexisting medical conditions such as congenital heart disease and adrenal insufficiency. Specific diagnostic testing that may be helpful to determine the source of hemodynamic instability may include computed tomography, echocardiogram, and angiography. However, the risk vs. benefit ratio of transfer for the diagnostic testing needs to be carefully considered especially if the patient remains hemodynamically unstable.

According to the Advanced Trauma Life Support (ATLS) guidelines\(^3\), laboratory testing is completed during the Secondary Survey. The Secondary Survey is a complete head-to-toe patient examination. It is not begun until the Primary Survey is complete and the patient is in overall stable condition. If clinical deterioration should occur at any time, return to the Primary Survey and resuscitation should take place\(^1\). A complete neurological exam and imaging including CT (Computerized Tomography) scans and FAST (Focused Abdominal Sonography for Trauma) exams are completed during the Secondary Survey. Laboratory studies are also completed during the Secondary Survey and typically include hemoglobin/hematocrit, serum chemistries, coagulation profiles, and blood product cross-matching.

Cervical spine injuries in children commonly occur in different locations than adults\(^1,3\). These injuries tend to be located at a higher level, which is usually at, or above cervical spine level C-3. Pseudosubluxation of the cervical spine is a common and benign finding in children. This is usually seen as the anterior displacement of cervical spine level C-2 onto C-3. History and physical examination are the initial steps in the evaluation of the cervical spine for the pediatric trauma patient\(^9,10\). Special attention should be given to the mechanism of injury, level of consciousness, gross neurological deficits, and the presence of midline cervical tenderness\(^1,3,11\). If neck tenderness, decreased sensorium, or neurological deficits are present, one must assume a cervical spine injury...
exists and a surgical consultation is strongly suggested. A CT scan of the cervical spine\textsuperscript{3,8,11} may be helpful in the identification of lesions not visible on plain radiographs. However, SCIWORA (Spinal Cord Injury Without Radiographic Abnormality) is a functional injury that has been estimated to occur in approximately 25-50% of pediatric patients with spinal cord injuries\textsuperscript{1,3,8}. SCIWORA can only be diagnosed with Magnetic Resonance Imaging (MRI).

The cervical spine cannot be cleared based solely on diagnostic imaging; cervical spine imaging must be used in conjunction with physical examination\textsuperscript{1,3,11}. Many centers perform cervical radiographs as part of a standard protocol for trauma patients. A CT scan of the cervical spine may be more effective in the identification of lesions when compared with a plain radiograph. The ATLS guidelines\textsuperscript{3} state that a CT scan of the neck can be substituted for a cervical spine radiograph. In older children, an odontoid or “open mouth” x-ray view can also be considered to evaluate the superior cervical vertebrae. Appropriate spine immobilization should continue during the intraoperative and postoperative periods if the cervical spine of the patient cannot be cleared in the preoperative period\textsuperscript{9}. MRI of the cervical spine may be indicated in the postoperative period if the cervical spine cannot be cleared by physical examination (i.e. patient remains unconscious, patient uncooperative with exam, distracting injuries).

Negative cervical spine imaging but with any of the following cannot be utilized to clear the cervical spine\textsuperscript{22}:
- Patient not alert
- Patient nonconversant (excluding pre-verbal children)
- Positive neurological deficits
- Midline cervical tenderness
- Presence of a painful distracting injury

In summary, the cervical spine can only be cleared on the basis of negative cervical spine imaging study\textsuperscript{9,10} as long as the physical exam is also unremarkable\textsuperscript{1,3}.

Anesthetic implications for this pediatric patient with a traumatic brain injury\textsuperscript{12,14} include maintenance of hemodynamic stability in order to preserve cerebral perfusion pressure. This patient with intracranial hemorrhage (ICH) has a high likelihood for having elevated intracranial pressure (ICP). Acute treatment for elevated ICP due to ICH may include hyperventilation, hyperosmolar therapy, cerebrospinal fluid (CSF) drainage, and surgical removal of the hematoma\textsuperscript{1,14}. An anesthetic technique should be developed to avoid increased sympathetic stimulation while maintaining hemodynamic stability. Other considerations for intraoperative management include obtaining appropriate vascular access for volume resuscitation, maintaining an increased sense of vigilance for undiagnosed traumatic injuries, as well as avoiding hyperglycemia, hypotension, and hyperthermia\textsuperscript{22}. 

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Mannitol is effective in reducing ICP in patients with space-occupying lesions; the most common dose range is 0.25-1.0 gram/kilogram. There is an initial increase in central venous pressure and ICP in response to the administration of mannitol; this is especially evident if given as a bolus or if the dura has not yet been opened. The administration of mannitol can also subsequently result in volume depletion and the production of hypernatremia. The onset time for mannitol has been reported to be 15-30 minutes.

Hyperventilation causes cerebral vasoconstriction to intact blood vessels which reduces cerebral blood volume and ICP. Avoidance of hyperventilation, except in acute circumstances, is recommended due to the risk for producing cerebral ischemia. Hyperventilation to a Paco₂ of less than 25 mm Hg is not more effective in further reducing brain bulk and more importantly accentuates cerebral ischemia. Obtaining an arterial blood gas will allow the comparison of the Etco₂ to Paco₂ gradient; this will permit continuous use of the Etco₂ to act as an estimate of Paco₂.

The administration of corticosteroids to patients with traumatic brain injury (TBI) has been associated with increased mortality as reported in a Cochrane Review. As a result of this meta-analysis and other studies, the administration of corticosteroids for TBI is not routinely recommended.

After the occurrence of a medical error, a single discussion should ideally take place with the parent(s), surgeon, and anesthesiologist. This discussion should occur in a quiet and private location. Social workers, clergy, and language interpreters should all be offered to the parent(s) if deemed appropriate. A discussion with the surgeon before speaking to the parent(s) to review the intraoperative events is recommended to prevent conflicting stories and a thoughtful discussion. Plan what to say to the parent(s) in advance. An objective and compassionate discussion on an appropriate educational level for the parent(s) should be the intention.

Several factors should be considered to make this experience as effective as possible. Disclose only the facts. Tell the parent(s) what you know and what you don't know. Take as much time as needed. Attempt to explain the medical conditions that occurred by using the most appropriate descriptions as possible. Tell what was done and what the future plans are. Be compassionate; it's appropriate to say, "I'm sorry" regarding their child's critical condition. Ask the parent(s) if they understand and if they have any questions. Sometimes parent(s) may request to hear limited information only; this may especially occur soon after an unexpected adverse event. Respect the parent(s)' wishes as much as possible.

Remember that many of the details regarding the medical error may still be unclear or unknown when speaking to the parent(s). In this particular case, it is proposed that an unflushed intravenous line was the cause for the cardiac arrest. This is based on the fact that since one line was not flushed it is likely that the other line was also not flushed. This reasoning may or may not be the true cause for the
cardiac arrest. New information may become available as time passes, an investigation is completed, and the condition of the patient changes. Update the parent(s) as new information becomes available. One should develop a process for the parent(s) to contact you if they think of additional questions after the initial discussion. Continue to provide postoperative visits and offer your expertise to the primary team caring for the patient. Be prepared to repeat all previous discussions with the parent(s). Many parents may only recall portions of your discussions due to the severe emotional stress from the event.

From a medical-legal perspective, recall that everything you say to the parent(s) and place in the medical record is discoverable and can be used in future litigation. The anesthesia record should be reviewed for accuracy, legibility, and completeness. A separate progress note can be used to document additional patient care details such as management in the intensive care unit, additional intraoperative information, and any discussion(s) with the parent(s). One should be cautious about stating anything in the medical record that is not an objective finding such as a suspected etiology or system error. The same general processes should be utilized for the handling of a medical error as well as a poor outcome not due to medical errors.

References