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Using Advanced Trauma Life Support to Manage a Pediatric Trauma Patient with Traumatic Brain Injury and Disclosure of Difficult News After a Poor Outcome

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Stem Case and Key Questions Content

Your patient is a 2 year old male who was involved in a motor vehicle accident. The motor vehicle was hit head-on at approximately 50 miles per hour; the patient was unrestrained in a car seat. The patient currently has a Glasgow Coma Scale (GCS) score of 4. Bag-mask-ventilation is being provided by the paramedics while en-route to your facility.
Estimated time for arrival (ETA) is 4 minutes.

The paramedics placed a cervical collar and backboard on the patient.
Peripheral intravenous access has been established with an intraosseous line in 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 ED physician is currently caring for another patient in status asthmaticus.

1. 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. Describe how to estimate the patient's weight if the age is known. Can the intraosseous (IO) line be utilized for medication delivery? If so, what are the appropriate medication doses when using an IO line?

The patient has the following vital signs after placement of a tracheal tube:
Temperature (axillary) 36.0 degrees Celsius
Respirations 36 (positive pressure ventilation via self-inflating bag)
Heart rate 174
Blood pressure 69/38
Oxygen saturation 74% (FiO_2 100%)
Positive carbon dioxide (CO_2) was confirmed after tracheal intubation.
Patient's estimated weight: 15 kilograms (kg).
Physical exam: absent breath sounds over the left chest.

2. Why do you think that tracheal intubation was not performed by the paramedics prior to arrival at the hospital?

3. 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 which resulted in significant improvement in breath sounds to the left chest.

The blood pressure remains at 69/38; heart rate 174, Oxygen saturation 96% (FiO2 100%).

4. If you would select the administration of volume expanders, how will you decide between administering crystalloid, colloid, or blood products? What type and amount of volume expander will you select to administer? Are there any advantages to one particular product?

5. 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?

Your plan for fluid resuscitation results in improvement of the vital signs. Vital signs include blood pressure 96/58, heart rate 116

You have just completed a brief head to toe examination of the patient:
Obvious injuries include multiple contusions to the head and an open fracture to the right lower extremity.

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

6. Describe an effective strategy to evaluate the cervical spine in this patient. Suppose the plain radiographs of the cervical spine are negative. Is this information sufficient enough 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?

<u>Diagnostic studies:</u>
Chest x-ray: no acute disease; no pneumothorax, tracheal tube in good position
Focused Assessment with Sonography for Trauma (FAST) exam: no free fluid identified
Laboratory studies are all pending
Computed tomography (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. You have been informed that the parents are currently unavailable but are on the way to the hospital.

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

Vital signs upon arrival in the operating room:
Temperature (axillary) 35.6 degrees Celsius
Respirations 24 (positive pressure ventilation via self-inflating bag)
Heart rate 102
Blood pressure 122/76
Oxygen saturation 98% (FiO_2 100%)
A 22 gauge peripheral intravenous line has been placed.

7. What are your main intraoperative goals and priorities for the anesthetic management of this pediatric patient with a Traumatic Brain Injury (TBI)?

8. 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?

The surgical procedure was completed. The patient has severe and diffuse cerebral hemorrhage. 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 parents.

9. What arrangements should you make prior to speaking with the parents regarding their child's critical condition and poor prognosis?

10. In general, what do you think should be discussed with the parents? What would you actually say to the parents? Is it appropriate to say that your "sorry"?

The parents state that they greatly appreciate you taking care of their child and all the time you have taken to update them on their child's progress.

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[1]. Most traumatic injuries in children are a result of one of the following: motor vehicle accidents, child abuse, drowning, thermal injury, or falls; motor vehicle accidents are the leading cause of death for children above the age of one year. Anesthesiologists should be familiar with the initial evaluation and management of pediatric traumatic injuries in order to continue this care in the perioperative setting[1].

Based on the 9th Edition of the Advanced Trauma Life Support (ATLS) guidelines[2] which were 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. 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 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 a heated treatment area to reduce hypothermia.

The patient in this clinical scenario requires emergent and definitive airway management initially due to severely depressed neurologic function[2]; 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 technique unless a difficult airway was suspected[3]. Preoxygenation followed by administration of medications[3] would occur as well as avoidance of mask ventilation; cervical spine immobilization would occur during airway management and all patient transfers. The use of cricoid pressure during a rapid sequence induction technique has been recently questioned. A cuffed tracheal tube (size 4.0 or 4.5) would be appropriate for this patient. Medications acceptable for tracheal tube placement in this case includes most intravenous induction agents (excluding ketamine), a neuromuscular blocking agent (such as rocuronium), intravenous lidocaine to blunt airway reflexes, and perhaps an opioid (such as 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)

Tracheal intubation may not have been performed in the prehospital setting due to multiple reasons[1]. 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 training in pediatric airway management skills such as tracheal intubation and do not typically have ongoing utilization of these skills. Recent guidelines have proposed that avoidance of airway instrumentation in the prehospital setting may just as effective as securing the airway for pediatric trauma 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.

The establishment of a secure airway cannot be overemphasized[3,4]. 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 initially 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. If a cuffed tracheal tube has been used, palpation of the cuff can also be used to evaluate the tip of the tracheal tube. A tracheal tube that is positioned too deep can typically result in a right mainstem intubation. Physical examination for a right mainstem intubation will commonly reveal decreased breath sounds on 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. A patient with a tension pneumothorax to 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 takes place, 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[2]. 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. Colloid has not been shown to be superior to the administration of crystalloid for the volume resuscitation of the pediatric trauma patient. 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[2]. However, no specific guidelines or ratios have been recommended for the use of specific blood products such as plasma or platelets. 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 for control of hemorrhage[4].

According to the Advanced Trauma Life Support (ATLS) guidelines[2], 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, regression to the primary survey and resuscitation should take place. 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 may include hemoglobin/hematocrit, serum chemistries, coagulation profiles, and blood product cross-matching.

Pediatric trauma patients develop unique injuries when compared with adults[3]. Head injuries are the most common isolated 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[5]. Blunt abdominal trauma in pediatric patients can frequently be treated with close observation and lack of operative treatment. 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.

Cervical spine injuries in children commonly occur in different locations than adults[6]. 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. Special attention should be given to the mechanism of injury, level of consciousness, gross neurological deficits, and the presence of midline cervical tenderness5.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[7] 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. SCIWORA can only be diagnosed by 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. 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[2] 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. 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 with any of the following cannot be utilized to clear the cervical spine: patient not alert, patient nonconversant (excluding pre-verbal children), positive neurological deficits, midline cervical tenderness, or presence of a painful distracting injury.

In summary, the cervical spine can only be cleared on the basis of negative cervical spine imaging study[7] as long as the physical exam is also unremarkable[1].

Anesthetic implications for this pediatric patient with a traumatic brain injury[8] 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. 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 possible volume resuscitation, maintaining an increased sense of vigilance for undiagnosed traumatic injuries, avoiding hyperglycemia, hypotension, and hypothermia.

Mannitol is effective in reducing ICP in patients with space-occupying lesions[8]; the most

common dose 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 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 now recommended due to the risk for producing cerebral ischemia. Hyperventilation to a $Paco_2$ of less than 25 mm Hg is not more effective in further reductions of brain bulk and more importantly accentuates cerebral ischemia[1].

The administration of corticosteroids to patients with traumatic brain injury (TBI) has been associated with increased mortality in a Cochrane Review[9]. 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 poor outcome, ideally a single discussion should take place with the parents, 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 parents if deemed appropriate. A discussion with the surgeon before speaking to the parents to review the intraoperative events is recommended to prevent conflicting stories and a thoughtful discussion. Plan what to say to the parents in advance[10]. An objective and compassionate discussion on an appropriate educational level for the parents should be the intention.

Several factors should be considered to make this experience as comfortable as possible[11]. Disclose only the facts. Tell the parents 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 parents if they understand and if they have any questions. Sometimes parents may request to hear limited information only; this may especially occur soon after an unexpected poor outcome. Respect the parents' wishes as much as possible.

Remember that many of the details regarding the poor outcome may still be unclear or unknown when speaking to the parents. New information may become available as time passes and the condition of the patient changes. Update the parents as new information becomes available[12]. One should consider developing a method for the parents 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.

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