Pediatric Trauma Program: CME OUTREACH ACTIVITY

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PEDIATRIC AIRWAY MANAGEMENT

AUTHOR: Lora Gibbs, CRNA, MS Chief Nurse Anesthetist, Division of Pediatric Anesthesiology University of Michigan Health System
Paul Reynolds, MD Chief of Pediatric Anesthesiology, Division of Pediatric Anesthesiology University of Michigan Health System

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Introduction

Resuscitation of a child who has been the victim of trauma often involves management of the airway. Pediatric airway management can be difficult under the best of circumstances and become increasingly challenging and stressful under suboptimal conditions. While management of an adult airway is familiar to most first responders and hospital personnel, management of the pediatric airway is a less frequent but more complex process. There is a wide variation in equipment sizes in pediatrics and medication doses must be calculated with more precision. This newsletter will discuss some of the unique characteristics of airway management in the pediatric patient including medication, equipment and techniques for securement.

Importance. The most common cause of cardiac arrest in children is the inability to establish or maintain a patent airway. Therefore, it is important for first responders/receivers are familiar with basic pediatric airway management and have the ability to establish an acute airway as soon as possible. Once in the hospital setting, a pediatric airway specialist must work in conjunction with the team of care providers to maintain the airway in an optimal fashion.

Pediatric Airway Evaluation & Initial Management

Unique anatomic characteristics. The first step in trauma resuscitation is to assess the airway and then secure it when necessary. Indications for endotracheal intubation include inability to oxygenate and ventilate and to protect the airway against aspiration. Appropriate management of the airway may be challenging without proper preparation and familiarity with the unique characteristics of the pediatric airway which include:

- Relatively large tongue in relation to the size of the mouth
- More anterior larynx and glottic opening compared to adults
- Smaller diameter and a shorter length of airway
- Edema occurring in an already small airway results in significant changes in the internal diameter of the airway and in increased resistance to airflow
- Short trachea makes right mainstem intubations more likely and increases the likelihood of extubation from small positional changes of the ET tube
- Small midface compared to the tongue, commonly resulting in airway obstruction

Initial airway management. A maneuver to ensure the obstructed airway remains patent (while keeping the c-collar in place) is a jaw thrust with suction. This technique lifts the tongue off the posterior airway while maintaining cervical stabilization. If the airway is still not patent after this maneuver, there should be consideration of a possible airway foreign body. Blood, vomit, teeth and food are common causes of an airway obstruction. In addition, children are often placed in a cervical collar that may be too large for the child.

The initial management of the pediatric airway involves bag-valve-mask ventilation (BVM) in combination with a jaw thrust maneuver. Intubation is indicated in patients with respiratory or cardiac compromise, or an altered level of consciousness. All pediatric trauma patients should be considered to have a “full stomach” and possible cervical spine injury. Because of this, the airway should be secured after a rapid sequence induction (RSI) which may include cricoid pressure) with manual in-line stabilization and oral endotracheal intubation. Trauma patients have 5 times the risk for aspiration compared to elective surgery.
Intubation of the Pediatric Patient

RSI. Rapid Sequence Intubation is recommended for every emergency intubation involving a child with intact upper airway reflexes by the Pediatric Emergency Medicine Committee of the American College of Emergency Physicians.

The rapid sequence induction for pediatric trauma patients can be accomplished with an induction agent, immediately followed by a muscle relaxant. Standard induction agents for trauma patients include:

- Etomidate (0.2-0.3 mg/kg) and Ketamine *(2-4 mg/kg)
- Fentanyl (2-4 mcg/kg), Midazolam (0.05-0.1 mg/kg) with Lidocaine (1 mg/kg)
- Propofol should be reserved for patients who are not hemodynamically unstable
- Consider use of Atropine 0.1 mg/kg as a pre-induction agent in children < 6 months to prevent bradycardic vagal response

*Ketamine is relatively contraindicated in patients with increased intracranial pressure. Muscle relaxation can be achieved with Rocuronium (0.8-1.2 mg/kg) or Succinylcholine (1-1.5 mg/kg).

Endotracheal tubes (ETT). When a child is unable to maintain adequate oxygenation, it may become necessary to intubate. Orotracheal intubation is the most reliable means of establishing an airway and administering ventilations to a child.

Cuffed vs. uncuffed. The recommendation of the Pediatric Anesthesia Department at Mott Children’s is the utilization of cuffed tubes in infants and children > 3.5 kg. The use of uncuffed or cuffed ETT in children each have their own advantages (Table 1). Uncuffed ETT are commonly used in infants because of the anatomic differences. However, the use of cuffed ETT, even in toddlers and small children, provides the benefit of improving ventilation and CO2 management. Previous concerns about cuffed ETT causing tracheal necrosis are no longer relevant due to improvements in the design of the cuffs.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Uncuffed Endotracheal Tubes</th>
<th>Cuffed Endotracheal Tubes</th>
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<tbody>
<tr>
<td>Larger Internal Diameter</td>
<td>Allows use of lower fresh gas flow</td>
<td></td>
</tr>
<tr>
<td>Lower resistance to airflow</td>
<td>Less use of inhalational agent, so economical</td>
<td></td>
</tr>
<tr>
<td>Prevents increased work of breathing</td>
<td>Reduced air pollution</td>
<td></td>
</tr>
<tr>
<td>Allows easy suctioning</td>
<td>Reduced risk of aspiration</td>
<td></td>
</tr>
<tr>
<td>Avoids trauma to sub-glottic region</td>
<td>Avoids multiple laryngoscopies and intubations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improved ventilation and end-tidal CO2 monitoring</td>
<td></td>
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</table>

Endotracheal tube sizing. Appropriate sizing of the pediatric endotracheal tube is vital to the appropriate ventilation of the pediatric patient. Tubes that are too small or too large will produce ineffective ventilation and oxygenation and may cause damage to the delicate pediatric airway. A simple technique to gauge the size of the ETT needed is to approximate the diameter of the child’s external nares or the tip of the child’s small finger. Commercially available length-based resuscitation tapes that will provide appropriate tube size based on weight and height of the child are available. There is also a reliable mathematic equation utilized to calculate tube size for children over 1 year of age. See Table 2 for appropriate sizes for ETT in children:

<table>
<thead>
<tr>
<th>Table 2</th>
<th>SIZING ETT IN CHILDREN</th>
</tr>
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<tbody>
<tr>
<td>AGE</td>
<td>TUBE SIZE</td>
</tr>
<tr>
<td>Neonate</td>
<td>3.0 mm</td>
</tr>
<tr>
<td>0 - 6 months</td>
<td>3.5 mm</td>
</tr>
<tr>
<td>6 - 12 months</td>
<td>4.0 mm</td>
</tr>
<tr>
<td>Over 1 year of age</td>
<td>(Age in years/4) + 4 = size of ETT mm**</td>
</tr>
</tbody>
</table>

** If using a cuffed ETT, the tube should be a half size smaller than calculated with this formula.

CASE SCENARIO: 12 year old child with GCS 6 after MVC. What size uncuffed ETT will you anticipate?

(12 years old/4) + 4 = ? ETT
(3) + 4 = 7 ETT
What size cuffed tube?
7 - 0.5 = 6.5 ETT

Alternate airway devices in children. While many devices are appropriate in size, provider unfamiliarity makes them an inappropriate choice in any urgent situation. Competence must be established before using any adjunct airway devices in a clinical situation.

Laryngeal mask airway (LMA). If initial intubation attempts are unsuccessful after an RSI, the patient should be ventilated with bag-mask ventilation. If they cannot be ventilated or if it is very difficult, an LMA can be placed to facilitate ventilation and subsequent intubation. However, an LMA does not protect the airway from aspiration and an LMA must be replaced by an endotracheal tube (ETT) as soon as skilled personnel become available. The stomach should be decompressed with a nasogastric or orogastric tube after intubation and a chest x-ray obtained to verify ETT position.
Trauma Considerations of Pediatric Airway Management

Clinical findings. The presence of rhinorrhea, otorrhea or ecchymosis around the eyes should raise suspicion about a possible basilar skull fracture. If so, avoid any instrumentation of the nasal passages, including passage of a nasal ETT or an N/G tube. Crepitus at the neck may indicate a tracheal disruption. Consider intubation under direct vision using a fiberoptic scope to avoid false passage of the ETT.

Head and/or cervical spine injury. In patients who have suffered loss of consciousness or head injury, the index of suspicion for cervical spine injury is high, even in the absence of radiologic evidence. When performing laryngoscopy, in-line axial stabilization must be performed. (SEE PIC 1) An assistant performs in-line axial stabilization during laryngoscopy. The assistant places both arms on either side of the patient’s head, while gripping the patient’s shoulders. The assistant’s function is to maintain the patient in a neutral position during laryngoscopy, avoiding flexion, extension or rotation of the cervical spine. Avoid the use of muscle relaxants until the airway is secured. If intravenous agents are required to induce anesthesia, use short acting agents such as Propofol and Remifentanil, which will blunt ICP responses to direct laryngoscopy, yet permit return of spontaneous respiration in case of failed intubation.

“Children see magic because they look for it” Christopher Moore

WHAT WOULD YOU DO?

ACTUAL CASE REVIEW

Situation: 6 year old female is standing on a step stool brushing her teeth, when she slips from the stool and the toothbrush becomes embedded in the child’s mouth (Pic 2). Parents leave toothbrush in place and EMS is contacted. EMS transports patient to C. S. Mott Children’s Hospital for evaluation and definitive care.

Assessment: Child presents to Emergency Department with toothbrush embedded in her left tonsilar pillar. She is alert and oriented, breathing is even and unlabored and she is handling secretions appropriately. She has no other medical or surgical history. Due to the placement of the impalement, it is unknown if the injury has injured her carotid artery.

NOW WHAT?

Course of Care: Patient is taken to angiography for imaging studies to assess for vascular injury. This is performed with IV sedation and pediatric anesthesia in attendance. The child tolerated the procedure well and did not require intervention to assist with ventilation. Fortunately there were no injuries to any vessels.

NOW WE NEED AN AIRWAY....... 

Course of Care: With no injuries to the vessels, the patient was taken to the OR for toothbrush removal. Because the patient could not be properly pre-oxygenated (to fit a bag-valve-mask appropriately was impossible) the patient could not undergo RSI. The patient was given Propofol only. The Pediatric Anesthesiologist was able to intubate using direct laryngoscopy and the toothbrush was removed. The patient had minimal bleeding and recovered without difficulty.

LESSONS LEARNED

Take the time to develop a well thought out plan! Always develop your plan based on patient presentation and not on injury alone. Include contingencies for the unexpected complication and include all key players in the plan development.
Management of the Unanticipated Difficult Airway

Problems with intubation are infrequent but can lead to death or brain damage. The clinical situation is not always managed well. Mott has developed guidelines for management of the unanticipated difficult tracheal intubation in the pediatric patient (Fig 1). These guidelines have been developed by consensus and are based on evidence and experience. The flow-chart outlining the steps for the unanticipated difficult airway are simple, clear and definitive. They can be fully implemented only when the necessary equipment and training are available. These guidelines are neither a minimum standard of practice, nor are they a substitute for good clinical judgment.

Adapted from: Weiss M, Engelhardt T; 2010
Surgical Management of the Pediatric Airway

Emergent cricothyrotomy. The advantage of performing emergent cricothyrotomy is that the cricothyroid membrane is superficial and readily accessible, with minimal dissection required. The disadvantage is that the cricothyroid membrane is small and adjacent structures (eg, conus elasticus, cricothyroid muscles, central cricothyroid arteries) are jeopardized; moreover, the cannula may not fit. Damage to the cricoid cartilage from the scalpel or pressure necrosis leads to perichondritis and possibly stenosis. The overall complication rate of emergent cricothyrotomy is 32%, which is 5 times that of the procedure under controlled circumstances.

Cricothyroid membrane anatomy in children vs. adults. Cricothyrotomy is not an option in patients under approximately 8 years of age. Cricothyrotomy is only an option in children over the age of approximately 8 years, when the cricothyroid membrane is large enough to accommodate the smallest available cricothyrotomy device (Table 2 & Figure 2).

<table>
<thead>
<tr>
<th>Age</th>
<th>&lt; 2 YEARS</th>
<th>2-8 YEARS</th>
<th>ADULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cricothyroid membrane</td>
<td>3 mm x 2.5 mm</td>
<td>10 mm x 8-10 mm</td>
<td>25 mm x 20 mm</td>
</tr>
</tbody>
</table>

Cricothyrotomy procedure. The patient’s neck is extended and stabilized. Palpate for the cricoid cartilage approximately 2-3 cm below the thyroid notch. (A)

A 1-cm horizontal incision is made just above the superior border of the cricoid (this avoids the vessels that run under the inferior border, in the same manner as the intercostal neurovascular bundles) to expose the cricothyroid membrane, which is then punctured in the midline (B).

The blade must be directed inferiorly to avoid trauma to the true vocal cords. Care is taken not to extend this puncture through the back wall of the larynx and into the esophagus (C).

Insert a blunt instrument (eg, knife handle) into the incision and rotate it perpendicularly to widen the incision to accommodate a small tube. Once the tube is in place, inflate the balloon to secure (D).

Needle cricothyrotomy. In small children, the cricoid cartilage is a delicate structure and provides the majority of support to the trachea. Injury to the membrane can lead to significant morbidity and lifelong laryngotracheomalacia. To avoid this, children younger than 8 years should undergo needle cricothyrotomy and jet insufflation of the trachea. For this procedure, a 16 g or 18g intravenous catheter is utilized to access the tracheal lumen through the cricothyroid membrane and is connected to a 100% oxygen source at a high flow rate of 10 to 12L/minute. This method, however, is only effective for a short time. Following stabilization of the child, endotracheal intubation or formal tracheostomy is necessary.

Tracheotomy. The two options for a surgical airway in children under 8 years of age are: needle tracheotomy and formal tracheotomy. Formal tracheotomy takes over 10 minutes to perform even in the most-skilled pediatric otolaryngologist’s hands. Therefore, in a crisis, the alternative is more likely to be a needle tracheotomy.

The need for a needle tracheotomy is a very rare occurrence. Because emergency pediatric needle tracheotomy is such a rare event, minimal literature exists about the technique and very little equipment has been developed. As a result, letters to the editor in several anesthesia journals have suggested many pieces of equipment as possibly being useful in this situation without ever being evaluated in humans, animals, or even experimental lung models.
Did you KNOW?

- Children are more likely, because of their neck musculature and their disproportionately large head size, to sustain cervical neck injuries above C3
- C-Spine fractures occur in 7-10% of children with TBI
- 60—70% of pediatric cervical spine fractures are in C1 or C2, compared to 16% in adults
- C-spine fractures are less common in pediatrics because of ligament flexibility

"Anyone who does anything to help a child in life is a hero to me"               Fred Rogers

TRAUMA IS A TEAM SPORT

The success of any trauma program is not reliant on any one discipline or department. The success of safe, reliable and efficient trauma patient care is the ability and willingness of all departments to achieve a common goal—the prevention and treatment of traumatically injured children.

Mott Pediatric Surgery: Trauma is a Team Sport

Injury Prevention

Take the Quiz!

KNOWLEDGE TEST AND AMA/PRA CATEGORY 1 CREDIT

After reading the article, continue the educational activity by taking the online CME quiz at:

https://cme.med.umich.edu/assessment/questions.asp?gid=151

After you initially take the test, the test will be immediately electronically scored.

If fewer than 70% of the questions are answered correctly, the questions that were not answered correctly will be noted in red. Review the CME content related to those topics and retake the test.

If 70% or more of the questions are answered correctly, the correct and incorrect answers for all questions will be shown along with explanations of the basis for the correct answer. The link to register and receive credit is shown at the end of the items and explanations. Complete the electronic credit request.