

# Critical Procedures in Pediatric Emergency Medicine

Fernando Soto, MD<sup>a,\*</sup>, Alison Murphy, MD<sup>b</sup>, Heather Heaton, MD<sup>c</sup>

## KEYWORDS

- Pediatric emergency medicine • Pediatric respiratory arrest
- Pediatric oral lacerations • Pediatric thoracostomy • ENT foreign bodies

## KEY POINTS

- Pediatric respiratory arrest offers different challenges than in the adult population: limited ventilatory reserve, the trachea is more anterior and superior, intraoral and supraglottic structures are relatively large and floppy, and neck extension might decrease airway size considerably.
- Bag-valve mask ventilation is an invaluable skill when dealing with pediatric respiratory arrests. It may be performed for a prolonged period in difficult airway situations. Consider inserting a nasogastric tube.
- Intraosseous vascular access can be used in all ages. When peripheral access cannot easily be obtained, the other preferred vascular approaches in the pediatric population include the external jugular, scalp veins, or femoral veins.
- When dealing with ear and nose foreign bodies, the size, shape, consistency, and depth of the object will determine the ideal extraction equipment. Avoid repeated attempts. Order radiographs when looking for button batteries and magnets.
- Small spontaneous pneumothoraces could be observed or aspirated through a needle; consider inserting a pigtail catheter in selected patients.
- Oral lacerations are seldom sutured. Antibiotic coverage remains controversial.
- When considering an infected ventricular shunt, consider performing a lumbar puncture in selected patients instead of directly tapping the shunt.
- To improve success rates in performing lumbar punctures, increase hip flexion; neck flexion rarely helps and may increase the risk of apnea in infants.
- An equally sized Foley catheter may be used to replace gastrostomy tubes.

---

<sup>a</sup> Pediatric Emergency Medicine Section, University of Puerto Rico School of Medicine, PO Box 29207, San Juan, PR 00929, USA; <sup>b</sup> Department of Pediatric Emergency Medicine, Wolfson Children's Hospital, 820 Prudential Drive, Suite 713, Jacksonville, FL 32207, USA; <sup>c</sup> Department of Emergency Medicine, University of North Carolina Hospitals, 1st Floor Physicians Office Building, 170 Manning Dr, CB#7594, Chapel Hill, NC 27599-7594, USA

\* Corresponding author.

*E-mail address:* [sotomd13@yahoo.com](mailto:sotomd13@yahoo.com)

## AIRWAY

Effective management of the pediatric airway is an essential skill for emergency medicine physicians. Pediatric airways provide unique challenges given the differences in anatomy between pediatric and adult populations, and the airways of infants and children are more susceptible to obstruction. **Box 1** details key principles that must be remembered when dealing with pediatric airways.

### ***Noninvasive Airway Management***

Noninvasive management of the airway in pediatrics is similar to adults, with 2 main maneuvers available for health care providers: chin-lift and jaw-thrust. Both allow the airway to remain in a neutral position, and therefore allow for better oxygenation and ventilation. In the chin lift, one hand is placed under the mandible, which gently lifts the chin anteriorly, while the other hand is placed on the forehead to tilt the head into a neutral position. The jaw thrust should be used when trauma is suspected given the ability to maintain cervical spine immobilization. To perform, a hand should be placed at the angle of the lower jaw on each side and the mandible should be moved forward.

Airway adjuncts, like oral and nasopharyngeal airways, are also useful in pediatric airway management. Oral airways lift the tongue and soft tissues off the posterior pharynx and should be used only in unconscious children. To choose an appropriate-sized oral airway, measure along the side of the child's face (the tip of the airway should reach the angle of the mandible). They are easily placed with the assistance of a tongue depressor. Nasopharyngeal airways are useful in conscious patients with obstructions caused by tongue and pharyngeal airway obstructions. The correctly sized nasopharyngeal airway should extend from the nostril to the tragus of the patient's ear. After lubricating the airway, it should easily slide into the nostril.

### ***Rapid Sequence Intubation***

When the emergency medicine physician is unable to maintain an adequate airway with noninvasive measures, rapid sequence intubation can be safely performed in children.<sup>1,2</sup> Although there is often little time to obtain consent before the intubation, if possible, parents should be counseled on the medications, procedure, and alternatives if intubation is unsuccessful (**Table 1**).

### ***Indications/contraindications***

There are no contraindications to performing an endotracheal intubation in patients unable to ventilate or oxygenate, or are presenting with altered mental status with unsecured airway; however, lack of equipment or expertise should be considered when encountered with this situation. Studies have shown that bag-valve mask ventilation can prove just as efficient in providing oxygenation and ventilation as

#### **Box 1**

##### **Anatomic principles of pediatric airways**

- The airway is more anterior; hyperextension of the neck can obstruct the airway.
- Airways are smaller and more susceptible to obstruction and edema.
- Neonates and infants have large occiputs causing neck flexion.
- Children have larger tongues that fall into the hypopharynx and cause obstruction.
- The narrowest portion of the pediatric airway is the subglottic space.

	<b>Dose</b>	<b>Indications</b>	<b>Contraindications</b>
Atropine	0.02 mg/kg IV, minimum single dose 0.1 mg, maximum single dose 0.5 mg	Can be considered in pretreatment approximately 2 min before intubation in all children less than 5 y old to help prevent bradycardia. <sup>9</sup>	
Lidocaine	1.5 mg/kg IV	Pretreatment in patients with suspected increased intracranial pressure and asthma. <sup>9</sup>	
Etomidate	0.3 mg/kg IV	Sedation in patients with hemodynamic instability	Transient adrenal corticoid suppression is a potential complication. <sup>10</sup>
Ketamine	1–2 mg IV	Safe for use in patients with hemodynamic instability as well as bronchospasms	Avoid in patients with increased intracranial pressure. <sup>11</sup>
Succinylcholine	Infants and young children: 2 mg/kg IV, older children: 1–1.5 mg/kg IV	Depolarizing agent with rapid onset (45–60 seconds) and short duration (6–10 minutes)	Avoid in patients with chronic myopathies, denervating neuromuscular disease, within 48–72 hours after burn, crush or denervating injury, malignant hyperthermia or in patients with pre-existing hyperkalemia. <sup>12,13</sup>
Rocuronium	0.6–1.2 mg/kg IV	Nondepolarizing neuromuscular blocking agent; rapid onset and short duration	

endotracheal intubations, especially in the prehospital field.<sup>3,4</sup> There are alternatives to orotracheal intubation such as supraglottic airway devices (i.e. LMA's, King LT's, Combitubes, etc), among other supraglottic airway rescue devices that may aid in intubation before securing an airway through endotracheal intubation (see the following).

### **Procedure**

Before intubation, the patient should be placed on a continuous cardiac monitor that follows the heart rhythm, respiratory rate, and oxygen saturation along with a noninvasive blood pressure monitor. Supplemental oxygen must be available as well. In preparation for the procedure, the patient should be preoxygenated with 100% inspired oxygen. Place the patient in the "sniffing position" to align the pharyngeal, tracheal, and oral axes and maintain airway patency. Further equipment required includes

suction, bag valve mask (BVM), airway adjuncts (oropharyngeal airways, nasopharyngeal airways), rescue devices, such as laryngeal mask airways, Combitube, King airway, or a gum elastic bougie in case the endotracheal tube cannot be placed. An end-tidal CO<sub>2</sub> detector is also required at the bedside to confirm successful placement.

When choosing the appropriate endotracheal tube, the literature supports the use of cuffed tubes in all pediatric patients outside of the newborn age as long as cuff pressures remain less than 20 cm H<sub>2</sub>O.<sup>5,6</sup> For uncuffed endotracheal tube sizing, the age-based formula 4+ (age in years/4) can be used, whereas cuffed tubes should be one-half size smaller than the age-based calculation recommendation.<sup>7,8</sup> Additionally, the clinician should have a tube one size smaller and one size larger easily accessible during the procedure. Place a stylet in the endotracheal tube to improve the firmness of the tube, but the tip of the stylet should not extend farther than the tip of the endotracheal tube.

Laryngoscope blades can be either curved or straight. The curved blade tip is placed in the vallecula, whereas the straight blade tip extends into the glottic opening for lifting of the epiglottis. Frequently, straight blades are preferred in infants and young children because they have a large floppy epiglottis. Blade sizes range from 00 for premature infants to 4 for large adults. Generally, size 0 to 1 can be used in most infants and size 2 can be used for most 2-year-olds. The blade should adequately move the tongue and soft tissues to allow for direct visualization of the vocal cords.

Rapid sequence intubation consists in applying interventions and medications in a continuous fashion in order to decrease the risk for aspiration. **Table 1** includes the indications and dosing of the most common medications. Once the medications are administered, apply cricoid pressure to help prevent gastric insufflation and regurgitation. Open the mouth using the scissor technique or with extension of the head. The provider should insert the laryngoscope into the patient's mouth to the appropriate position based on the blade type and sweep the tongue to the left. Lift the handle up to move the soft tissue structures out of the way and to improve visualization. Avoid "rocking" the blade backward onto teeth. Once the epiglottis is visualized, continue lifting up to expose the vocal cords. With the endotracheal tube in the right hand, slide the tube through the vocal cords and pull the stylet out. The endotracheal tube tip should be midpoint between the thoracic inlet and the carina. Intubation should be confirmed immediately. After visualizing the tube pass through the cords, watch for visible chest rise and mist in the endotracheal tube. Further, breath sounds should be audible in both axillae, but not over the stomach. Continuous pulse oximetry and end-tidal CO<sub>2</sub> should also confirm placement. Secure the tube and minimize head movement to decrease the chances of tube dislodgement.

### ***Approach to the Difficult Airway***

---

When definite airway management is necessary and intubation is either not possible or has failed, different methods of emergency airway access must be considered. Needle cricothyroidotomy can be performed in patients of any age, but is considered preferable to a surgical cricothyroidotomy in infants and children up to age 10 to 12 years because it is easier to perform and less likely to cause permanent damage.<sup>14-17</sup> The main indication to undergo this procedure is inability to maintain an airway with standard airway procedures. Contraindications include any injury to the larynx, cricoid cartilage, or trachea (ie, laryngeal fracture or tracheal rupture). Relative contraindications include situations in which a potential anatomic distortion is present.

Setup for a needle cricothyroidotomy includes universal precautions (gown, cap, mask, eye protection, sterile gloves), iodine for site cleansing, sterile drapes, 1%

lidocaine without epinephrine for local anesthesia, 10 mL syringe filled with sterile saline, and a large-bore catheter (infants and young children: 16 to 18 gauge; adolescents and adults: 12 to 18 gauge). Connectors should also be available to connect to a BVM or oxygen tubing. The patient is placed on a continuous cardiac monitor. The insertion site is identified by localizing the cricothyroid membrane region and is prepared with basic sterile technique procedures. The site is cleansed with iodine and local anesthetic should be injected if needed. The trachea is held in place with skin tension using the provider's nondominant hand. The needle is attached to the half-filled saline syringe and inserted at the inferior margin of the cricothyroid membrane, directed toward the patient's feet. Advance the needle while applying continuous negative pressure on the syringe until air bubbles are seen, then slide the catheter off the needle into the trachea and remove the syringe and needle. Hold the catheter in place at all times, even after it has been secured.

### ***Special Considerations: Permanent Tracheotomies***

---

Pediatric patients with permanent tracheotomies present a unique set of challenges for emergency medicine providers. On presentation, these patients should be placed in a room with advanced airway equipment, including multiple endotracheal tubes and tracheostomy tubes.

If a patient with a tracheostomy presents with respiratory distress, check for obstruction with a foreign body, blood, or mucus. If an obstruction is not obvious during examination, suction through the cannula. If the patient continues to have distress, the tracheostomy should be removed, inspected, and cleaned. Insert a catheter through the tracheostomy tube before removing the tube to ensure proper replacement, especially if the tracheostomy site is less than 4 weeks old. When replacing the tracheostomy, lubricate the cannula and advance with a semicircular motion as it curves into the trachea. If tracheostomy tubes are not immediately available, one can also place an endotracheal tube through a tracheostomy opening. Do not force the tube, as this may create false passages within the soft tissue of the neck.

## **VASCULAR ACCESS**

Obtaining vascular access is of vital importance in providing care for children. Intravenous fluid administration, antibiotics, and other therapies are commonly provided parenterally. Although commonly needed, venous access can still prove to be a challenge for even experienced health care providers. Access is usually obtained in the dorsum of the hand or foot, or in the antecubital fossa; however, these can be difficult in well-nourished or chronically ill patients, or in certain critical situations. Approaches are different in the pediatric population, including a predilection for the femoral vein if central access is to be considered, the potential for cannulation of scalp veins, and the widespread use of intraosseous access. For all of these procedures, it is important to address parental issues and discuss options.

To perform the procedure, the child should be kept in a stable and fixed position, minimizing movement. The procedure site is draped and cleansed in the usual manner before performing the procedure. After venous access is obtained, the catheter is fixed in place and covered with a clear protective adhesive shield. See **Table 2** for a description of each of the procedures.

## **PROCEDURAL SEDATION**

Certain procedures in the emergency department (ED) require cooperation by the patient. Others are deemed too traumatic or painful to be performed in awake

**Table 2****Venous access procedures**

<b>Site/Procedure</b>	<b>Population</b>	<b>Materials</b>	<b>Procedure</b>	<b>Complications</b>
Scalp cannulation	Neonates and infants	22- to 25-gauge catheters or butterfly needles	Place rubber band cephalad to eyebrows and cannulate veins	Arterial cannulation is identified by blanching of scalp after saline infusion <sup>18</sup>
External jugular	All ages	22-gauge to 24-gauge catheters in younger children; 16-gauge to 18-gauge in adolescents	Place in Trendelenburg to increase venous return	Arterial cannulation is possible; if noted by pulsations visualized on the catheter, remove and apply pressure
Central line: femoral, subclavian, internal jugular. Femoral is preferred site initially	All ages	Use Seldinger technique kits and consider ultrasound-guided approach	As per available kit use over the wire approach after localizing the vein.	Air embolus, bleeding, arterial cannulation, site infection, thrombus formation
Umbilical vessels	Vein – up to 2 wk after birth. Artery – 24 h to 1 wk of age <sup>18,19</sup>	A feeding tube or catheter (5F FT/ 3.5F PT) is attached to a 5 mL syringe filled with NS and the system is flushed. Tie or sutures to tie purse string at base of umbilical cord	Tie cord or purse string stitch at the base of umbilical cord, cut the stump with a scalpel approx 2 cm from the abdominal wall and inserted into the large, thin walled vein normally at the 12 o'clock position on the cord. Introduce 4–5 cm until blood returns. Tie with sutures	Thrombosis, embolism, vessel perforation, infection, tissue ischemia and damage, hepatic necrosis, hydrothorax, and multiple cardiac complications <sup>20</sup>
Intraosseous access (IO)	All Ages Preferred sites in Peds–2 cm below tibial tuberosity or distal tibia superior to medial malleolus	18 gauge needle, Bone marrow needles, or any commercially available IO kit	Firm, steady pressure is used during placement. Bone cortex is evidenced when sudden decrease in resistance is noted. Confirmation is made when able to aspirate marrow or blood with a 5–10 mL syringe	Avoid placement along areas of infection Common complications include discomfort with infusion, infection and extravasation of fluids (localized swelling). Less common complications include fat and air emboli, growth plate injuries, as well as tibial fractures <sup>21–24</sup>

*Abbreviations:* FT, full term; IO, intraosseous; NS, normal saline; PT, Preterm.

**Box 2****Basic definitions used in analgesia and sedation**

*Analgesia:* Pain relief without purposely producing a sedated state.

*Minimal sedation:* Patient is able to respond normally to verbal commands but cognitive function and coordination may be impaired. Patient is able to maintain his or her own airway and cardiovascular function.

*Moderate sedation:* Patient responds purposefully to verbal commands with or without light touch and maintains his or her own airway and cardiovascular function.

*Deep sedation:* Patient cannot be easily aroused but does respond purposefully to painful stimuli. Occasionally requires assistance to maintain airway but cardiovascular function is normally maintained.

*Dissociative sedation:* Trancelike cataleptic state associated with profound analgesia and amnesia, but able to protect airway and maintain hemodynamic stability.

patients. Pediatric patients pose significant challenges in that they have limited understanding and coping mechanisms and in these cases sedation is useful. For basic definitions frequently used in sedation, please refer to **Box 2**.<sup>25-27</sup>

Before sedation, patients are assessed thoroughly with an in-depth history, including last oral intake, and physical examination. Prior reactions to anesthesia as well as family reactions to sedation and general anesthesia should be ascertained. To limit the risk of aspiration, fasting recommendations include a minimum of 2 hours for clear liquids, 4 hours for breast milk, and 6 hours for formula, nonhuman milk, and solids.<sup>28</sup> Further, American Society of Anesthesiologists (ASA) physical status classification should be assigned (see **Box 3**).<sup>26</sup>

The decision to place a patient under sedation should not be undertaken lightly, and the care provider must be able to deal with emergency airway management, adverse medication effects, and unintended deep sedation.<sup>28,29</sup> Children with ASA class I and II are suitable candidates for procedural sedation; however, those who qualify for class III or IV have special needs, or anatomically abnormal airways should only be sedated with the assistance of anesthesiology and possibly in the controlled setting of an operating room.<sup>26</sup>

In addition to the physician managing the sedation, a nurse should be present to monitor the patient. All patients should be placed on a continuous cardiac monitor so as to monitor heart rate, respiratory rate, pulse oximetry, and noninvasive blood pressure.

The American College of Emergency Physicians developed a clinical policy describing use of medications for sedation and analgesia in the ED, focusing on the following medications in **Box 4**.<sup>30</sup>

**Box 3****American Society of Anesthesiologists physical status classifications**

Class I: healthy patient

Class II: mild systemic disease (eg, mild asthma)

Class III: severe systemic disease (eg, moderate to severe asthma, pneumonia)

Class IV: severe systemic disease that is a constant threat to life (eg, advanced cardiac disease)

Class V: moribund patient not expected to survive without the operation/procedure (eg, septic shock, severe trauma)

**Box 4****Medications used in sedation and analgesia in the ED**

Etomidate

Fentanyl/midazolam

Ketamine

Methohexital

Pentobarbital

Propofol

Dosing, side effects, and contraindications are discussed in **Table 3**.

In addition to sedative and analgesic medications, nitrous oxide can be used in light sedation cases. Nitrous oxide is usually mixed with 50% oxygen and provides mild analgesia, sedation, amnesia, and anxiolysis.<sup>34–36</sup> While using nitrous oxide, patients are able to maintain their airway without assistance and remain hemodynamically stable. Minimal side effects include nausea, vomiting, and dysphoria. Contraindications include nausea and vomiting, pregnancy, and any situation in which gas is trapped, such as bowel obstructions.<sup>25</sup>

Before discharge, the patient should be easily arousable and talking if age appropriate, able to sit up without assistance if appropriate, have a patent airway and stable cardiovascular status, and be able to maintain oral hydration.

## THORACOSTOMY PROCEDURES

Thoracostomy is the surgical formation of an opening into the chest cavity. It is an uncommon emergency procedure in pediatric patients.<sup>37,38</sup> Certain characteristics that make pediatric chest trauma unique include limited pulmonary reserve, compact vital structures, and small lung volumes.<sup>37</sup> In neonates and young children, emergent thoracostomies are performed either during the neonatal period as part of treatment for conditions such as meconium aspiration or a simple pneumothorax,<sup>39</sup> whereas in older children, it is usually observed following blunt or penetrating trauma.<sup>40,41</sup> Other indications (eg, empyema, effusion) are usually treated by pediatric surgeons or in the intensive care unit. Because trauma is the leading cause of death and disability in patients ages 1 through 40 years,<sup>42</sup> most of the thoracostomies that an emergency physician will perform will be either spontaneous or secondary to trauma. Being that pediatric chest trauma remains an uncommon occurrence, most studies are small and descriptive with no randomized control trials available.<sup>38,42</sup> These focus mainly on epidemiology, descriptive findings, pathophysiology, and offer no recommendations to the preferred method of pleural fluid drainage.<sup>38</sup>

Various types of thoracostomy procedures have been described: needle thoracostomy, catheter thoracostomy (Seldinger method), and tube thoracostomy are the most common.<sup>43</sup> These techniques and equipment have different success rates depending on the fluid to be removed and few have studies performed in the ED. There is a lack of evidence for treatment in traumatic pneumothoraces, especially in pediatric patients; however, there is a growing body of evidence about the expected treatment of primary spontaneous pneumothorax.<sup>44–49</sup>

Chest radiography has been established as the standard for the initial approach to diagnosing and assessing pneumothorax size<sup>50</sup>; however, ultrasound is emerging as a useful tool in the treatment of pleural fluid collections.<sup>51,52</sup> More and more



pneumothoraces (traumatic, spontaneous, or iatrogenic) are being diagnosed by bedside ultrasound in the ED.<sup>53,54</sup> Even after diagnosis takes place, bedside US can be used to treat the pneumothorax by guiding placement and monitoring complications. Some studies have shown ultrasound to improve placement of pigtail catheters for successful drainage of pleural effusions.<sup>55,56</sup>

Whatever the approach, this procedure follows a similar process with the goal of accessing the pleural cavity, removing the offending agent, and eventually reexpanding the lung while decreasing the potential for reaccumulation and further complications. The next sections provide recommendations for the drainage of fluid in the pleural space.

## **Needle Thoracostomy**

---

### **Indications**

Needle thoracostomy is the immediate insertion of a small catheter or needle into the pleural space for the temporary relief of pressure. Concern has been raised recently that this procedure may not be as effective as once thought. Investigators claim that, at least in adults, the recommended length for catheters (5 cm) may not drain the air in as many as 30% of patients.<sup>57-59</sup> Regardless, this procedure is necessary for the immediate removal of air causing a tension pneumothorax and the stabilization of the patient. Even if uncertain as to which side is affected, the procedure should be performed empirically in those clinically presenting the symptoms. If no improvement is noted after procedure, decompression of the contralateral side is indicated.

### **Contraindications**

There are no absolute contraindications for the procedure but diagnosis of pneumothorax in the youngest patients, especially neonates, may prove challenging. In stable patients, relative contraindications include clotting disorders (which should be addressed before placement, if possible) (**Box 5**).

### **Procedure**

The preferred site for needle thoracostomy is the second or third intercostal spaces at the midclavicular line, but these can be modified depending on the patient's position. Cleanse the area with chlorhexidine or povidone-iodine solution. Administer anesthetic to the area. Attach the angiocath to a syringe with 3 mL of normal saline. Introduce the needle in the aforementioned space just until there is a change in resistance. The presence of bubbles as the pleural space is entered confirms the presence of a pneumothorax. The needle is removed while the catheter is left in place to continue draining the pneumothorax. The catheter can be attached to a cutoff surgical glove or a Heimlich valve to avoid air entering the pleural space.

In neonates, the procedure is similar, but a butterfly needle is used, placed in the same space as a syringe aspirates the air and bubbles are seen. The butterfly needle is left in place and the tubing is submerged in 4 mL water in a cup or baby bottle so that air continues to come out while creating a seal. More than one needle may be necessary to resolve the condition and, ultimately, a chest tube is placed.<sup>39</sup>

## **Tube Thoracostomy**

---

### **Indications**

Tube thoracostomy should be considered in all but the simplest pneumothoraces encountered (see earlier in this article). Spontaneous pneumothoraces may be observed in as many as 2% of neonates (particularly in the neonatal intensive care setting). In older children and adolescents, the most common indications for this

**Table 3**  
**Medications for sedation and analgesia in the ED**

	<b>Description</b>	<b>Dose</b>	<b>Side Effects</b>	<b>Contraindications</b>
Etomidate	Nonbarbiturate hypnotic agent with 5–30 sec until onset and duration of 5–15 min. Does not affect hemodynamic stability or intracranial pressure.	0.1–0.3 mg/kg IV	Has been associated with transient adrenal suppression.	Not recommended for use in children under age 10.
Fentanyl	Synthetic opioid providing analgesia. Rapid onset (2–3 min) and short duration (30–60 min).	1–4 µg/kg IV	Hypoxia, respiratory depression. Chest wall and glottic rigidity have been reported in neonates.	
Midazolam	Short acting benzodiazepine with rapid onset; provides sedation but no analgesia, often combined with opioids like fentanyl	6 mo to 5 y: 0.05–0.1 mg/kg IV, may repeat every 2–3 min as needed with max 0.6 mg/kg total 6–12 y: 0.025–0.05 mg/kg IV x1, repeat every 2–3 min as needed, max 0.4 mg/kg total >12 y: 0.5–2 mg IV x1, repeat every 2–3 min	Can result in respiratory depression when combined with fentanyl	

Ketamine	Phencyclidine derivative that acts as a dissociative sedative. Rapid onset and short duration of action.	>3 mo: 1.5 mg/kg IV over 1 min >3 mo; 4–5 mg/kg IM	Can be associated with laryngospasm, more commonly when given IM. Vomiting, increased salivation can also be seen. Older children (>15 y/o) can experience unpleasant hallucinations.	Younger than 3 mo, airway instability, hypertension, angina/heart failure, increased intracranial pressure, increased intraocular pressure, porphyria, thyroid disease, psychosis all are contraindications for use.
Methohexital	Very short acting barbiturate with onset within 30–60 seconds when given IV and duration of 5–10 min	>1 mo: 6.6–10 mg/kg IM	Hypotension, respiratory depression potentiated when used with other sedatives or opiates <sup>31</sup>	Do not use in children with temporal lobe epilepsy <sup>32</sup> or porphyria.
Pentobarbital	Barbiturate with 3–5 minutes until onset when given IV and duration of 30–45 min	2–6 mg/kg IM 1–3 mg/kg IV	Hypotension, respiratory depression potentiated when used with other sedatives or opiates <sup>31</sup>	Do not use in patients with porphyria.
Propofol	Nonopioid, nonbarbiturate sedative hypnotic with immediate clinical effect. Also has some antiemetic properties.	1–18 years old: 1 mg/kg IV × 1 (max 40 mg), then 0.5 mg/kg IV (max 20 mg) as needed	Hypotension, oxygen desaturation, apnea. Because of the quick onset, it is difficult to titrate <sup>33</sup>	Children with allergies to egg and/or soybeans should not receive propofol.

**Box 5****Materials required for needle thoracostomy**

Skin-cleansing materials, such as chlorhexidine or povidone-iodine solution

Gauze

Angiocath (16–20 gauge) or butterfly-type needle (23–25 gauge; 19 or 25 mm in length) for neonates<sup>a</sup>

Syringe filled with 2–3 mL of sterile normal saline (optional)

Flutter valve, underwater seal, such as a cup of water, or a commercially available 1-way valve (Heimlich)

<sup>a</sup> Depending on the age and weight of the infant, variable catheter sizes should be available ranging from 25 gauge in premature infants to 16 gauge in adolescents.

procedure are hemothorax or pneumothorax secondary to penetrating or blunt trauma.

**Contraindications**

There are no absolute contraindications for this procedure, especially if the patient is symptomatic.

**Materials**

As this should be a sterile procedure, the area should be cleansed and draped with sterile solution, such as chlorhexidine or povidone-iodine solution. The provider should wear sterile gloves and mask, and work on a sterile field (**Box 6**).

**Procedure**

If the patient is unstable and a tension pneumothorax is considered, release of air from the pleural space by needle thoracostomy is of vital importance.

In the intubated unstable patient, consider opening the chest cavity to release air in selected patients. Perform an incision in the upper ribs at the midaxillary line and bluntly dissect the tissues until reaching the pleural space. A “popping sound” followed by a gush of air may indicate arrival into the pleural space. After initial

**Box 6****Materials required for chest tube placement (materials will vary depending on technique used)**

Sedation and analgesia as needed

Oxygen by nasal cannula or mask if required

Cleansing solution (povidone-iodine or chlorhexidine)

No. 10 scalpel

Lidocaine 1% with epinephrine

Large straight scissors

Curved Mayo scissors

Large clamps

Dressing gauzes (may apply antibiotic for protection and further aid in seal)

Needle holder

2–0 silk sutures

Seldinger kit or percutaneous drainage catheterization kit or other minimally invasive approach as indicated and available

Gauze (4 × 4 inches)

Chest tubes: size depending on patient's weight and anatomy (see **Fig. 1**)

Suction tubing and adaptors

Suction or water seal device or Heimlich valve

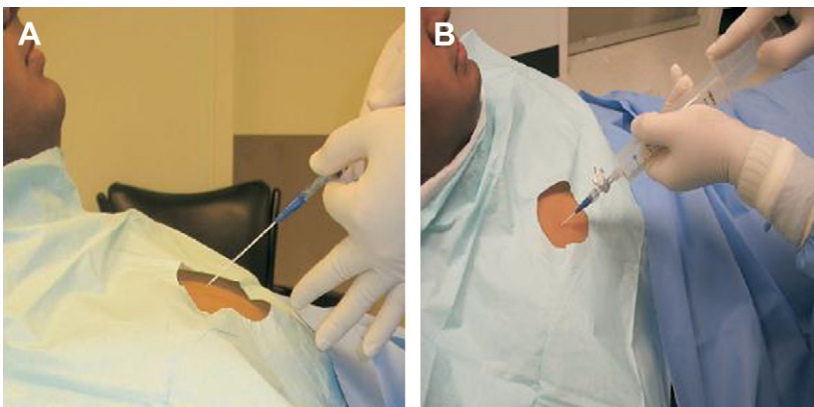
stabilization, that wound may be closed as a chest tube is inserted to drain that space or a tube may be placed inside that same wound for drainage.

In stable patients, the procedure should be discussed and consent (or assent if the patient understands), should be obtained. Sedation of the patient is invaluable, especially in younger, uncooperative patients, who may not understand or follow commands. Even with sedation and local anesthesia, some degree of restraint may be required. To select the adequate chest tube size, a length-based tape can be consulted or see **Fig. 1** for the recommended size based on weight.<sup>42</sup> Consider the reason for tube placement, as larger tubes will be required for draining fluid (eg, blood) whereas smaller tubes might be used to drain air.

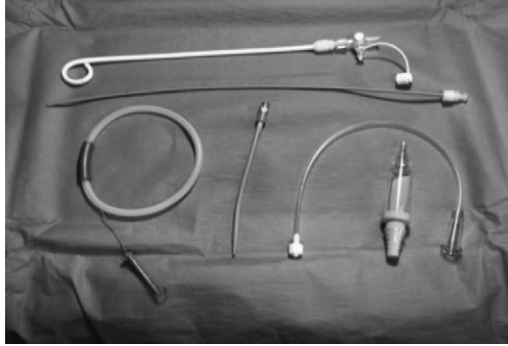
Select the appropriate area for placement and make sure the equipment is ready. Although most needle thoracostomies are performed at the midclavicular line, most tube thoracostomies are performed laterally, at the anterior axillary line at the fourth through sixth level; however, they may be placed anteriorly as well. Drape the area and cleanse. Anesthetize the intercostal space to be incised. Perform a small incision at the site. The incision should be approximately 3 times longer than the tube diameter.

Perform a blunt dissection with a finger or hemostat to create a subcutaneous tract, superiorly to a rib above the initial level so that the subcutaneous tissue further helps in covering and affixing the tube. Introduce the hemostat into the pleural space just above the rib by performing a blunt dissection into the intercostal muscles or by carefully cutting or pushing through the intercostal muscle. Make sure that the point of entry is immediately on the superior surface of the rib, as the neurovascular bundle for each rib is directly underneath it.

There are different modifications to this procedure. For example, in the Seldinger technique, the needle is introduced into the pleural space followed by a wire, which is used to guide the placement of either a catheter or dilators of increasing size (**Fig. 2**). Once the desired gauge is acquired, the smallest tube possible to get the specific fluid out optimally is introduced. A systematic review by Argall and Desmond<sup>60</sup> published in 2003 searched for any studies comparing these methods and found only



**Fig. 1.** Needle aspiration of a primary spontaneous pneumothorax. Midclavicular line second or third space is prepped and draped while the patient is placed at 45°. The area is anesthetized and the catheter (attached to a 3-way valve) and a syringe is introduced. Pneumothorax is suctioned on multiple occasions until no more air returns. (From Zehtabchi S, Rios CL. Management of emergency department patients with primary spontaneous pneumothorax: needle aspiration or tube thoracostomy? *Ann Emerg Med* 2008;51:91–100; with permission.)



**Fig. 2.** Pigtail catheter equipment. Pigtail equipment (Cook system). (From Kulvatunyou N, Vijayasekaran A, Hansen A, et al. Two-year experience of using pigtail catheters to treat traumatic pneumothorax: a changing trend. *J Trauma* 2011;71(5):1104–7; with permission.)

3 relevant studies. There was no evidence to support that the Seldinger technique was superior to traditional methods.<sup>60,61</sup>

There is some evidence to suggest that use of small catheters, such as the pigtail catheter, which is usually placed following the Seldinger (over the wire) technique, may be successful in removing the offending agent and reexpanding the lungs. Roberts and colleagues<sup>62</sup> studied the treatment of pneumothoraces and pleural effusions in a Pediatric intensive care unit. The investigators showed this procedure might be effective in draining both air and fluid from the pleural space. They concluded that this procedure was successful in draining chylous effusions and “somewhat less efficacious” in draining hemothorax or pneumothorax.

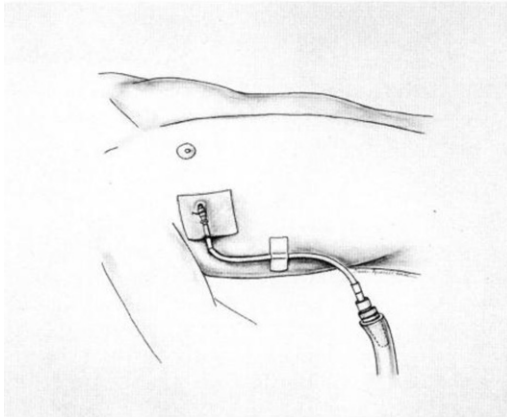
On a different study, Dull and colleagues<sup>43</sup> published a small retrospective study, in which it was shown that pigtail catheters were comparably as effective as the classic pneumothorax technique in draining both traumatic and spontaneous pneumothoraces. Patients were less likely to require analgesics than their chest tube counterparts. In this study, it was also demonstrated that pediatric emergency physicians are capable of performing this procedure and successfully placing pigtail catheters in the ED.

Finally, after the catheter or chest tube is placed, it should be affixed to the skin with sutures and attached to a suction source to continue the lung expansion and drainage of the fluid (**Fig. 3**). Commercially designed units are available that allow for tubing from the chest tube or catheter to be connected to a reservoir. This, in place is connected to wall suction, which can be modified depending on the level of suction required.

### **Monitoring and complications**

Complications and monitoring recommendations are similar for tube as well as needle thoracostomies, yet they present different incidence of complications depending on the selected approach. During the procedure, any number of injuries may occur, including surrounding organs, lungs, ribs, blood vessels, and nerves. Specific injuries will require specific treatments, which reach beyond the scope of this article.

Many pneumothoraces, hemothoraces, or other collections may recur, requiring suction for a longer period. Subcutaneous placement is more common with closed (classic) chest tube placement than with pigtail placement.<sup>43,63–65</sup> Incidences of tube kinking or dislodgement are similar.<sup>63</sup> These complications require that the tube be repositioned.



**Fig. 3.** Pigtail catheter secured at the skin. Pigtail is affixed at the skin with sutures, taped to the chest and connected to a suction device. (From Roberts JS, Bratton SL, Brogan TV. Efficacy and complications of percutaneous pigtail catheters for thoracostomy in pediatric patients. *Chest* 1998;114(4):1116–21; with permission.)

For hemothorax, the presence of more than 15 mL/kg of blood initially or more than 3 to 4 mL/h of blood are indications for surgical thoracostomy in the operating room. Close monitoring for any signs of clinical deterioration is crucial. Pediatric patients have a higher rate of complications and require early surgical intervention more often than adults.<sup>38</sup>

### EAR, NOSE, AND THROAT FOREIGN BODY REMOVAL

Evolving from their curious nature, pediatric patients are prone to place foreign bodies (FBs) into their ears and noses. Close to 90% of nasal FBs occur in patients younger than 4 years of age.<sup>66</sup> And although most cases can be found in the pediatric population, certain psychiatric, mentally delayed, or other types of patients may present with this condition. Despite their uncommon presentation, they are a challenge to the practitioner and may be potentially life threatening.<sup>66–71</sup>

Common FBs in children include toys, beads, pieces of foam, earrings, paper, or food, such as popcorn and peanuts.<sup>66–70</sup> Notorious for damaging tissues if ingested or placed in certain orifices are button batteries, which may cause tissue necrosis in a matter of hours and should be promptly removed.<sup>72–77</sup> On the other hand, the most common ear FBs in adults are insects (ie, cockroaches) that crawl into the ear.<sup>68</sup> As part of the initial evaluation, the emergency physician should include inspection of the both ears and nostrils, in search for potential FBs. Many patients may be asymptomatic on presentation, especially if early in the course.<sup>78</sup> Signs of ear FBs include ear pain, decreased hearing, dizziness, or vertigo or bleeding. In one study, 30% of pediatric patients presented with decreased hearing.<sup>66</sup> In nasal FBs, the most common symptoms are pain and discomfort and classic findings include foul-smelling nasal discharge and halitosis.

As time progresses, the FBs will accumulate bacteria, fester, swell, and/or mineralize and eventually will become symptomatic, such as purulent rhinitis with unilateral vestibulitis on examination, seen in **Fig. 4**.<sup>79</sup> Atypical presentations of common conditions, such as chronic sinusitis and otitis media, may prompt the examiner to consider FBs as likely etiology for the persistent symptoms. Rare occurrences of a calcified FBs



**Fig. 4.** Unilateral vestibulitis as evidence of nasal foreign body in a child with purulent rhinitis. (From Kalan A, Tariq M. Foreign bodies in the nasal cavities: a comprehensive review of the etiology, diagnostic pointers, and therapeutic measures. *Postgrad Med J* 2000;76(898):484–7; with permission.)

have been noted in the literature. Chronic sinusitis or persistent epistaxis should prompt the physician to consider calcified nasal FBs as a possible cause.<sup>80–83</sup>

### **Ear Canal Foreign Body Removal**

#### **Indications/contraindications**

Most FBs found in the EAC do not require immediate removal. It is crucial that the patient be cooperative and that the object is easily visible. Some experts claim that because most EAC FBs are removed easily, more than one attempt or using more than one technique should prompt an ear, nose, and throat (ENT) referral.<sup>66,69</sup> Blind attempts can cause harm and should be avoided. Consider ENT consultation for any challenging removal.

Irrigation, in particular, has special considerations. Avoid this procedure if the suspected agent might be vegetable matter (popcorn, peas, beans, and so forth), as these tend to swell up during the process and further decrease the chance of removal. Other contraindications for irrigation include symptoms of otitis externa, uncooperative patient, myringotomy tubes, inner ear disturbances, suspicion of tympanic membrane perforation, or history of inner or middle ear disease (**Box 7**).<sup>84</sup>

#### **Procedure**

Explain the procedure to the patient and caretaker. Consider instilling a few drops of topical anesthetic into the canal before attempting removal. In the case of insects,

<b>Box 7</b>	
<b>Materials for ear FB removal</b>	
Adequate lighting from head light, surgical light or held by assistance	Sterile water
Alligator forceps	12-French Foley catheter or No. 4 or 5 vascular Fogarty catheter
Cyanoacrylate (glue) with 20-mL syringe with 16-gauge catheter tip	Suction equipment (Frazier or soft tip)
	Forceps
	Right hook or paper clip-shaped at an angle



instilling microscopic immersion oil, “baby oil,” or viscous lidocaine will paralyze the vermin in less than 2 minutes.<sup>85</sup> Consider sedation with sedatives or dissociative agents like ketamine.<sup>86</sup>

Depending on the type of FB, different approaches for a successful removal can be made. The site, consistency, origin, and depth of the FB also play a role in its successful removal (**Fig. 5**).

### **Irrigation**

First, gather history of any suspicion of tympanic membrane rupture. If this is a concern, irrigation should not be used (see previous section). Change the patient into a gown and cover the area of the head with towels. Place the patient on his or her side with the affected ear up. Warming the water closer to body temperature will decrease the chance of vestibular response and secondary nausea or vomiting through caloric stimulation. Ask an assistant to gently pull on the pinna to straighten the canal.

Using a 20-mL syringe and a 16-gauge or 18-gauge catheter, flush the saline forcefully.<sup>84</sup> An alternative to this procedure includes using the tubing from a butterfly needle after cutting the wings and needle off and placing it in the canal. Guide the irrigation toward the superior-posterior portion of the canal. Certain commercially available systems are available for this procedure. If the offending agent is cerumen, consider applying hydrogen peroxide or other cerumenolytics before performing the procedure. If the patient complains of sudden pain or tinnitus during the procedure, stop the procedure, as this may signal a tympanic membrane (TM) perforation.<sup>84</sup>

### **Suction-tip catheters**

This technique is effective in removing round and rubber objects, which may otherwise be difficult to grasp. The noise could startle small patients, so appropriate restraining



**Hook**      **Frazier tip suction**      **Schuknecht**      **Right angle ball hook**      **Forceps**      **Alligator forceps**

**Fig. 5.** Equipment for ear foreign body removal. Different equipment and techniques should be available to the practitioner. The position and consistency of the FB will determine the ideal technique used. (From Kalan A, Tariq M. Foreign bodies in the nasal cavities: a comprehensive review of the etiology, diagnostic pointers, and therapeutic measures. *Postgrad Med J* 2000;76(898):484–7; with permission.)

should be anticipated and be in place before performing the procedure. To prevent iatrogenic injury, inform the patient of the impending noise to prevent sudden movements from a startle reflex. Place either the blunt or the soft plastic tip against the object and slowly withdraw. If using a suction instrument with a thumb-controlled release valve (as with the Frazier suction), remember to cover the port to activate the suction.

Place the patient on his or her side and make sure there is adequate visualization of the FB before removal attempt by having an assistant gently pull on the pinna to straighten the EAC. Press the suction to the FB before activating the suction. Avoid the skin or sealing tightly around the canal since the creation of a vacuum may cause TM rupture.

### ***Manual instrumentation***

For manual removal, the patient is placed in a position similar to the prior techniques and the operating otoscope is used to visualize the FB. An assistant should handle the pinna to line up the canal to gain optimal visibility. The nondominant hand is used to grasp the otoscope while the dominant hand stabilizes against the head of the patient while the instrument is introduced. There are multiple different types of instruments to remove specific objects. If the object is a round and smooth, like a bead or plastic pellet, a right angle hook is advanced past the object, rotated 90° and placed posterior to the object before pulling it out slowly. Small alligator forceps may be used to remove soft materials like paper, foam, or other organic materials.

### ***Complications and monitoring***

Examine both ears after performing the procedure to assess for any other FBs, remaining particles, bleeding, or TM rupture. Damage to ossicles, external ear lacerations, and TM perforations are uncommon but potentially serious complications, and should be documented. A small amount of bleeding from small abrasions and lacerations can be expected from the procedure and should be documented. These generally heal spontaneously with no complications.<sup>66–69</sup> If the FB cannot be successfully removed, the patient should be referred to ENT for removal. Otherwise, no further follow-up is usually required.

## ***Nasal FB Removal***

---

### ***Indications***

Indications for nasal FB removal include any FB presenting after initial evaluation. A complete examination of ears and nose is warranted. In some instances in which there is evidence of chronic infection or recurrent epistaxis (even in the absence of a history of FB insertion) a full examination is indicated. Some FBs require prompt removal, such as magnets and button batteries, because, according to some reports, batteries may cause necrosis in just a few hours after insertion.<sup>72,81,87–89</sup> Magnets, such as those used to imitate piercing, may cause septal necrosis if they remain in place long enough.

### ***Contraindications***

Some authorities believe that superiorly located FBs (close to the cribriform plate) should be referred to ENTs for removal, fearing possibility of trauma to this area, which may increase the risk of perforating into the meninges. Also, if the FB cannot be removed or if the patient cannot be sedated, consider referral for removal. Keep in mind that some require immediate consultation, such as for button batteries, magnets, or those presenting respiratory complaints (**Box 8**).

Box 8 Materials for nasal foreign body removal <sup>a</sup>	
Adequate lighting form head light, surgical light, or held by assistance	Right hook <sup>a</sup>
Nasal speculum(optional)	12-French Foley catheter or No. 4 or 5 vascular Fogarty catheter <sup>a</sup>
1% Lidocaine without epinephrine (max 0.3 mL/kg)	Alligator forceps <sup>a</sup>
Nasal decongestant: oxymethozaline, epinephrine (1:1000), or neosynephrine	Suction equipment <sup>a</sup>

<sup>a</sup> Depending on the level of comfort, the location, and the consistency of the FB, different types of materials may be used.

### Procedure

Engage the caretakers as well as the child (especially if verbal) and explain the procedure. If there is a concern or doubt about the nature of the FB, consider skull radiographs (anteroposterior and lateral) to exclude rhinolithiasis, magnets, or button batteries (Fig. 6).<sup>80–83,90</sup> Attempts to reduce parental or child anxiety may prove useful, because successful removal is directly linked to patient cooperation. Have more than tool for removal easily accessible at to anticipate every possibility. If, at any point, the patient is too distressed to tolerate the procedure, consider conscious sedation. Ketamine is ideal for manual removal; especially if there have been other failed attempts.<sup>88</sup> If sedation is to be used, cardiovascular monitoring and advanced airway equipment should be readily available at the bedside (see previous section).

Generally speaking, the shape and consistency of the FB will determine the optimal removal technique. For example, rugged, irregular foreign bodies may be removed with alligator forceps, whereas round and smooth FBs may be removed with positive-pressure, curettes, or a Fogarty apparatus, such as the Katz method.<sup>91,92</sup> Age and level of anxiety by the caretakers, as well as the patient, should also be gauged to determine the ideal approach to removal. Position and lighting are of paramount importance. A headlight or surgical light that allows the physician to work with both hands are invaluable for this procedure.



**Fig. 6.** Lateral and anteroposterior views of a 9-year-old male with a button battery in the nose. (From Dane S, Smally AJ, Peredy TR. A truly emergent problem: button battery in the nose. *Acad Emerg Med* 2000;7:204–6; with permission.)

### **Positive-pressure method**

For some FBs, especially those that occlude most or all of the nasal passage, an ideal method is to perform positive pressure while occluding the contralateral nostril. Older children may be able to attempt this on their own. The patient is asked to close the unaffected nostril and blow. Another way of replicating this process is to ask the parent to blow into the patient's mouth hard and fast while occluding the contralateral nostril. This "parent's kiss" has been shown to be effective in some studies and has the advantage that it can be performed without restraints or sedation, by someone known to the patient. It can significantly reduce anxiety.<sup>93-95</sup> This may also be performed by placing the patient in the semi-sitting or prone position and holding the patient down gently. The unaffected side is occluded and a bag valve mask is placed covering only the mouth and creating a seal. A short, quick blow from a bag valve mask is done. More than one attempt may be required for successful removal.<sup>96,97</sup>

Modifications to the positive pressure method as discussed include blowing through a straw instead of direct contact of the parent's mouth but this is not indicated in children who cannot create an adequate seal around the straw. Another option is to perform this procedure by closing the mouth and placing rubber tubing in the unaffected nostril before blowing hard. A small study claims success in removing close to 40 FBs with no complications.<sup>98</sup>

A few drops of epinephrine (1:1000) or phenylephrine may be used as decongestants to decrease the nasal swelling and aid in passage of the FB while using this method. The practitioner must make sure the FB is large enough as to diminish the chance of aspiration. It is believed that the reduction in swelling from these vasoconstrictors may reduce edema and loosen the FB before extraction by positive pressure.<sup>91</sup>

### **Mechanical extraction**

Success in removing FBs by mechanical extraction depends on the position of the FB as well as the shape. For direct visualization, a nasal speculum is placed in the anterior-posterior position as to avoid pressure on the septum. Visualization can also be obtained by using the thumb to gently elevate the nose to visualize the nares. Blind attempts at removal are discouraged, as they may cause undue harm without any success. For recommendations about removal approach based on the type of FB, see **Table 4**.<sup>91</sup>

Anterior FBs may be removed by placing a curette or hook posterior and superior to it and performing gentle traction. Foreign bodies positioned in the posterior aspect

<b>Procedure</b>	<b>FB Type</b>	<b>Location</b>	<b>Degree of Obstruction</b>
Positive pressure	Any	Ant/post <sup>a</sup>	Complete
Washout	Friable	Ant/post	Complete
Hooks	Hard	Ant	Incomplete
Forceps	Soft	Ant	Incomplete
Catheter	Any	Ant/post	Incomplete
Magnet	Metallic	Anterior	Complete/incomplete

<sup>a</sup> Ant, anterior; FB, foreign body; post, posterior.

Data from Kiger JR, Brenkert TE, Losek J. Nasal foreign body removal in children. *Pediatr Emerg Care* 2008;24(11):785-92.

undergo a similar process in which a Fogarty or Foley catheter is placed, passing the object superior and posterior to it. The catheter is filled with saline: 1 mL for a Fogarty catheter or 2 to 3 mL for a Foley catheter and the object is gently retracted. Commercially available versions of this catheter are available (**Fig. 7**).

### **Complications and further monitoring**

Bleeding and localized swelling are the most common complications but are usually self-limited and resolve with a few minutes of pressure. In some instances, the patient may aspirate the FB during removal. If there is any airway compromise, the patient should be stabilized. If the patient develops respiratory symptoms during or after the procedure, the patient should consult an otolaryngologist for a rigid bronchoscopy.

If the procedure is a success, no specific follow-up will be required. If symptoms of chronic sinusitis or otitis media were noticed, a course of antibiotics may be considered.<sup>91</sup>

## **ORAL LACERATIONS**

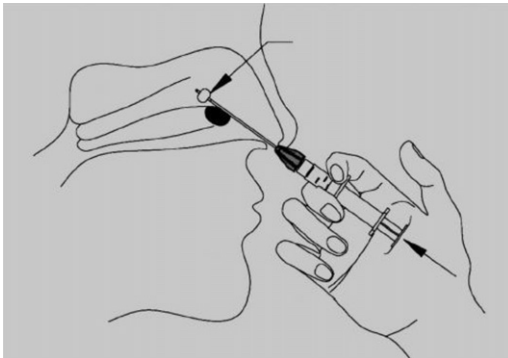
### **Introduction**

Trauma to the oral cavity is common in pediatric emergency practice.<sup>99,100</sup> Evaluation of the oral cavity includes attention to the face, head, and neck, as well as to the mouth and any other trauma observed. Isolated tooth trauma is promptly referred to a dentist for evaluation depending on the severity of dental trauma. As a general rule, dental repair is undergone before gingival suturing to avoid displacing the sutures. Consider radiographs if there are severe injuries associated with dental fractures to exclude teeth fragments in the soft tissue.<sup>100</sup>

There are certain areas of controversy in the treatment of oral trauma. For example, treating tongue lacerations by primary closure with sutures is controversial, with some studies showing no benefit.<sup>101,102</sup> Furthermore, prescription of antibiotics has also shown to be controversial.<sup>103</sup> Despite these controversies, both therapies remain common accepted practice.

### **Indications**

Most lacerations to the oral mucosa require no treatment at all. Oral lacerations to the tongue or gingival that present with a flap or measure more than 1 cm should be



**Fig. 7.** Nasal foreign body removal. Example of a Katz extractor procedure. Foley and Fogarty catheters are used in the same manner for FB removal. (From Kiger JR, Brenkert TE, Losek J. Nasal foreign body removal in children. *Pediatr Emerg Care* 2008;24(11):785–92; with permission.)

approximated. Although evidence is lacking, the rationale behind closure to these wounds is to decrease the chance of food presence and therefore minimize infection.<sup>102</sup>

### **Contraindications**

If the patient is unable to sit still, trauma is severe, or there are any contraindications to sedation, consider performing these repairs in the operating room. Severe lacerations include those with damage to the salivary glands or ducts, or that expose the facial nerve, as well as those too complex for the ED (which require more than 1 hour in repairing). Consult the oral surgery service for these types of injuries (**Box 9**).

### **Procedure**

Place the patient in a comfortable position with airway equipment and cardiac monitor available at the bedside. Adequate lighting and suction equipment are crucial for adequate performance of the procedure. Administer anesthesia to the affected area. Consider blocks, such as the inferior alveolar blocks, depending on the area involved. Wash the area with saline solution. Inspect the area for any foreign bodies or damage to deep structures. The oral mucosa is generally sutured with absorbable sutures. Lacerations to the mucosa, gingiva, and tongue that do not gape or measure less than 1 cm are generally left alone. Through-and-through lacerations require approximation on both ends to decrease rate of infection and decrease healing time. Evaluate wounds for foreign bodies (ie, teeth fragments) while using radiography in selected cases to look for said fragments. External skin lacerations are approximated using nonabsorbable sutures, such as 6-0 nylon.

Special attention is given to tongue lacerations; most lacerations heal well with no interventions. For example, the small avulsions, like those encountered in a seizing patient, will heal normally without intervention. Suture those that gape, have exposed muscle, or measure more than 2 cm. The tongue must be fixed to decrease movement through the procedure. Have an assistant secure the tongue by holding it with gauze. An alternative to this is to place a suture at the tip of the anesthetized tongue to keep the tongue still. Uncooperative patients should undergo sedation with a dissociative or sedative agent. Ketamine is a good choice because it does not cause respiratory depression. Consider the concomitant administration of atropine to decrease salivation during the procedure. Administer lidocaine with epinephrine locally or by lingual block. Begin the repair with either a local infiltration of anesthetic or a lingual block. To close the wound, use absorbable 4-0 sutures. Sutures should be deep, anchoring levels of muscle and knots should be buried if possible to decrease the likelihood of loosening up with normal biting and movement.

### **Disposition and Further Monitoring**

Inform caretakers that the patient should have a soft diet for the next 7 days. Through-and-through lacerations should be rechecked in 48 hours and the patient should

<b>Box 9</b>	
<b>Materials for oral laceration repair</b>	
Suture equipment: 3-0 and 4-0 absorbable sutures, such as chromic gut for mucosal surfaces; for skin use 6-0 nonabsorbable sutures	Syringe with 25-gauge or 27-gauge needles
Suction equipment	Sterile gloves and mask
1% Lidocaine with epinephrine	Saline solution

follow-up with dental service or oral surgery for further evaluation. Wounds that are more likely to get infected (eg, through-and-through) lacerations should likely receive a short course of antibiotics. However, there is inconclusive evidence to suggest the use of prophylactic antibiotics for any oral laceration repaired in the ED.<sup>103</sup> Infections are rare but if present, consider admission to oral or dental service to avoid abscess formation that may spread in the face and neck fascial planes.

Finally, oral trauma may bring about concerns for abuse. Almost half of abused infants present with facial and intraoral lesions and it has been thought that a torn frenulum is pathognomonic for abuse. However, a recent review of the literature shows there is no evidence to support that a torn frenulum, in isolation of other injuries, means that there has been nonaccidental trauma.<sup>104</sup>

## **ORTHOPEDIC PROCEDURES**

### ***Nursemaid's Elbow Reduction***

---

#### ***Introduction***

Radial head subluxation (ie, nursemaid's elbow) usually occurs in children younger than 6 years of age, but has been reported in 6-month-old babies, as well as preteen patients, with an average age of 2.5 years. It is the most common presenting complaint in the painful upper extremity in children younger than 6 years of age.<sup>105</sup> The mechanism is considered to be secondary to traction of the arm with the forearm and wrist pronated.<sup>106</sup> This leads to a detachment (sliding or tear) of the annular ligament to the radial head.<sup>107</sup> When the arm is released, the ligament becomes trapped between the radial head and the capitellum.

History may be inconsistent with the classic "pulling" mechanism.<sup>106</sup> In one study, approximately half of the presenting patients had a history of pulling as a possible mechanism, whereas the second most common mechanism was falling from bed.<sup>105</sup> Patients will present with the arm adducted, mildly pronated, and minimally flexed. Pain might be referred to the wrist region, but further examination will show no point tenderness at the level of the wrist. On examination, the patient will refuse to use the arm and there might be some pain on palpation of the radial head area. Although this procedure can be undertaken without any radiographs, findings such as ecchymosis, swelling, or deformity should raise concern for other possible diagnoses and will require further studies.

Although usually unnecessary, the physician should assess if the patient will be willing to undergo the reduction without any sedation. Analgesia in the form of oral ibuprofen would most likely suffice. Care must be taken to discuss the plan and procedure with the caretakers to diminish anxiety. They should understand that there is nothing broken and that only a ligament will be fixed into position. It should also be made clear that the patient will feel pain or discomfort briefly but that the symptoms will improve shortly after the procedure.

#### ***Contraindications***

If there is any evidence of pain or deformity to palpation around the shoulder, humerus, forearm, or wrist, radiographs should be evaluated to exclude fracture or dislocations, such as a Monteggia, radial head, or supracondylar fracture. Otherwise, the procedure may be attempted before radiographic testing.<sup>108</sup>

#### ***Procedure***

The patient should be sitting comfortably in the lap of the caretaker or assistant and held. The affected arm is held in extension. The examiner is positioned in front of the child. There are 3 approaches to this reduction: supination/flexion, hyperpronation,

and forced pronation/flexion (not shown) (**Fig. 8**). Supination/flexion is the classic technique. Hyperpronation or forced pronation/flexion is perceived by caretakers and physicians to be less painful.<sup>108–114</sup>

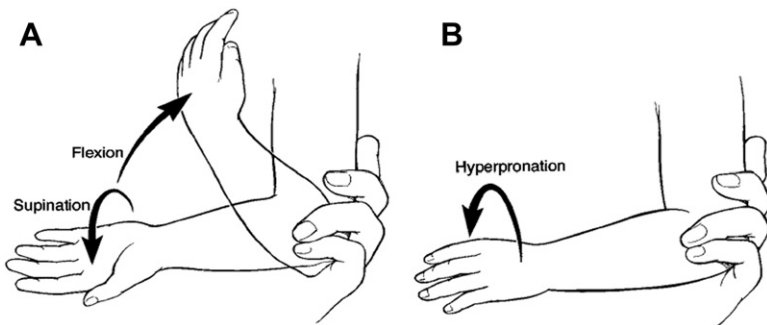
**Supination technique** Using the hand in front of the injured arm, the practitioner should grasp the elbow with the thumb palpating the radial head. With the other hand, the wrist is grasped and guided to supination and elbow flexion. A clicking sound may be heard while the radial head is being reduced. If a click is heard or felt, it is very likely that the reduction has been a success; however, absence of a clicking sound does not suggest that the procedure has been a failure.

**Hyperpronation** After preparing the child in the same manner, the hand is grasped in a similar fashion as described previously. Instead of flexing the elbow, the wrist is forcefully hyperpronated. A click is sought in the same manner as previously.

**Forced pronation/flexion** The patient is prepared in the same manner and the grip is similar to the prior procedures. The practitioner pronates the wrist and immediately flexed the elbow. A click may be felt, indicating reduction.

### Complications and disposition

After the procedure, the child should be observed and reevaluated after 10 to 15 minutes. In most cases, the child will show full use of the extremity after this observation time. Based in previous study protocols, if the child is not using the extremity after 15 to 30 minutes, the procedure may be repeated up to 3 times before ordering films.<sup>108,112</sup> Usually there are no complications during or after the procedure aside from the pain; brief, if successful, but more pronounced if an undiagnosed fracture is being manipulated. Sometimes movement of the arm may not be observed until after a period longer than 30 minutes. Follow-up instructions should include reevaluation with a pediatric orthopedist 24 hours after the evaluation if symptoms persist. Immobilization is not recommended unless there are recurrent symptoms.<sup>114</sup> Although rare, there have been reports of nonreducible nursemaid's elbows requiring visualization and repair in the operating room after radiographs and examination were found to be consistent with this pathology but the patient remained unable to move the extremity.<sup>115</sup>



**Fig. 8.** Nursemaid's elbow reduction. (A) Supination at the wrist followed by flexion at the elbow; (B) Hyperpronation at the wrist. (From Macias CG, Bothner J, Wiebe R. A comparison of supination/flexion to hyperpronation in the reduction of radial head subluxations. *Pediatrics* 1998;102(1):e10; with permission.)



## CENTRAL NERVOUS SYSTEM PROCEDURES

### Evaluation a Ventricular Shunt

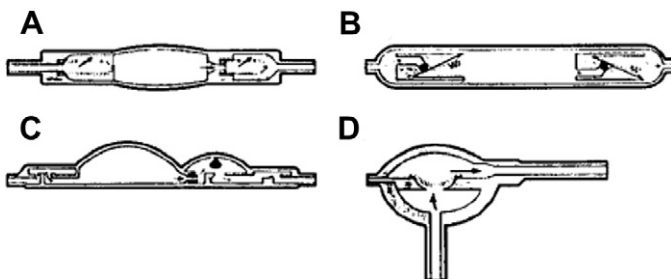
Intracranial shunts are used whenever patients require a continuous drainage of cerebrospinal fluid for conditions such as hydrocephalus.<sup>116</sup> Shunt failure rates approximate 14% during the first month,<sup>117–120</sup> and nearly half will fail within the first year.<sup>121</sup> Infection risks are lower but considerable, approaching 11% during the first 24 months in one series. Risk factors for shunt infections include procedure performed at a younger age, previous shunt infection, multiple prior shunt revisions, and prolonged procedure.<sup>122,123</sup>

Shunts may vary in shape, distal insertion site, and components, but most have a similar functionality. There are many different types of valves, which provide for access to the cerebrospinal fluid (CSF) (Figs. 9 and 10). There is generally proximal tubing, a valve, and a distal portion. The most common site for distal placement is the peritoneal cavity, known as the VP shunt (Fig. 11). Other sites include the atrium (VA shunt), venous vessels (VV shunt), or less commonly lumboperitoneal shunts (LP) may be used.<sup>120</sup>

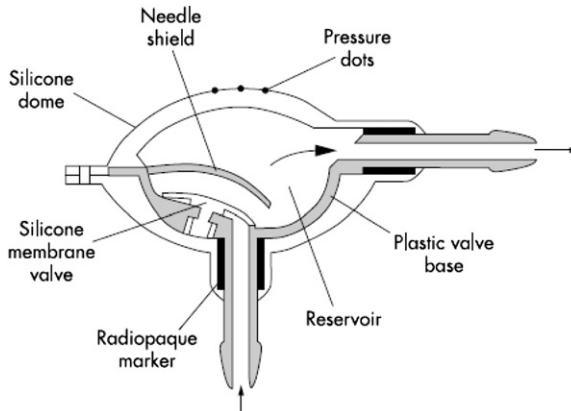
The usual presentation of shunt failure or infection may be nonspecific and could include headache, vomiting, blurred vision, generalized malaise, fever, lethargy, and seizures. In children, the symptoms are usually noticed by the caretaker.<sup>120,124</sup> Evaluation and concurrent diagnosis of shunt failure is a challenge to the practicing emergency medicine physician, as signs and symptoms may be subtle while physical findings remain obscure. This is why the possibility of shunt failure should be entertained with any complaint presented by children with shunts as the etiology for their symptoms.

To evaluate a shunt, the clinician should carefully observe and palpate the head and neck for any signs of erythema, swelling, or tenderness, as well as any evidence of exposed hardware. Initial assessment includes a “shunt series” of radiographic studies that includes skull radiographs in the anteroposterior and lateral views, as well as chest and abdomen views, looking for shunt displacement, breakage, or kinking. Computed tomography of the head is useful, especially when comparing it with previous studies for any indication of increased or decreased ventricle size. If these studies are inconclusive, further studies are recommended and include magnetic resonance imaging, lumbar puncture, and shunt tapping.

Part of the evaluation of a shunt includes the potential for tapping the shunt to assess the pressure while excluding infection. According to a protocol published by

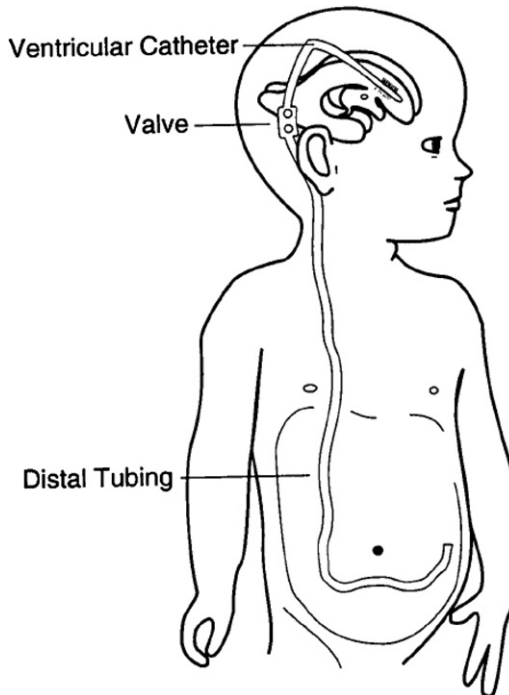


**Fig. 9.** Cerebrospinal fluid shunt valves. (A) Holter valve (*slit valve*); (B) Hakim valve (*ball valve*); (C) miter valve (*on-off device to right of pumping chamber*); (D) diaphragm valve (*proximal end sits in the burr hole*). (From Key CB, Rothrock SG, Falk JL. Cerebrospinal fluid shunt complications: an emergency medicine perspective. *Pediatr Emerg Care* 1995;11(5): 265–73; with permission.)



**Fig. 10.** Structure of a typical CSF shunt valve. (From Pople IK. Hydrocephalus and shunts: what the neurologist should know. *J Neurol Neurosurg Psychiatr* 2002;73(Suppl 1): i17–22; with permission.)

Miller and associates, most shunts may be evaluated without the use of a tap.<sup>124</sup> Based on this study, it was recommended that radiographic studies be performed initially. They also recommended performing a lumbar puncture in patients with a communicating hydrocephalus, stating that the information gathered from tapping the shunt would not be worth the potential risk for infection.<sup>124</sup>



**Fig. 11.** Ventriculoperitoneal shunt system. (From Pople IK. Hydrocephalus and shunts: what the neurologist should know. *J Neurol Neurosurg Psychiatr* 2002;73(Suppl 1): i17–22; with permission.)

## Diagnostic Tap of a Ventricular Shunt

### Indications

Ventricular shunt tapping is performed whenever there is a concern for possible ventricular shunt blockage or infection and as part of a full evaluation of shunt function. Consider shunt tapping only in selected cases (see previously).

### Contraindications

Evidence of cellulitis or any sign of infection around the valve site should raise concern about introducing infection into the system. Some investigators advocate that tapping the shunt is of limited value in most patients.<sup>124</sup> If only infection is being sought, and the patient has a communicating hydrocephalus, consider performing a lumbar puncture instead of a shunt tap. However, if patients have distorted anatomies or lower back conditions (eg, myelomeningocele), a lumbar puncture may prove close to impossible to perform, and other alternatives should be considered (**Box 10**).

### Procedure

Discuss the advantages and risks of performing this procedure in the ED with the neurosurgery service at your institution. Whenever possible, consult the neurosurgeon who initially performed the shunt. Most patients with suspicion of a VP shunt malfunction or infection will require neurosurgery evaluation. So consider transferring to a tertiary institution. After gathering consent from the patient or surrogate decision maker, the area should be examined for any evidence of infection or discharge. Although there are different types of valves, most of them possess a reservoir for potential tapping.<sup>125</sup> Localize the valve and clear the area of any hair or particulates. Sterile lubricant can be used as a gel to part the hair and further removal of hair should be performed using scissors. Avoid shaving the area, as it may further irritate the skin. The scalp is then prepared and cleansed with povidone-iodine solution and draped in the usual sterile fashion.

The butterfly needle tubing is attached to a 3-mL syringe and it is inserted at a 30° angle. The CSF may drain spontaneously or with less than 1 mL of pressure, signifying good flow has been established. More pressure may be required on the syringe (2–3 mL) for filling but this may signify decreased flow.

Opening pressures can be determined by using a column or manometer and placing it next to the patient's ear. Document well where the column was placed so as to aid in the interpretation of this pressure. Some studies use a cutoff value of 25 cm H<sub>2</sub>O as a diagnosis of increased pressure; yet pressures above 15 cm H<sub>2</sub>O may be considered abnormal.

Finally, place the CSF samples into specimen tubes and send for analysis. Laboratory examination should include glucose and protein levels, cell count, Gram stain, and culture. Definitions of infection vary depending on the source. Based on a study by McGirt and colleagues,<sup>118</sup> shunt infection was considered if CSF culture yielded

#### Box 10

#### Materials for ventricular shunt tapping

Sterile gloves	Cerebrospinal fluid (CSF) manometer (optional)
Cleansing solution (povidone-iodine or chlorhexidine)	Scissors or razor for hair removal
Sterile fenestrated drape	Gauzes
Syringe	Numbered CSF tubes
Three-way stopcock	
Butterfly needles, 23 or 25 gauge	

a pathogenic organism or indicated CSF pleocytosis (white blood cell count higher than 150 per  $\text{mm}^3$ ) with associated fever ( $38.5^\circ\text{C}$ ), shunt malfunction, or presence of suggestive neurologic symptoms. On the other hand, Lan and colleagues<sup>126</sup> defined infection when leukocytosis was greater than 100 leukocytes per  $\text{mm}^3$  and also observed the presence of eosinophilia.

### ***Complications and further monitoring***

The patient should be monitored further for any other symptoms, such as worsening neurologic status. There is a low risk for shunt infection after a tap, but damage to the shunt secondary to the procedure could occur, requiring a revision.<sup>127</sup> Rare complications have been described, such as intracranial bleeding, after this procedure.<sup>128</sup> Most patients will require admission for observation and further workup. Although usually a safely performed procedure for both the hardware and the patient, the valve may be damaged during the tap. This will require neurosurgery evaluation. Consider early referral or transfer based on your resource capabilities. Monitor for any neurologic deterioration during and after the procedure.

## ***Lumbar Puncture***

---

### ***Introduction***

A lumbar puncture (LP), or “spinal tap,” is performed in patients requiring evaluation and treatment of neurologic emergencies. The use of magnetic resonance imaging and the computed tomography scans (CT) have limited the use of this technique to the diagnosis of infections, inflammatory disorders, and intracranial bleeding (subarachnoid hemorrhage). The lumbar puncture remains the only way in which we can access fluid for assessment of its contents as well as to perform bacteriologic or immunologic testing of the cerebrospinal fluid.

Although useful in the diagnosis and treatment of many conditions, it is important to observe that treatment, referral, and further testing should not be delayed pending an LP. In many instances, such as meningitis, therapy should be started immediately on suspicion (eg, antibiotics) and not withheld pending completion or results to this test.<sup>129</sup>

### ***Indications***

The most common indication for this procedure is to evaluate for the possibility of CNS infection (meningitis or meningoencephalitis), subarachnoid hemorrhage, and inflammatory neurologic syndromes (eg, Guillan-Barré). Other rare indications include conditions such as idiopathic intracranial hypertension (pseudotumor cerebri).

### ***Contraindications***

Allergy to any of the components of the equipment or to local anesthetic is a contraindication to the procedure. Suspicion of increased intracranial pressure is a well-known, albeit controversial, contraindication for an LP. Fortunately a rare entity, it is estimated to occur in fewer than 5% of patients with bacterial meningitis.<sup>130,131</sup> Some investigators state that increased intracranial pressure is invariably present in all cases of meningitis and that many of those who herniate would do so with or without the procedure.<sup>131</sup> CT may not be enough to exclude cerebral edema or anticipate a herniation syndrome, while at the same time the physical examination may not correlate with abnormal CT findings in all patients. In those patients with focal neurologic deficits, rapidly decreasing mental status, papillary abnormalities, or recent seizures, LP should be reconsidered and perhaps delayed.<sup>130</sup> In many cases, it may be safer to begin treatment while further evaluation, history, or even radiographic studies are made available. In patients with a distorted anatomy, as in myelomeningocele, alternatives to the

procedure should be sought. Evidence or suspicion of infection at the puncture site is another contraindication to the procedure. On the other hand, patients with bleeding diatheses (platelets  $<50,000$  or international normalized ratio  $\geq 1.4$ ) or prolonged coagulation parameters should undergo correction before the procedure, so as to avoid epidural hematomas or persistent bleeding (**Box 11**).<sup>132</sup>

### Technique

Positioning of the child presents the physician with 2 main options: lateral decubitus and sitting position. Studies have shown that interspinous processes are maximally separated in the latter one when there is maximal hip flexion.<sup>133,134</sup> Either position is appropriate. The assistant can hold the infant's hands between the flexed legs with one hand and then hold the head or shoulders with the other hand. The spinal cord ends at the level of L1-L2 and ideal sites for lumbar puncture are the interspaces between L3-L4 and L4-L5. Landmarks can be determined using the iliac crest, which is at the level of the L4-L5 interspace. Using a sterile technique, prepare a large area using povidone iodine. Infants and children feel pain with lumbar punctures and should have topical or local anesthesia before puncture.<sup>135</sup> Evidence has shown that local anesthesia does not add difficulty or increase the failure rate.<sup>136</sup> If topical anesthesia was not used (eg, EMLA), inject local anesthesia (1% lidocaine plain) by first injecting a small intradermal wheal and then deeper into the desired interspace. It is important to aspirate to ensure you do not inject into a vessel or into the spinal canal. After the area is anesthetized, insert the spinal needle with the bevel facing up (toward the ceiling) in the midline. A "pop" and decreased resistance can be felt once through the ligamentum flavum and then once through the dura. Remove the stylet and check for CSF, if not present replace stylet and advance slowly and check again for CSF. Once CSF is flowing, collect 1 mL in each of the tubes. Replace the stylet before removing the needle. Cleanse area and place a gauze or cover.

### Complications

The most common complication of an LP is headache, usually associated with nausea and vomiting. Postdural postspinal headache (PDPH) was thought to be uncommon in younger children, yet recent data suggest a similar incidence across all age groups.<sup>132,137,138</sup> The incidence of postspinal headache has been shown to decrease with smaller-gauge needles and with the use of round (atraumatic) needles, instead of the classic cutting ones.<sup>137</sup>

Other complications include local pain at site of puncture, spinal cord bleeding, infection, and rarely a subarachnoid epidermal cyst (owing to foreign body reaction). Finally, apnea is another complication, especially in neonates. This can be prevented

#### Box 11

##### Equipment for lumbar puncture

Povidone-Iodine Solution	Commercial LP Tray	Sterile Gloves
Assistant to help position patient	22-gauge spinal needles with variable lengths: 1.5 in. for $<1$ y old 2.5 in. for 1 y to middle childhood, 3.5 in. for older children (Consider using noncutting needles to reduce incidence of postspinal headache)	Topical anesthetic or lidocaine for local injection Cerebrospinal fluid manometer (optional)

by avoiding extreme neck flexion. In fact, a study by Abo and colleagues<sup>133</sup> suggests that neck flexion does not increase interspinous spaces, and should be avoided.

Perhaps the most feared complication regarding LPs is the brainstem herniation syndrome (see previously). If this should occur, the patient should be immediately stabilized, including endotracheal intubation and admitted to the intensive care unit.<sup>130</sup>

### **Monitoring**

Young patients should be offered fluids to keep hydrated. They should be observed for movement of all extremities.

Older patients should be followed for any evidence of worsening back pain or decreased sensation. Lying in bed for 2 hours after the procedure has been advocated as a method to decrease the rate of PDPH, but this has not been shown to decrease this complication. The patient should be monitored closely for any worsening neurologic symptoms, weakness, sphincter tone loss, or incontinence. Disposition of the patient depends on the initial indication and results of the CSF testing. If discharged, the caretakers should be given instructions regarding proper monitoring at home.

## **GASTROINTESTINAL PROCEDURES**

### **Gastrostomy Tube Replacement**

---

#### **Introduction**

Gastrostomy tube (G-tube) placement is becoming increasingly common within the pediatric population. The most common indications for a G-tube placement include failure to thrive and swallowing disorders (ie, debilitating neuromuscular disease). Complications may occur and may be minor, such as blockage, leakage, or dislodgement, which occurs in approximately 70% of patients. Major complications, such as gastric outlet obstruction, peritonitis, septicemia, and death, may be seen in approximately 5% of cases.<sup>139</sup> Many of these will present to an ED for diagnosis and treatment.<sup>140,141</sup>

#### **Indications**

Once a gastrostomy tube inadvertently is removed, it is important to try to replace it as quickly as possible. After placement of a simple gastrostomy tube, it takes about 1 to 2 weeks to form a tract. Once the tube is out, the tract can narrow or close completely within hours. If the tube is only partially dislodged, it will need to be fully removed before replacing. It should slide out easily with minimal resistance.

#### **Contraindications**

If the tract is younger than 3 weeks old or if it is unclear how long ago it was originally placed, the patient may need operative replacement or replacement under fluoroscopy.<sup>142</sup> A gastrostomy tube should not be replaced in the ED if there is any evidence of infection or peritonitis, including extensive erythema, pus drainage, or warmth around the site. If active bleeding is a concern, emergent consultation should take place.

#### **Equipment**

A new tube should be used for replacement, as there may be a mechanical problem with the original device (ie, faulty balloon or balloon rupture) or if the tube is clogged. An alternative is to use a Foley catheter of similar size.<sup>143</sup> For a complete list of materials needed for this procedure, see **Box 12**.

#### **Procedure**

The child should be restrained in the supine position (or older, cooperative children may be most comfortable in recumbent/supine position). The tract should be gently

**Box 12****Equipment for gastrostomy tube replacement**

Gloves	New tube or Foley
Stethoscope	“External bolster”
Lubricant	Syringe (to insufflate air to check placement)
Saline	Syringe for saline (to inflate balloon)

probed with a lubricated cotton tipped swab or a blunt stylet (be careful not to form a false tract). Hold the tube between your thumb and forefinger and use the heel of your hand to stabilize the abdominal wall. Hold tube perpendicular to the abdominal wall and after lubricating tube, slide it into the tract with gentle pressure.<sup>144</sup> This may take 30 to 45 seconds of gentle steady pressure to allow the tube to pass. Be careful not to force it, as it can form a false tract. If the same size tube does not fit, use the next size smaller or a Foley catheter of similar size.<sup>143</sup> Insert the tube until the entire balloon or mushroom tip is advanced past the abdominal wall.

If the tube is inserted correctly into the stomach, it should move freely and you should be able to aspirate gastric contents. If no gastric contents are aspirated, place 30 mL of normal saline through the tube and aspirate again. If no gastric contents are aspirated or there is any doubt about placement, then tube placement can be radiographically verified by placing 20 to 30 mL of water-soluble contrast (gastrograffin, do not use barium) and then take supine abdominal x-ray within 1 to 2 minutes.<sup>145</sup>

**Complications and monitoring**

Complications with tube changes have an incidence of less than 5%.<sup>140</sup> These include intraperitoneal placement, minor bleeding, infection, and internal migration (if using Foley catheter may migrate causing a gastric outlet obstruction).<sup>146</sup> There is at least one case in the literature of esophageal rupture secondary to placement of a Foley catheter into the esophagus.<sup>147</sup> If no gastric contents can be aspirated or if there is any doubt about placement, then radiographic verification is recommended. Verify intragastric placement as described previously. If placement has been verified, no further workup is necessary.<sup>148</sup>

**Incarcerated Inguinal Hernia Reduction**

Inguinal hernias occur when an intra-abdominal structure protrudes through a defect in the abdominal wall. Studies describe an overall incidence of hernias in childhood of approximately 5% rising to 30% in premature infants. These can become incarcerated and commonly occur in the first year of life.<sup>149,150</sup> Most inguinal hernias in infants and children are indirect inguinal hernias, which occur when the processus vaginalis fails to close and intra-abdominal contents protrude through this space. According to recent studies, the risk of incarceration more than doubles if the patient has to wait more than 14 days for elective surgery.<sup>151</sup> Current recommendation is that they be repaired promptly after diagnosis owing to risk of incarcerations while waiting for elective repair; especially during the first 12 months of life.<sup>150,152</sup>

Diagnosis of a hernia is suggested by bulging present in the inguinal region. A hernia may be seen after an infant or child is crying or straining and may resolve when the child is sleeping. Therefore, spontaneously reducing hernias may be absent on examination. Techniques must be used in the very young to assess for hernias during the examination. In the very young, the child should be examined while crying. Older children can blow into a glove or straw to cause Valsalva maneuvers. If the hernia persists and is found to be tender to palpation, firm, erythematous, and edematous, it is likely

incarcerated. In these cases, the child will be fussy, not wanting to feed, crying, or inconsolable. An incarcerated hernia can be organ-threatening or life-threatening if not managed quickly. Bowel, ovary, testes, or other organs can become strangulated and ischemia, necrosis, and perforation can occur. Reduction is important to allow for the edema to resolve and permit an elective repair, which has less risk to the patient.<sup>150</sup> Ultrasound is rapidly emerging as an invaluable tool in the evaluation and diagnosis of inguinal masses, including hernias. Differentiation between hydroceles and bowel can be easily performed at the bedside.<sup>153,154</sup>

### ***Indications/contraindications***

Manual reduction is required after the diagnosis of incarcerated hernia is made. It should not be attempted if the patient has any signs of systemic toxicity (including peritoneal signs, abdominal distention, bilious vomiting, or discoloration of the entrapped viscera). If any signs of toxicity are present, the patient should be resuscitated and an emergent surgical consultation obtained. Early consultation with the surgery service is recommended, because depending on their availability, they may request to be present during the attempts at manual reduction.

### ***Procedure***

The patient is placed in mild Trendelenberg position with the ipsilateral leg externally rotated and flexed. Apply uniform pressure along the incarcerated bowel by placing one hand at the hernia bulge at the upper edge of the external inguinal ring while the other hand applies steady firm pressure for up to 5 minutes. The contents of the bowel will be reduced first and then the bowel itself reduced back into the abdomen. If the hernia is not reduced after 5 minutes of steady pressure, consider sedation. If again reduction is not successful after 5 to 10 minutes with the patient sedated and comfortable, an emergent surgical consult should be obtained. When reduction is not successful it is usually secondary to an ovary or incarcerated bowel outside the inguinal ring.<sup>144</sup>

### ***Complications and disposition***

Common complications include pain and edema. Other complications are rare, such as damage to bowel (perforation), ovaries, and testes. There have been reported cases of associated testicular or ovarian torsion.<sup>155</sup> Incarcerated hernias can be successfully reduced in 80% of cases.<sup>148</sup> If manual reduction is unsuccessful, the bowel may progress to necrosis and gangrene. In these cases, a surgeon should be consulted for immediate reduction in the operating room. Following the reduction, patients should be admitted following herniorrhaphy once edema has subsided in 24 to 48 hours.<sup>148</sup> They should be monitored closely for any deterioration, signs of recurrence, or toxicity.

### ***Rectal Prolapse***

---

Rectal prolapsed is defined as a herniation of the rectum through the anus. It may involve the mucosa or all the layers of the rectum. Age of presentation is usually in the preschool years. Caretakers usually observe a painless episode in which a red mass protrudes from the rectum before reducing spontaneously.<sup>156,157</sup> Several predisposing factors include increased intra-abdominal pressure, diarrhea, neoplastic diseases, malnutrition, and conditions associated with pelvic floor weakness, as well as straining and constipation.<sup>157,158</sup> It is important to ask about history of cystic fibrosis, history of neonatal stooling problems, excessive straining, and prolonged sitting on the toilet. If the patient has recurrent rectal prolapse, he or she should have follow-up for cystic fibrosis testing, as close to 10% of patients with rectal



prolapse may have the condition. The patient should be examined while sitting or squatting if possible. The differential diagnosis includes intussusception; this can be distinguished by inserting a finger between the mucosa of the mass and the anal wall.<sup>159</sup>

### **Indications**

Many instances of rectal prolapse will reduce by itself. Rectal prolapse should be manually reduced if it fails to reduce spontaneously or is associated with passive congestion and swelling or hemorrhage.<sup>157,158</sup>

### **Contraindications**

Evidence of necrosis of the bowel, strangulation, infection, or bleeding should prompt a surgical consultation (**Box 13**).<sup>158</sup>

### **Procedure**

Consider sedation and position the child prone on the knees. Lubricate gloves and use gauze to hold edges of prolapsed rectum. Apply pressure with both hands on both sides alternating to reduce the prolapse. Afterward, have the child lie on his or her side. A digital rectal exam should be performed to ensure reduction complete. If the prolapse occurs immediately again after reduction the buttocks may be taped together for several hours after subsequent reduction.<sup>157</sup> If the reduction is difficult owing to edema or large size, up to one-half cup of topical table sugar can be applied to the mucosa, which acts as a desiccating agent to help decrease the edema and allow reduction. This may take up to 30 to 90 minutes and can reduce the edema by as much as 50%. Sugar will not irritate the tissue as salt does.<sup>160</sup>

### **Complications and disposition**

Most will reduce without further complications. Patients should be discharged with instructions to avoid straining and constipation by keeping a high-fiber diet, stool softeners, and plenty of hydration.

In some cases there will be some minor bleeding and pain, which is self limited. Follow-up should be arranged with a pediatric gastroenterologist for further workup so as to seek an etiology for the prolapsed rectum.

## **UROLOGIC PROCEDURES**

### **Suprapubic Bladder Aspiration**

#### **Indications**

Suprapubic bladder aspiration has been considered the gold standard technique to obtain urine for diagnosis of urinary tract infection in infants and young children up to 2 years old.<sup>161</sup> The bladder in infants extends above the symphysis pubis into the lower abdomen when it is distended and can easily be percussed or palpated. The procedure is most likely to be successful if the bladder is palpable or able to be percussed, or if you see a full bladder on bedside ultrasound. It is more painful than transurethral catheterization; however, there is less contamination. The procedure is faster than transurethral catheterization but less efficient, as a physician needs to do the procedure instead of a nurse.<sup>161</sup>

#### **Box 13**

#### **Equipment for rectal prolapse reduction**

Gloves  
Lubricant

Gauze  
Sugar

**Box 14****Equipment for suprapubic bladder catheterization**

Sterile gloves  
3-mL syringe

1.5 cm 22-gauge needle  
Povidone iodine prep

**Contraindications**

Organomegaly, congenital abnormalities of the genitourinary or gastrointestinal tract, and volume depletion (and likely empty bladder) are all contraindications.

**Procedure**

Restrain patient supine in the frog leg position. Prep area to be punctured (approximately 1–2 cm superior to the pubic symphysis) with povidone iodine. Occlude the urethral opening (as the procedure may cause the infant to urinate) by applying pressure to the urethral meatus in girls or gently squeezing the penile urethra in boys. Insert the needle into the abdominal wall at an angle approximately 10 to 20° cephalad. Aspirate and slowly withdraw needle. If no urine is obtained before completely removing the needle from abdominal wall, re-angle more perpendicular to abdomen and attempt again. After the third attempt it is unlikely to be successful. At this point, waiting an hour or 2 for the bladder to fill or performing transurethral catheterization are options to consider.<sup>145</sup> Ultrasound can be used to determine if the bladder is full (Box 14).

**Complications**

Complications can include infection, bowel perforation, and microscopic hematuria (gross hematuria is rare).<sup>145,161</sup>

**SUMMARY**

When a child needs to undergo a procedure in the ED it can be a high-stress situation, especially in community EDs that see few children. The initial approach to critical procedures in infants and children is the same as with adults, beginning with airway, breathing, and circulation assessments. Differences in anatomy (eg, airway) and physiology (eg, limited ventilator reserve) must be taken into account when performing procedures on infants and children. Restraints should be used when applicable for the safety of the child, and may reduce pain and distress by making the procedure faster and easier for the physician. Alternatives such as distraction can also be considered when age appropriate. Keep in mind the developmental age of the child and involve the parents whenever possible, including explaining emergent procedures, such as intubation if time allows.

**REFERENCES**

1. Sagarin MJ, Chiang V, Sakles JC, et al. Rapid sequence intubation for pediatric emergency airway management. *Pediatr Emerg Care* 2002;18:417–23.
2. Brownstein D, Shugerman R, Cummings P, et al. Prehospital endotracheal intubation of children by paramedics. *Ann Emerg Med* 1996;28:34–9.
3. Gerritse BM, Draaisma JM, Schalkwijk A, et al. Should EMS-paramedics perform paediatric tracheal intubation in the field? *Resuscitation* 2008;79(2):225–9.
4. Gausche M, Lewis RJ, Stratton SJ, et al. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. *JAMA* 2000;283:783–90.

5. Fine GF, Borland LM. The future of the cuffed endotracheal tube. *Paediatr Anaesth* 2004;14:38–42.
6. Kleinman ME, Chameides L, Schexnayder SM, et al. Part 14: pediatric advanced life support: 2010 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2010; 122:S876.
7. King BR, Baker MD, Braitman LE, et al. Endotracheal tube selection in children: a comparison of four methods. *Ann Emerg Med* 1993;22:530–4.
8. Wheeler M, Coté CJ, Todres ID. The pediatric airway. In: Coté C, Lerman J, Todres ID, editors. *A practice of anesthesia for infants and children*. 4th edition. Philadelphia: Saunders-Elsevier; 2009. p. 237.
9. Schneider RE, Caro DA. Pretreatment agents. In: Walls RM, Murphy MF, editors. *Manual of emergency airway management*. 2nd edition. Philadelphia: Lippincott, Williams & Wilkins; 2004. p. 183–8.
10. Schenarts CL, Burton JH, Riker RR. Adrenocortical dysfunction following etomidate induction in emergency department patients. *Acad Emerg Med* 2001;8(1):1–7.
11. Mace SE. Ketamine. In: Mace SE, Ducharme J, Murphy M, editors. *Pain management and sedation*. New York: McGraw Hill; 2006. p. 132–8.
12. Schneider RE, Caro DA. Neuromuscular blocking agents. In: Walls RW, Murphy MF, editors. *Manual of airway management*. 2nd edition. Philadelphia: Lippincott, Williams & Wilkins; 2004. p. 200–11.
13. Mace SE. Challenges and advances in intubation: Rapid sequence intubation. *Emerg Med Clin North Am* 2008;26:1043–68.
14. Mutzbauer TS, Munz R, Helm M, et al. Emergency cricothyrotomy—puncture or anatomical preparation? Peculiarities of two methods for emergency airway access demonstrated in a cadaver model. *Anaesthesist* 2003;52:304–10 [in German].
15. Sise MJ, Shackford SR, Cruickshank JC, et al. Cricothyroidotomy for long-term tracheal access. A prospective analysis of morbidity and mortality in 76 patients. *Ann Surg* 1984;200:13–7.
16. Craven RM, Vanner RG. Ventilation of a model lung using various cricothyrotomy devices. *Anaesthesia* 2004;59:595–9.
17. Chan TC, Vilke GM, Bramwell KJ, et al. Comparison of wire-guided cricothyrotomy versus standard surgical cricothyrotomy technique. *J Emerg Med* 1999;17: 957–62.
18. Christopher NC, Cantor RM. Venous and arterial access. In: Barkin RM, editor. *Pediatric medicine: concepts and clinical practice*. 2nd edition. St. Louis (MO): Mosby; 1997. p. 153–4.
19. Lipton JD, Schafermeyer RW. Umbilical vessel catheterization. In: Henretig FM, King C, editors. *Textbook of pediatric emergency procedures*. Baltimore (MD): Williams & Wilkins; 1997. p. 515–23.
20. Green C, Yohannan MD. Umbilical arterial and venous catheters: placement, use, and complications. *Neonatal Netw* 1998;17(6):23–8.
21. Ribeiro JA, Price CT, Knapp DR Jr. Compartment syndrome of the lower extremity after intraosseous infusion of fluid. A report of two cases. *J Bone Joint Surg Am* 1993;75(3):430–3.
22. Blumberg S, Gorn M, Crain E. Intraosseous infusion: a review of methods and novel devices. *Pediatr Emerg Care* 2008;24(1):50–6.
23. Hasan MY, Kissoon N, Khan TM, et al. Intraosseous infusion and pulmonary fat embolism. *Pediatr Crit Care Med* 2001;2(2):133–8.
24. van Rijn RR, Knoester H, Maes A, et al. Cerebral arterial air embolism in a child after intraosseous infusion. *Emerg Radiol* 2008;15(4):259–62.

25. Krauss B, Green SM. Procedural sedation and analgesia in children. *Lancet* 2006;367(9512):766–80.
26. American Academy of Pediatrics, American Academy of Pediatric Dentistry, Coté CJ, et al. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: an update. *Pediatrics* 2006;118(6):2587–602.
27. Sacchetti A, Schafermeyer R, Geradi M, et al. Pediatric analgesia and sedation. *Ann Emerg Med* 1994;23(2):237–50.
28. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: a report by the American Society of Anesthesiologist Task Force on Preoperative Fasting. *Anesthesiology* 1999;90(3):896–905.
29. Sury M, Bullock I, Rabar S, et al. Sedation for diagnostic and therapeutic procedures in children and young people: summary of NICE guidance. *BMJ* 2010;341:c6819.
30. Mace SE, Barata IA, Cravero JP, et al. Clinical policy: evidence-based approach to pharmacologic agents used in pediatric sedation and analgesia in the emergency department. *Ann Emerg Med* 2004;44(4):342–77.
31. Coté CJ. Sedation for the pediatric patient. A review. *Pediatr Clin North Am* 1994;41(1):31–58.
32. Rockoff MA, Goudsouzian NG. Seizures induced by methohexital. *Anesthesiology* 1981;54(4):333–5.
33. Green SM, Krauss B. Propofol in emergency medicine: pushing the sedation frontier. *Ann Emerg Med* 2003;42(6):792–7.
34. Gamis AS, Knapp JF, Glenski JA. Nitrous oxide analgesia in a pediatric emergency department. *Ann Emerg Med* 1989;18(2):177–81.
35. Hennrikus WL, Simpson RB, Klingelberger CE, et al. Self-administered nitrous oxide analgesia for pediatric fracture reductions. *J Pediatr Orthop* 1994;14(4):538–42.
36. Kanagasundaram SA, Lane LJ, Cavalletto BP, et al. Efficacy and safety of nitrous oxide in alleviating pain and anxiety during painful procedures. *Arch Dis Child* 2001;84(6):492–5.
37. Nakayama DK, Ramenofsky ML, Rowe MI. Chest injuries in children. *Ann Surg* 1989;210:770–5.
38. Peterson RJ, Tiwary AD, Kissoon N, et al. Pediatric penetrating thoracic trauma: a five-year experience. *Pediatr Emerg Care* 1994;10(3):129–31.
39. Margau R, Amaral JG, Chait PG, et al. Percutaneous thoracic drainage in neonates: catheter drainage versus treatment with aspiration alone. *Radiology* 2006;241(1):223–7.
40. Reinhorn M, Kaufman HL, Hirsch EF, et al. Penetrating thoracic injury in a pediatric population. *Ann Thorac Surg* 1996;61:1501–5.
41. Roux P, Fisher RM. Chest injuries in children: an analysis of 100 cases of blunt chest trauma from motor vehicle accidents. *J Pediatr Surg* 1992;27:551–5.
42. Bliss D, Silen M. Pediatric thoracic trauma. *Crit Care Med* 2002;30(Suppl 11):S409–15.
43. Dull KE, Fleisher GR. Pigtail catheters versus large-bore chest tubes for pneumothoraces in children treated in the emergency department. *Pediatr Emerg Care* 2002;18(4):265–7.
44. MacDuff A, Arnold A, Harvey J. On behalf of the BTS Pleural Disease Guideline Group Management of spontaneous pneumothorax: British Thoracic Society pleural disease guideline 2010. *Thorax* 2010;65(Suppl 2):ii18–31.

45. Brandler ES, Fontenette D, Stone MB. Needle aspiration of spontaneous pneumothorax. *Acad Emerg Med* 2010;17:e25–6.
46. Choi SH, Lee SW, Hong YS, et al. Can spontaneous pneumothorax patients be treated by ambulatory care management? *Eur J Cardiothorac Surg* 2007;32(1):183.
47. Hassani B, Foote J, Borgundvaag B. Outpatient management of primary spontaneous pneumothorax in the emergency department of a community hospital using a small-bore catheter and a Heimlich valve. *Acad Emerg Med* 2009;16(6):513–8.
48. Cho S, Lee EB. Management of primary and secondary pneumothorax using a small-bore thoracic catheter. *Interact Cardiovasc Thorac Surg* 2010;11(2):146–9.
49. Liu CM, Hang LW. Pigtail tube drainage in the treatment of spontaneous pneumothorax. *Am J Emerg Med* 2003;21(3):241–4.
50. Siström CL, Reiheld CT, Gay SB, et al. Detection and estimation of the volume of pneumothorax using real-time sonography: efficacy determined by receiver operating characteristic analysis. *AJR Am J Roentgenol* 1996;166:317–21.
51. Elia F, Ferrari G, Molino P, et al. Lung ultrasound in postprocedural pneumothorax. *Acad Emerg Med* 2010;17:e81–2.
52. Lichtenstein DA, Mezière G, Lascols N, et al. Ultrasound diagnosis of occult pneumothorax. *Crit Care Med* 2005;33:1231–8.
53. Chan SS. Emergency bedside ultrasound to detect pneumothorax. *Acad Emerg Med* 2003;10:91–4.
54. Stone MB. Ultrasound diagnosis of traumatic pneumothorax. *J Emerg Trauma Shock* 2008;1(1):19–20.
55. Liang SJ, Tu CY, Chen HJ, et al. Application of ultrasound-guided pigtail catheter for drainage of pleural effusions in the ICU. *Intensive Care Med* 2009;35(2):350–4.
56. Volpicelli G. Sonographic diagnosis of pneumothorax. *Intensive Care Med* 2011;37(2):224–32.
57. Givens ML, Ayotte K, Manifold C. Needle thoracostomy: implications of computed tomography chest wall thickness. *Acad Emerg Med* 2004;11(2):211–3.
58. Gaudio M, Hafner JW. Simple aspiration compared to chest tube insertion in the management of primary spontaneous pneumothorax. *Ann Emerg Med* 2009;54:458–60.
59. Zehtabchi S, Rios CL. Management of emergency department patients with primary spontaneous pneumothorax: needle aspiration or tube thoracostomy? *Ann Emerg Med* 2008;51:91–100.
60. Argall J, Desmond J. Seldinger technique chest drains and complication rate. *Emerg Med J* 2003;20:169–70.
61. Parry GW, Morgan WE, Salama FD. Management of haemothorax. *Ann R Coll Surg Engl* 1996;78(4):325–6.
62. Roberts JS, Bratton SL, Brogan TV. Efficacy and complications of percutaneous pigtail catheters for thoracostomy in pediatric patients. *Chest* 1998;114(4):1116–21.
63. Kulvatunyou N, Vijayasekaran A, Hansen A, et al. Two-year experience of using pigtail catheters to treat traumatic pneumothorax: a changing trend. *J Trauma* 2011;71(5):1104–7.
64. Gammie J, Banks MC, Fuhrman CR, et al. The pigtail catheter for pleural drainage: a less invasive alternative to tube thoracostomy. *JSLs* 1999;3(1):57–61.
65. Lin YC, Tu CY, Liang SJ, et al. Pigtail catheter for the management of pneumothorax in mechanically ventilated patients. *Am J Emerg Med* 2010;28(4):466–71.

66. Baker MD. Foreign bodies of the ears and nose in childhood. *Pediatr Emerg Care* 1987;3(2):67–70.
67. Balbani AP, Sanchez TG, Butugan O, et al. Ear and nose foreign body removal in children. *Int J Pediatr Otorhinolaryngol* 1998;46(1–2):37–48.
68. Ryan C, Ghosh A, Wilson-Boyd B, et al. Presentation and management of aural foreign bodies in two Australian emergency departments. *Emerg Med Australas* 2006;18(4):372–8.
69. Marin JR, Trainor JL. Foreign body removal from the external auditory canal in a pediatric emergency department. *Pediatr Emerg Care* 2006;22(9):630–4.
70. Bressler K, Shelton C. Ear foreign-body removal: a review of 98 consecutive cases. *Laryngoscope* 1993;103(4 Pt 1):367–70.
71. Timm N, Iyer S. Embedded earrings in children. *Pediatr Emerg Care* 2008;24(1):31–3.
72. McRae D, Premachandra DJ, Gatland DJ. Button batteries in the ear, nose and cervical esophagus: a destructive foreign body. *J Otolaryngol* 1989;18(6):317.
73. Schulze SL, Kerschner J, Beste D. Pediatric external auditory canal foreign bodies: a review of 698 cases. *Otolaryngol Head Neck Surg* 2002;127(1):73–8.
74. DiMuzio J Jr, Deschler DG. Emergency department management of foreign bodies of the external ear canal in children. *Otol Neurotol* 2002;23(4):473–5.
75. Ansley JF, Cunningham MJ. Treatment of aural foreign bodies in children. *Pediatrics* 1998;101(4 Pt 1):638–41.
76. Singh GB, Sidhu TS, Sharma A, et al. Management of aural foreign body: an evaluative study in 738 consecutive cases. *Am J Otol* 2007;28(2):87–90.
77. Bengner JR, Davies PH. A useful form of glue ear. *J Accid Emerg Med* 2000;17:149–50.
78. Yasny JS, Stewart S. Nasal foreign body: an unexpected discovery. *Anesth Prog* 2011;58(3):121–3.
79. Kalan A, Tariq M. Foreign bodies in the nasal cavities: a comprehensive review of the aetiology, diagnostic pointers, and therapeutic measures. *Postgrad Med J* 2000;76(898):484–7.
80. Hadi U, Ghossaini S, Zaytoun G. Rhinolithiasis: a forgotten entity. *Otolaryngol Head Neck Surg* 2002;126:48–51.
81. Gomes CC, Sakano E, Lucchezi MC, et al. Button battery as a foreign body in the nasal cavities. Special aspects. *Rhinology* 1994;32(2):98–100.
82. Cheng CC, Fang TJ, Lee LA, et al. Rhinolith from a plastic object in the nasal cavity for more than 20 years. *Pediatr Int* 2011;53:135–6.
83. Ezsiás A, Sugar AW. Rhinolith: an unusual case and an update. *Ann Otol Rhinol Laryngol* 1997;106:135–8.
84. Kumar S, Kumar M, Lesser T, et al. Foreign bodies in the ear: a simple technique for removal analysed in vitro. *Emerg Med J* 2005;22(4):266–8.
85. Leffler S, Cheney P, Tandberg D. Chemical immobilization and killing of intra-aural roaches: an in vitro comparative study. *Ann Emerg Med* 1993;22(12):1795–8.
86. Brown L, Denmark TK, Wittlake WA, et al. Procedural sedation use in the ED: management of pediatric ear and nose foreign bodies. *Am J Emerg Med* 2004;22(4):310–4.
87. Dane S, Smally AJ, Peredy TR. A truly emergent problem: button battery in the nose. *Acad Emerg Med* 2000;7:204–6.
88. Brown CRS. Intra-nasal button battery causing septal perforation: a case report. *J Laryngol Otol* 1994;108:589–90.
89. Alvi A, Bereliani A, Zahtz GD. Miniature disc battery in the nose: a dangerous foreign body. *Clin Pediatr* 1997;36:427–9.

90. Royal SA, Gardner RE. Rhinolithiasis: an unusual pediatric nasal mass. *Pediatr Radiol* 1998;28:54–5.
91. Kiger JR, Brenkert TE, Losek J. Nasal foreign body removal in children. *Pediatr Emerg Care* 2008;24(11):785–92.
92. Ryan NJ. Removal of nasal foreign bodies using the fogarty catheter. *Emerg Med* 1996;8:11–3.
93. Purohit N, Ray S, Wilson T, et al. The 'parent's kiss': an effective way to remove paediatric nasal foreign bodies. *Ann R Coll Surg Engl* 2008;90(5):420–2.
94. Taylor C, Acheson J, Coats TJ. Nasal foreign bodies in children: kissing it better. *Emerg Med J* 2010;27:712–3.
95. Botma M, Bader R, Kubba H. 'A parent's kiss': evaluating an unusual method for removing nasal foreign bodies in children. *J Laryngol Otol* 2000;114(8):598–600.
96. Backlin SA. Positive-pressure technique for nasal foreign body removal in children. *Ann Emerg Med* 1995;25:554–5.
97. Fox J. Fogarty catheter removal of nasal foreign bodies. *Ann Emerg Med* 1980;9:37–8.
98. Sorrels WF. Simple noninvasive effective method for removal of nasal foreign bodies in infants and children. *Clin Pediatr (Phila)* 2002;41(2):133.
99. Nelson LP, Shusterman S. Emergency management of oral trauma in children. *Curr Opin Pediatr* 1997;9(3):242–5.
100. Wood GD, Leeming KA. Oral and maxillofacial surgery in accident and emergency departments. *J Accid Emerg Med* 1995;12(4):270–2.
101. Lamell CW, Fraone G, Casamassimo PS, et al. Presenting characteristics and treatment outcomes for tongue lacerations in children. *Pediatr Dent* 1999;21:34.
102. Ud-din Z, Aslam M, Gull S. Should minor mucosal tongue lacerations be sutured in children? *Emerg Med J* 2007;24(2):123–4.
103. Mark DG, Granquist EJ. Are prophylactic oral antibiotics indicated for the treatment of intraoral wounds? *Ann Emerg Med* 2008;52:368.
104. Maguire S, Hunter B, Hunter L, et al. Diagnosing abuse: a systematic review of torn frenulum and other intra-oral injuries. *Arch Dis Child* 2007;92(12):1113–7.
105. Schutzman SA, Teach S. Upper-extremity impairment in young children. *Ann Emerg Med* 1995;26:474–9.
106. Schunk J. Radial head subluxation: epidemiology and treatment of 87 episodes. *Ann Emerg Med* 1990;19(9):1019–23.
107. Salter RB, Zaltz C. Anatomic investigations of the mechanism of injury and pathologic anatomy of "pulled elbow" in young children. *Clin Orthop* 1971;77:134–42.
108. Macias CG. Radial head subluxation. *Acad Emerg Med* 2000;7:207–8.
109. Macias CG, Bothner J, Wiebe R. A comparison of supination/flexion to hyperpronation in the reduction of radial head subluxations. *Pediatrics* 1998;102(1):e10.
110. McDonald J, Whitelaw C, Goldsmith LJ. Radial head subluxation: comparing two methods of reduction. *Acad Emerg Med* 1999;6(7):715–8.
111. Green DA, Linares MY, Garcia Peña BM, et al. Randomized comparison of pain perception during radial head subluxation reduction using supination-flexion or forced pronation. *Pediatr Emerg Care* 2006;22(4):235–8.
112. Bek D, Yildiz C, Köse O, et al. Pronation versus supination maneuvers for the reduction of 'pulled elbow': a randomized clinical trial. *Eur J Emerg Med* 2009;16(3):135–8.
113. Toupin P, Osmond MH, Correll R, et al. Radial head subluxation: how long do children wait in the emergency department before reduction? *CJEM* 2007;9(5):333–7.

114. Jones J, Cote B. "Irreducible" nursemaid's elbow. *Am J Emerg Med* 1995;13(4):491.
115. Corellaa F, Hornaa L, Villab JA, et al. Irreducible 'pulled elbow': report of two cases and review of the literature. *J Pediatr Orthop* 2010;19:304–6.
116. Bondurant CP, Jimenez DF. Epidemiology of cerebrospinal fluid shunting. *Pediatr Neurosurg* 1995;23:254–8.
117. Wu Y, Green NL, Wrensch MR, et al. Ventriculoperitoneal shunt complications in California: 1990 to 2000. *Neurosurgery* 2007;61(3):557–62.
118. McGirt MJ, Leveque JC, Wellons JC 3rd, et al. Cerebrospinal fluid shunt survival and etiology of failures: a seven-year institutional experience. *Pediatr Neurosurg* 2002;36:248–55.
119. Korinek AM, Fulla-Oller L, Boch AL, et al. Morbidity of ventricular cerebrospinal fluid shunt surgery in adults: an 8-year study. *Neurosurgery* 2011;68(4):985–94.
120. Key CB, Rothrock SG, Falk JL. Cerebrospinal fluid shunt complications: an emergency medicine perspective. *Pediatr Emerg Care* 1995;11(5):265–73.
121. Liptak GS, McDonald JV. Ventriculoperitoneal shunts in children: Factors affecting shunt survival. *Pediatr Neurosci* 1985;12:289–93.
122. McGirt MJ, Zaas A, Fuchs HE, et al. Risk factors for pediatric ventriculoperitoneal shunt infection and predictors of infectious pathogens. *Clin Infect Dis* 2003;36:858–62.
123. Naradzay JFX, Browne BJ, Rolnick MA, et al. Cerebral ventricular shunts. *J Emerg Med* 1999;17:311–22.
124. Miller J, Fulop SC, Dashti SR, et al. Rethinking the indications for the ventriculoperitoneal shunt tap. *J Neurosurg Pediatr* 2008;1:435–8.
125. Pople IK. Hydrocephalus and shunts: what the neurologist should know. *J Neurol Neurosurg Psychiatr* 2002;73(Suppl 1):i17–22.
126. Lan CC, Wong TT, Chen SJ, et al. Early diagnosis of ventriculoperitoneal shunt infections and malfunctions in children with hydrocephalus. *J Microbiol Immunol Infect* 2003;36(1):47–50.
127. Noetzel MJ, Baker RP. Shunt fluid examination: risks and benefits in the evaluation of shunt malfunction and infection. *J Neurosurg* 1984;61:328–32.
128. Maartens NF, Aurorab P, Richards PG. An unusual complication of tapping a ventriculoperitoneal shunt. *Europ J Paediatr Neurol* 2000;4(3):125–9.
129. Tunkel AR, Hartman BJ, Kaplan SL, et al. Practice guidelines for the management of bacterial meningitis. *Clin Infect Dis* 2004;39(9):1267–84.
130. Nakagawa K, Smith WS. Evaluation and management of increased intracranial pressure. *Continuum (Minneap Minn)* 2011;17(5):1077–93.
131. Oliver WJ, Shope TC, Kuhns LR. Fatal lumbar puncture: fact versus fiction—an approach to a clinical dilemma. *Pediatrics* 2003;112(3 Pt 1):e174–6.
132. López T, Sánchez FJ, Garzón JC, et al. Spinal anesthesia in pediatric patients. *Minerva Anesthesiol* 2012;78(1):78–87.
133. Abo A, Chen L, Johnston P, et al. Positioning for lumbar puncture in children evaluated by bedside ultrasound. *Pediatrics* 2010;125(5):e1149–53.
134. Rodrigues AM, Roy PM. Post-lumbar puncture headache. *Rev Prat* 2007;57(4):353–7.
135. Kaur G, Gupta P, Kumar A. A randomized trial of eutectic mixture of local anesthetics during lumbar puncture in newborns. *Arch Pediatr Adolesc Med* 2003;157(11):1065–70.
136. Carriaccio C, Feinberg P, Hart LS, et al. Lidocaine for lumbar punctures, a help not a hindrance. *Arch Pediatr Adolesc Med* 1996;150(10):1044–6.



137. Apiliogullari S, Duman A, Gok F, et al. Spinal needle design and size affect the incidence of postdural puncture headache in children. *Paediatr Anaesth* 2011; 20(2):177–82.
138. Kokki H, Hendolin H, Turunen M. Postdural puncture headache and transient neurologic symptoms in children after spinal anaesthesia using cutting and pencil point paediatric spinal needles. *Acta Anaesthesiol Scand* 1998;42(9):1076–82.
139. Friedman JN, Ahmed S, Connolly B, et al. Complications associated with image-guided gastrostomy and gastrojejunostomy tubes in children. *Pediatrics* 2004; 114(2):458–61.
140. Saavedra H, Losek JD, Shanley L, et al. Gastrostomy tube-related complaints in the pediatric emergency department: identifying opportunities for improvement. *Pediatr Emerg Care* 2009;25(11):728–32.
141. Wollman B, D'Agostino HB, Walus-Wigle JR, et al. Radiologic, endoscopic, and surgical gastrostomy: an institutional evaluation and meta-analysis of the literature. *Radiology* 1995;197(3):699–704.
142. Minchff TV. Early dislodgement of percutaneous and endoscopic gastrostomy tube. *J S C Med Assoc* 2007;103:13–5.
143. Kadakia SC, Cassaday M, Shaffer RT. Prospective evaluation of Foley catheter as a replacement gastrostomy tube. *Am J Gastroenterol* 1992;87(11):1594–7.
144. Burke DT, El Shami A, Heinle E, et al. Comparison of gastrostomy tube replacement verification using air insufflation versus gastrograffin. *Arch Phys Med Rehabil* 2006;87(11):1530–3.
145. Ruddy RM. Illustrated techniques of pediatric emergency procedures. In: Fleisher GR, Ludwig S, Henretig FM, editors. *Textbook of pediatric emergency medicine*. 5th edition. Philadelphia: Lippincott Williams and Wilkins. 1861–955.
146. Kenigsberg K, Levenbrown J. Esophageal perforation secondary to gastrostomy tube replacement. *J Pediatr Surg* 1986;21(11):946–7.
147. Whiteley S, Liu P, Tellez DW, et al. Esophageal rupture in an infant secondary to esophageal placement of a Foley catheter gastrostomy tube. *Pediatr Emerg Care* 1989;5(2):113–6.
148. Showalter CD, Kerrey B, Spellman-Kennebeck S, et al. Gastrostomy tube replacement in a pediatric ED: frequency of complications and impact of confirmatory imaging. *Am J Emerg Med* 2012;30(8):1501–6.
149. Brandt ML. Pediatric hernias. *Surg Clin North Am* 2008;88(1):27–43, vii–viii.
150. Skinner MA, Grosfield JL. Inguinal and umbilical hernia repair in infants and children. *Surg Clin North Am* 1993;73(3):439–49.
151. Zamakhshary M, To T, Guan J, et al. Risk of incarceration of inguinal hernia among infants and young children awaiting elective surgery. *CMAJ* 2008; 179(10):1001–5.
152. Kaya M, Huckstead T, Schier F. Laparoscopic approach to incarcerated inguinal hernia in children. *J Pediatr Surg* 2006;41:567–9.
153. Bradley M, Morgan D, Pentlow B, et al. The groin hernia—an ultrasound diagnosis? *Ann R Coll Surg Engl* 2003;85(3):178–80.
154. Jamadar DA, Jacobson JA, Morag Y, et al. Sonography of inguinal region hernias. *Am J Roentgenol* 2006;187(1):185–90.
155. Waseem M, Pinkert H, Devas G. Testicular infarction becoming apparent after hernia reduction. *J Emerg Med* 2010;38(4):460–2.
156. Zganjer M, Cizmic A, Cigit I, et al. Treatment of rectal prolapse in children with cow milk injection sclerotherapy: 30-year experience. *World J Gastroenterol* 2008;14(5):737–40.

157. Siafakas C, Vottler TP, Anderson JM. Rectal prolapse in pediatrics. *Clin Pediatr* 1999;38(2):63.
158. Goldstein SD, Maxwell PJ 4th. Rectal prolapse. *Clin Colon Rectal Surg* 2011; 24(1):39–45.
159. Ibrahim AI. Prolapsed ileocolic intussusception. *Ann Pediatr Surg* 2011;7:76–8.
160. Coburn WM, Russell MA, Hofstetter WL. Sucrose as an aid to manual reduction of incarcerated rectal prolapse. *Ann Emerg Med* 1997;30(3):347.
161. Pollack CV, Pollack ES, Andrew WE. Suprapubic bladder aspiration versus urethral catheterization in ill infants: success, efficacy and complication rates. *Ann Emerg Med* 1994;23(2):225.