Chapter 10
Button Battery Foreign Body (Pediatric)

Claire Sampankanpanich Soria

Case Outline

Learning Objectives

1. Discuss intraoperative management of suspected airway vs. esophageal foreign body.
2. Identify causes of respiratory distress post-extubation.
3. Discuss management of post-extubation stridor.

Simulator Environment

1. Location: operating room of a children's hospital
2. Manikin setup:
   (a) Age: infant
   (b) Lines: 1 x 22 Gauge (G) peripheral intravenous (PIV) catheter in foot – which the learner will find is infiltrated.
   (c) Monitors: none on patient at start of case

C. Sampankanpanich Soria (✉)
University of California, San Diego Medical Center, San Diego, CA, USA
e-mail: cssoria@health.ucsd.edu

C. Sampankanpanich Soria, S. Trivedi (eds.), *Pediatric and Adult Anesthesiology Simulation Education*,
https://doi.org/10.1007/978-3-030-95338-6_10

3. Medications available: normal saline, propofol, dexmedetomidine, ketamine, midazolam, succinylcholine, rocuronium, epinephrine, albuterol, fentanyl, dexamethasone.
4. Equipment available
   (a) Airway equipment: ventilator, face mask, laryngoscope and cuffed and uncuffed endotracheal tubes (ETTs) of various sizes, stylet, oral airway, nasal trumpet, laryngeal mask airway (LMA), suction.
   (b) Monitors: pulse oximeter, blood pressure cuff, 3-lead electrocardiogram (EKG).
   (c) Lines: 24 G and 22 G PIV catheters, intraosseous kit, tourniquet, IV pigtail and flush.
   (d) Additional equipment: vein finder, ultrasound.
   (e) Crash cart with defibrillator
   (f) Paperwork: pre-operative anesthesia history and physical

Actors

1. Scrub tech
   (a) The scrub tech is busy assisting the surgeon and setting up equipment. They are hesitant to get involved when the patient is agitated and the learner needs help restraining the child for an awake PIV.
2. Circulator nurse
   (a) The nurse is helpful and attentive. When the patient appears to be struggling to breathe after extubation, the nurse points out all signs that the patient is having respiratory distress and asks the anesthesiologist if they planx to reintubate and go to the pediatric intensive care unit (PICU).
3. Surgeon
   (a) The surgeon is efficient and able to remove the foreign body quickly.

Case Narrative

1. Scenario background given to participants:
   (a) You are the anesthesiologist starting a case of a 13-month-old, 11 kilogram (kg) boy who is having a button battery removed from the esophagus. It is 10 pm. Around 6:30 pm, the dad saw his son climb up to the dinner table and

picked up a button battery and put it in his mouth. Since then, he noticed that his son has been breathing fine but drooling a lot. He took him straight to the emergency department (ED). A PIV was placed and a chest radiograph (CXR) anterior-posterior (AP) and lateral was done that is strongly supportive of a single button battery being present in the esophagus.

(b) Preoperative history: ex-full term; healthy; no recent upper respiratory infection (URI) symptoms; eating and growing well, meeting all developmental milestones; ate dinner about 3 hours prior to surgery.
(c) Preoperative physical: well-nourished infant resting comfortably in mom's arms, breathing comfortably on room air.
(d) Preoperative vital signs: within normal limits (WNL).
(e) Preoperative labs: none.

2. Scenario development

(a) Phase 1: awake PIV placement in agitated child

(i) The learner may start to place monitors on the patient first. The patient is initially tearful and starting to cry, but overall cooperative, remaining on the operating room (OR) table.
(ii) When the learner eventually tries to administer medications through the PIV, the child will scream and pull away and the skin will turn red and appear raised, indicating that the PIV has infiltrated and no longer functional.
(iii) The nurse will ask the learner if they can just mask the patient and place the PIV asleep. The learner should recognize that this patient is a full stomach with a possible airway foreign body, so the patient requires an awake PIV.
(iv) The child will begin to struggle more and try to get off of the OR table and run away. The learner should ask the nurse / scrub tech / surgeon / assistants to help restrain the child so they can place a new PIV. For this scenario, the patient will not be a difficult PIV. The learner will be able to place the PIV successfully on the first attempt.

(b) Phase 2: mild laryngospasm during laryngoscopy.

(i) The surgeon wants the anesthesiologist to keep the patient spontaneously ventilating so they can do a suspension laryngoscopy, survey the tracheobronchial tree quickly, and make sure there is no foreign body in the airway. After that, the surgeon plans to intubate the patient and proceed with upper endoscopy and removal of the esophageal foreign body.
(ii) The learner may do a combination of inhaled and IV anesthetic to induce the patient. The learner must be careful to watch the child and

make sure they are spontaneously ventilating, since the table will be turned 90 degrees and the chest / abdomen will be covered with a blue towel and a suspension laryngoscope.

(iii) The learner should provide supplemental oxygen. Options include nasal cannula, oxygen attached to side port of laryngoscope, or deep oxygen insufflation using an ETT placed in the oropharynx/proximal larynx.

(iv) During suspension laryngoscopy, the surgeon will report that the child seems a bit light and has coughed and laryngospasmed. The learner will need to decide whether and how to intervene. Options include deepening the anesthetic with propofol infusion / bolus, dexmedetomidine infusion / bolus, or ketamine bolus. The child will not desaturate. The laryngospasm will resolve before the learner tries to give succinylcholine.

(c) Phase 3: post-extubation stridor

(i) The surgeon will report that the survey of the tracheo-bronchial tree shows no foreign body, so they are confident that the foreign body is in the esophagus. The surgeon will go ahead and intubate the child since they are already at the head of the bed with a good view of the vocal cords. *The surgeon will not ask what size ETT to use. They will go ahead and insert whatever ETT is handed to them by the scrub tech. The tube happens to be 4.5 cuffed ETT, which is too large for the child. The surgeon will state that it's a bit snug and there's some resistance, but they were able to pass it and will proceed.*

(ii) *The learner may choose to check for a cuff leak or recommend downsizing the ETT to a more appropriate size. This is acceptable and smaller cuffed ETTs will be available.*

(iii) The surgeon will quickly remove the button battery from the esophagus, the table will be turned with the head back to the anesthesiologist. The learner will proceed to extubate the patient.

(iv) After extubation, the patient will display stridor and respiratory distress – tracheal tugging, sternal retractions, audible stridor heard outside the door, only mildly alleviated by repositioning the patient by turning them onto their side, oxygen saturation (SpO_2) 96% on 4 liters (L)/minute (min) simple face mask.

(v) The learner must decide how to proceed – whether to reintubate and go to PICU, to wait and watch in the OR, to take to post-anesthesia care unit (PACU) and try administering racemic epinephrine.

(vi) The scenario will end here.

Scoring Rubric

Table 10.1 Scoring rubric for case scenario on Button Battery Foreign Body Ingestion

Topic: Button Battery Foreign Body		
Participant Name:		
Evaluator Name:		
Score:		
	Completed	Not Completed
Vascular access		
Identifies infiltrated in situ peripheral intravenous (PIV) line		
Removes infiltrated PIV		
Identifies need for awake PIV		
Places awake PIV in a timely fashion		
Laryngospasm		
Maintains spontaneous ventilation under general anesthesia		
Maintains anesthetic with IV and/or inhaled agents		
Provides supplemental oxygen (options: Nasal cannula, side port of laryngoscope, endotracheal tube (ETT))		
Identifies laryngospasm		
Treats laryngospasm (deepens anesthetic with propofol, precede, ketamine)		
Recognizes that patient is stable and does not require administration of muscle relaxant to break the laryngospasm		
Post-extubation stridor		
Gives appropriate-sized ETT to surgeon for intubation at end of surgery		
Administers high dose dexamethasone 0.5 milligrams (mg)/kilogram (kg) (max 12 mg)		
Identifies signs of respiratory distress after extubation: Tracheal tugging, sternal retractions, audible stridor		
Attempts to treat respiratory distress: 1. Repositions patient (lateral decubitus)		
2. Provides continuous positive airway pressure (CPAP) via circuit face mask		
3. Inserts nasal trumpet or oral airway		
4. Provides chin lift or jaw thrust manually		
5. Provides 100% fraction of inspired oxygen (FiO_2)		
Communicates to surgeon that patient is in respiratory distress		
Identifies post-extubation stridor as cause of respiratory distress		
Assesses severity of respiratory distress based on vital signs and appearance of patient's breathing		
Makes disposition plan based on clinical severity: (a) may decide to reintubate and go to the pediatric intensive care unit (PICU), or (b) may decide to remain extubated and go to the post-anesthesia care unit (PACU) and administer racemic epinephrine		

Summary of Clinical Teaching Points

Do you need an awake peripheral intravenous (PIV) line in a child with an ingested or aspirated foreign body? [1–4].

Table 10.2 Considerations for placing an awake peripheral intravenous line in a pediatric patient

Considerations	Strategies
What are the indications for an awake peripheral IV?	Known or anticipated difficult airway – Difficult intubation and/or difficult mask ventilation Anticipated difficult airway due to airway foreign body Full stomach – Recent per oral intake, trauma, full stomach, delayed digestion
How do you manage an agitated child?	Multiple providers to help restrain the child Optimize first attempt at peripheral IV placement with an experienced provider Weigh the pros/cons of having a parent in the operating room
How do you handle a difficult peripheral IV?	Ultrasound guidance Vein finder Central line – Femoral vein may be easiest in awake child who is unable to remain still Intraosseous line – Tibial placement often most accessible

What is the anesthetic management of an aspirated or ingested foreign body? [1–4]

- General anesthetic – no response to surgical stimulus (bronchoscopy, esophagoscopy)
- Goal is to maintain spontaneous ventilation until it is safe to intubate the patient and establish a secure airway
  - Highly stimulating but not painful procedure, hopefully of short duration
  - Deep enough anesthetic that you avoid patient coughing/bucking, laryngospasm, bronchospasm, or dislodgement of the foreign body
  - No accurate end-tidal carbon dioxide ($ETCO_2$) available
  - Rely on visualization of chest rising and falling to confirm spontaneous ventilation intact
  - Supplemental oxygen sources: nasal cannula, ventilator circuit to side port of bronchoscope, endotracheal tube (ETT) in the oropharynx

- Drugs of choice
  - Avoid volatile anesthetic – open field, caution against polluting operating room environment and exposing staff to volatile anesthetic
  - Propofol infusion (good starting point 200–250 micrograms (mcg)/kilogram (kg)/minute (min)) + boluses in line
  - Dexmedetomidine boluses
  - Ketamine boluses
  - Spray the vocal cords with lidocaine

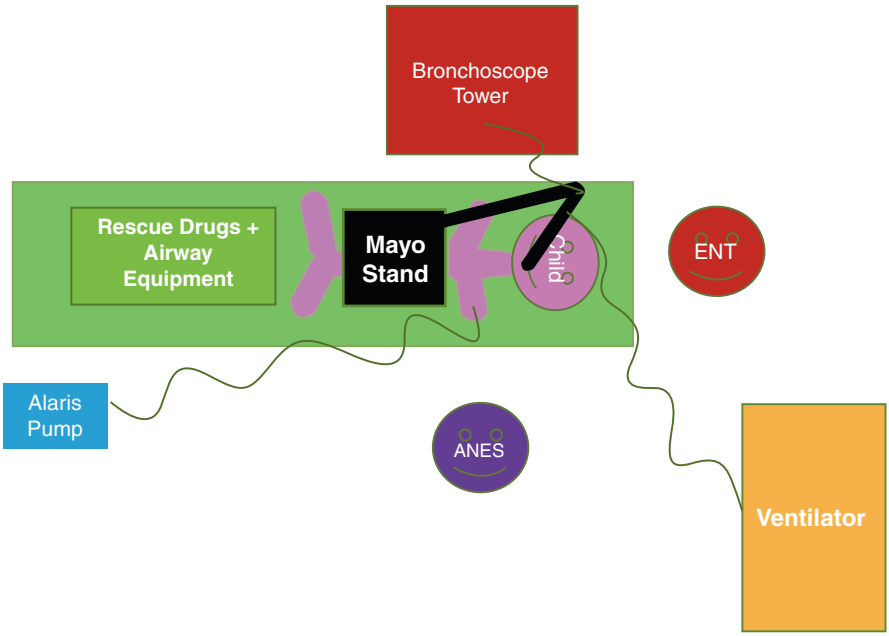

Fig. 10.1 Diagram of layout of equipment for shared airway procedures

What could possibly go wrong?

Table 10.3 Common complications and management strategies for removal of ingested and aspirated foreign bodies

Problem	Solution
Light anesthetic → coughing/bucking → laryngospasm, bronchospasm → oxygen desaturation	Albuterol – Limited route of administration when no secured airway Epinephrine – How much do you give? Good starting dose is 0.1 micrograms (mcg)/kilogram (kg). If in cardiac arrest, code dose is 10 mcg/kg Succinylcholine – Consider how much is a "small dose" for your patient (e.g. standard intubating dose is 1–2 milligrams (mg)/kilogram (kg)). Consider how you will re-establish ventilation after administering succinylcholine – May need to temporarily place an endotracheal tube, wait for paralysis to resolve and oxygen levels to rise, and then extubate and resume surgery Supplemental oxygen – Consider multiple routes of administration, such as nasal cannula, side port of bronchoscope, endotracheal tube, face mask
Apnea	Intubate – Consider potential for dislodging the foreign body in an even less accessible location Mask ventilate – Consider potential for full stomach, foreign body in trachea that may become dislodged in difficult-to-reach location, and challenges of mask ventilating with table turned 90 degrees Jet ventilate – Consider potential for dislodging an airway foreign body, caution with using appropriate pressures in a pediatric patient, may not be readily available
Foreign body or multiple foreign bodies that are difficult to remove	Continue to optimize anesthetic and provide a motionless surgical field for the surgeon Be prepared for the foreign body to become dislodged and impede ability to maintain two-lung ventilation
Foreign body becomes dislodged and completely occludes trachea, resulting in absent ventilation and absent oxygenation	Give the ear/nose/throat (ENT) surgeon an endotracheal tube and tell them to intubate the patient and purposefully right mainstem the foreign body. Begin one-lung ventilation. Not ideal but at least you'll restore some degree of ventilation and oxygenation
Failure to ventilate, failure to oxygenate, resulting in cardiac arrest	Initiate Pediatric advanced life support (PALS), including chest compressions, intubation, and administration of epinephrine 10 micrograms (mcg)/kilogram (kg) intravenously (IV)

What are common causes of post-extubation respiratory distress?

Remember to maintain constant vigilance, especially during emergence and extubation. There are many stressors in the operating room that may lead us to cut corners or rush through emergence and extubation and transport from the OR to the PACU. In the grand scheme of things, no one will remember if you stayed in the OR 5 minutes longer to safely extubate your patient. But if you bring a blue (cyanotic) and apneic patient to PACU and have to emergently reintubate, people will definitely remember you.

We often look to common physical signs as evidence of breathing and successful extubation. However, in the busy operating room with a small pediatric patient, it can be easy to misinterpret these as successful indicators of a well-ventilating patient. The following table describes how these signs can be misinterpreted and result in failure to recognize apnea.

Table 10.4 Common physical signs of ventilation that are misinterpreted post-extubation

Signs of Breathing	Source of Confusion	Possible Remedies
Fogging of face mask	Small child – May be hard to see fogging of small face mask on a small child Glare – Fluorescent light reflecting on plastic may be misconstrued as fogging	Pinch the face mask gently around the nose to observe fogging in concentrated area
Rise and fall of chest	Small child – Hard to see the chest rise and fall Blankets/gown – Cover up provider's view of chest wall movement Heart beating – In small child, chest wall movement from heart beating can be misinterpreted as chest rise/fall from lungs expanding	Remove gowns and blankets to expose chest and abdomen. Enables provider to observe chest and abdomen rise/fall, as well as pattern of breathing and coordination of chest and abdominal wall movements. Put your hand on the chest gently to feel it rise and fall.
Green bag on ventilator or Mapleson inflating and deflating	If you have a poor seal of your face mask, you will have a leak and will not be able to see the green bag inflating (exhalation) and deflating (inhalation)	After extubation, immediately place face mask on the patient to obtain good seal. Provide chin lift and neck flexion/head extension to optimize positioning. Check for green bag inflating and deflating and for positive end-tidal carbon dioxide ($ETCO_2$) on capnogram.
Audible breathing peripherally	In a small child/infant in a noisy environment, you may not hear audible breathing peripherally.	Listen with your stethoscope. Ask for quiet and attention in the room at the time of emergence/extubation.
Pink versus cyanotic appearance	An inexperienced provider may erroneously dismiss cyanosis as the patient's natural skin tone or poor lighting.	Always take discoloration seriously and assume it is cyanosis until proven otherwise. Check the pulse oximeter readings. Re-check other confirmatory signs of adequate ventilation.
Breath sounds on auscultation	It is very difficult to fake spontaneous breath sounds on auscultation. This is a reliable indicator of appropriate ventilation.	Use your stethoscope frequently: Immediately after extubation, after repositioning patient from the OR table to the transport gurney/bed, and upon arrival in the PACU. Ask for quiet and attention in the OR at the time of emergence/extubation. Turn off the Bair hugger. Minimize other noise distractions.

What are possible post-extubation complications in pediatric patients?

Table 10.5 Common causes of pediatric post-extubation complications

Event	Cause	Prevention and Treatment
Upper airway obstruction	Excessive narcotics Obstructive sleep apnea	Larger adolescent: Reposition to head of bed elevated Smaller: Reposition to lateral decubitus position with head extension
Laryngospasm	Deep extubation / laryngeal mask airway (LMA) removal Secretions Stage 2 emergence/extubation	Ensure adequate ventilation prior to leaving the operating room Minimize secretions by thoroughly suctioning Minimize head/neck manipulation post-extubation
Stridor	Airway edema Traumatic intubation Nerve injury	Early recognition Intravenous dexamethasone Racemic epinephrine Head of bed elevation
Bronchospasm	Recent upper respiratory infection Known asthma	Albuterol nebulizer Intravenous epinephrine

What are strategies for early detection and intervention on post-extubation apnea?

It is important to establish a through systematic approach that you can do routinely with every extubation to ensure that you can identify and treat post-extubation apnea. The following is one such strategy.

1. Confirm that the current stage of anesthesia is the intended stage of anesthesia for extubation. You can extubate in stage 1 (awake) or stage 3 (deep), depending on the patient and surgery. You should never extubate in stage 2.
2. Suction the oropharynx well. Minimize secretions as much as possible.
3. Extubate.
4. Immediately after extubation, put the face mask on the patient, obtain a good seal, provide chin lift and/or jaw thrust, neck flexion, and head extension, and close the airway pressure release valve to 5–10 centimeters of water (cmH_2O) to deliver continuous positive airway pressure (CPAP).
5. Identify signs of adequate ventilation:
   (a) Positive ETCO2 on capnogram.
   (b) Visualize/palpate the circuit green bag inflating and deflating.
   (c) Visualize chest rising and falling.
   (d) Auscultate breath sounds using stethoscope.
   (e) Auscultate breath sounds peripherally.
   (f) Visualize fogging of face mask.

6. If at any point, any one of the above signs in Step 5 is missing, assume apnea and intervene.
7. If all of the above criteria in Step 5 are met, then assume adequate ventilation and proceed next step.
8. Gradually release CPAP.
9. Ensure all signs of adequate ventilation from Step 5 are still met. If so proceed to next step.
10. Gradually release chin lift and/or jaw thrust.
11. Ensure all signs of adequate ventilation from Step 5 are still met. If so proceed to next step.
12. Transition from circuit face mask to simple face mask.
13. Move patient from OR table to transport gurney/bed.
14. Confirm adequate ventilation.
    (a) Visualize chest rising and falling.
    (b) Auscultate breath sounds using stethoscope.
    (c) Auscultate breath sounds peripherally.
    (d) Visualize fogging of face mask.
15. Transport to the PACU or other post-op destination (e.g. PICU).
16. Before completing handoff and leaving the patient's bedside, again confirm adequate ventilation.
    (a) Visualize chest rising and falling.
    (b) Auscultate breath sounds using stethoscope.
    (c) Auscultate breath sounds peripherally.
    (d) Visualize fogging of face mask.

References

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