Toddlers and Button Batteries: A Deadly Combination

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Objectives:
1. Describe the mechanisms of injury after button battery ingestion.
2. Critically analyze factors responsible for the rising incidence of devastating complications following button battery ingestion in children.
3. Summarize the triage and treatment guidelines for button battery ingestion in children.
4. Recognize the clinical presentation of aorto-enteric fistula following button battery ingestion.
5. Discuss recent legislation and technological advances aimed at improving safety mechanisms for lithium batteries.

Case Description:
A 20-month-old previously healthy boy presents to the emergency department with drooling and difficulty swallowing. He was playing with his older brother’s toy car remote and developed sudden onset coughing and choking, which subsided after a few minutes. Physical examination reveals a toddler who is irritable and drooling excessively, but without respiratory distress. His vital signs are stable and the parents tell you he had a bottle of formula an hour before the choking episode.

Questions:
1. Discuss the differential diagnosis of acute onset drooling and dysphagia in young children.
2. How would you confirm the diagnosis of foreign body ingestion?
3. What are the radiographic telltale signs of button battery ingestion?
4. How does the location of the button battery effect the clinical management?

Case Description:
It has been three hours since the initial choking episode. The Gastroenterologist would like to perform an upper gastro-intestinal (GI) endoscopy and removal of button battery as soon as possible.

Questions:
1. How does the patient’s NPO status affect your anesthetic management?
2. Does the patient need any additional laboratory tests prior to the procedure?
3. How would you induce general anesthesia in this patient?

Case Description:
After an uneventful induction and intubation, the gastroenterologist is able to visualize the button battery in the mid esophagus and remove it. Extensive necrosis and esophageal erosion is noted upon button battery removal.
Questions:
1. What are the mechanisms of injury and potential complications after button battery ingestion? Discuss the factors responsible for the rising incidence of button battery ingestion injuries in children.
2. Would you extubate this patient upon completion of the GI endoscopy?
3. How would you monitor this patient postoperatively for potential complications? What radiographic investigations might be helpful?

Case Description:
On postoperative day seven, the patient develops sudden onset respiratory distress in the intensive care unit. Despite supplemental oxygen via face mask, the patient’s clinical condition deteriorates and the pediatric surgeon wishes to perform a rigid bronchoscopy in the operating room.

Questions:
1. What is the differential diagnosis for acute respiratory distress in this patient?
2. What are the key anesthetic considerations for a rigid bronchoscopy?
3. How would you anesthetize this patient?

Case Description:
On postoperative day fourteen, the patient develops an episode of hematemesis and spits up 5 mL of bright red blood. The gastroenterologist wishes to perform a repeat upper GI endoscopy.

Questions:
1. What is the differential diagnosis of hematemesis in this patient? What is the significance of this sentinel bleed? What are your anesthetic concerns for this patient with hematemesis?
2. Does the patient need any laboratory tests prior to the endoscopy? Are additional monitors or intravenous access required?
3. Should other surgical services be consulted prior to endoscopy? Explain your rationale.

Case Description:
After a prolonged hospitalization, the patient is discharged from the hospital.

Questions:
1. Discuss strategies for raising public awareness regarding button battery ingestion in children.
2. Describe new technological developments in button battery safety.
3. Discuss recent legislation aimed at improving mechanisms for lithium batteries. What are the barriers for successful implementation of the recent legislation?
Discussion:
Foreign body ingestions are a common occurrence in the pediatric population. Although foreign body ingestions in adults are usually intentional, 98% of ingestions in pediatric patients are accidental and involve objects commonly found in the home\(^1\). Children may present with non-specific symptoms such as drooling, dysphagia, odynophagia, feeding refusal or vomiting; stridor, wheezing or respiratory distress; fussiness and chest or abdominal pain. They also may be asymptomatic. These vague symptoms can make diagnosing a foreign body ingestion difficult, especially if it is unwitnessed and the child is pre-verbal. Other common pediatric disorders that could be considered with this presentation are upper respiratory infections, epiglottitis, croup and asthma. If a foreign body ingestion is suspected, an x-ray can determine the location and, possibly, identity of the object.

Button battery ingestions are particularly concerning because of the potential for severe acute and long-term injuries from these objects. Analysis of data from a variety of sources, including the National Battery Ingestion Hotline, National Poison Data System and medical literature, has shown that although the incidence of button battery ingestion has remained stable over time, there has been an increase in major morbidity and death after these ingestions\(^2\). An initial analysis in 1992 indicated that most button battery ingestions were benign with a major complication rate of 0.1% (consisting of two patients with esophageal strictures) and no deaths\(^3\). Subsequent analyses have shown a stable incidence of ingestion, but with a 6.7-fold increase in major and fatal complications\(^2\). Causes of major morbidity include esophageal perforation, stricture or stenosis; tracheal injury including tracheo-esophageal fistula, stenosis or tracheomalacia; pneumothorax or pneumoperitoneum; mediastinal or pulmonary infection; recurrent laryngeal nerve damage; and cardiac or respiratory arrest\(^2\). Of thirteen reported fatalities, ten were due to fatal hemorrhage, while the remainder were due to tracheal injuries or tension pneumothorax. All cases of fatal hemorrhage occurred in toddlers up to 3 years of age and the majority involved injury to the aorta\(^4\).

Multiple reviews have been published in the gastrointestinal literature to elucidate the factors that increase the risk of severe morbidity or mortality after button battery ingestion. Children at greatest risk include those under 5 years old who ingest of batteries \(\geq 20\text{mm} \) in diameter or multiple batteries\(^1\). The damage seen after battery ingestion is mostly due to chemical injury. Batteries generate an external electrolytic current, which results in tissue hydrolysis and creation of a caustic alkaline environment. When batteries become impacted, tissue exposure to the battery’s alkaline environment is prolonged, increasing tissue damage. Impaction also results in pressure injury, which is a less important component of tissue damage after battery ingestion\(^2\). Two factors have played a role in the increased severity of injuries seen over the last few decades. The first is battery composition. Button batteries are now commonly composed of lithium, which is more electrochemically powerful than previous batteries. Lithium batteries are able to generate more current than their predecessors, resulting in more rapid tissue hydrolysis and hydroxide generation at the negative pole of the battery. This alkaline environment causes tissue damage. The second change is an increase in button battery diameter from less than 18mm to greater than 20mm. Modern batteries are large enough to become impacted in a toddler’s esophagus, leading to more severe damage\(^2\). Tissue injury begins as soon as 15 minutes after battery ingestion, making rapid removal of the battery an important determinant of patient outcome. In addition, injury progresses after battery removal, with case reports of fatal hemorrhage occurring up to 19 days after battery removal\(^1\).

Consensus guidelines for the management of button battery ingestion have recently been published in the gastroenterology literature\(^1\). Anesthesiologists should be familiar with these guidelines, as they may be involved in the care of these patients at multiple points during their
hospital course. Interventions requiring anesthetic care include initial battery removal, follow-up
diagnostic procedures to assess evolving tissue injury and emergent operative management of
severe complications. All esophageal batteries must be removed emergently (within 2 hours of
presentation). The management of gastric and small bowel batteries depends on patient age,
battery size and presenting symptoms. Batteries in these locations may be removed emergently,
urgently (within 24 hours) or followed by serial radiographs and removed electively if they do not
pass on their own. It is important to note that gastric and small bowel batteries may have been
impacted in the esophagus prior to passing to those locations and may still be associated with
significant esophageal injury. Endoscopic removal should occur in the operating room with
general and/or cardiothoracic surgical services available given the potential for severe injury. If
esophageal injury is noted at the time of removal, hospital admission and further endoscopy or
imaging studies are indicated to follow progression of injury.

Given the significant morbidity and mortality that can result from button battery ingestion, even
when treated appropriately, emphasis must be placed on prevention of these events. A review of
button battery ingestions found that the majority occurred in children under 6 years old and
involved batteries that were obtained from their intended product, while a minority were obtained
from battery packaging or found loose by children. The most common intended products were
remote controls and toys, though a wide variety of products were implicated [5]. Current safety
standards mandate that battery compartments in toys intended for children under 3 years old must
be secured in such a way that a child could not accidentally obtain a battery from those products.
Unfortunately, these safety standards resulted in only a modest decrease in button battery
ingsentions and subsequent legislation which would have expanded this requirement to a wider
range of products was not enacted by Congress [6]. The mainstay of prevention at this time relies
on parent education regarding the dangers of battery ingestions. Research to make batteries
themselves safer is currently ongoing. For instance, one group has created a pressure-sensitive
coating which allows batteries to function only in high-pressure surroundings, such as standard
battery housings. In low-pressure settings, such as the GI tract, the battery becomes non-
conductive, preventing tissue injury in large animal models. Importantly, no modifications are
required to standard battery housings for these batteries to work [6]. Further research in this field
may alleviate the injury caused by button battery ingestion. Unfortunately, there are currently
millions of conventional lithium batteries in circulation. Therefore, we will likely continue to see
these types of injuries for years to come, unless a massive recall is instituted.

References:
Pediatric Gastroenterology and Nutrition* 2015; 60(4): 562-74.
3. Litovitz T, Schmitz BF. Ingestions of Cylindrical and Button Batteries: An Analysis of
Hemorrhage in Children. *Journal of Pediatric Gastroenterology and Nutrition* 2011;
52(5):585-89.
5. Litovitz T, Whiatker N, Clark L. Preventing Battery Ingestions: An Analysis of 8648
6. Laulicht B, Traverso G, Deshpande V, et al. Simple Battery Armor to Protect Against
Gastrointestinal Injury from Accidental Ingestion. *Proceedings of the National Academy
of Sciences* 2014; 111(46): 16490-16495.