Case Report

Successful management of an aorto-esophageal fistula following button battery ingestion: A case report and review of the literature

ABSTRACT

Foreign body ingestion is a common event among pediatric patients, especially in children less than 6 years of age. Although most cases are relatively benign, with the foreign body passing spontaneously or requiring a brief endoscopic procedure for removal, button battery ingestion is known to cause significant morbidity with the potential for mortality. Although aorto-esophageal fistula (AEF) is a rare complication following button battery ingestion, its clinical manifestations are significant and outcomes are poor. Early diagnosis and aggressive treatment are key in preventing fatal complications. We describe the successful management of an AEF which presented with hematemesis 8 days after removal of a button battery in a 17-month-old female. The literature regarding button battery ingestion and AEF is reviewed and treatment options including intraoperative anesthetic care discussed.

Key words: Aorto-esophageal fistulae; button battery ingestion; pediatric anesthesia

Introduction

The ingestion of foreign bodies is a relatively common event among pediatric patients. The ingested items generally pass spontaneously or require brief anesthetic care during endoscopic removal. Rarely, severe complications may occur related to tissue damage from the foreign body that is ingested. The most recent data from the National Capital Poison Center reported 3,244 cases of button battery ingestions in 2017, 1986 (61%) of which involved children less than 6 years of age.[1] Although the incidence of button battery ingestion has remained unchanged for the past 30 years, the incidence of moderate, major, or fatal complications has risen dramatically with an almost ten-fold increase as compared with 1985. This change is due to the introduction of a more powerful battery (20 mm, 3-volt) to the household market.[2] All fatalities and 98% of major adverse effects occurred in children less than 6 years of age. The incidence of major morbidity or death in this age group has been reported to be as high as 12.6% compared to a lower incidence of major complication or death in all ages (0.3-1%).[1,2] Button battery ingestion can result in significant morbidity and mortality

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including aorto-esophageal fistula (AEF) formation or fistula formation between major blood vessels. We describe the successful management of a life-threatening AEF which formed after button battery ingestion. The literature regarding button battery ingestion and AEF is reviewed and treatment options including intraoperative anesthetic care discussed.

Case Report

Review of this case report and presentation in this format was in accordance with the guidelines of the Institutional Review Board of Nationwide Children's Hospital (Columbus, Ohio). The patient was a previously healthy 17-month-old female infant who presented to the emergency department (ED) with hematemesis and anemia. The patient's past medical history revealed 2 contacts with the ED over the past 10 days for non-specific symptoms including vomiting, diarrhea, congestion, cough, fever, and appetite loss. Discharge diagnoses included gastroesophageal reflux disease and upper respiratory infection. During the current admission, a chest radiograph demonstrated a round, opaque foreign body (23.5 mm), which was presumed to be a button battery [Figure 1]. The patient was immediately scheduled for foreign body removal in the operating room (OR). At the time of pre-operative assessment, the patient was tachycardic (heart rate of 154 beats/minute) and hypertensive (non-invasive blood pressure 108/67 mmHg). The hemoglobin and hematocrit were 8 gm/dL and 21%, respectively, and hence a type and cross was obtained. After pre-oxygenation, rapid sequence induction (RSI) was performed with propofol (3 mg/kg) and rocuronium (1.2 mg/kg) and the trachea was intubated on the first attempt. On endoscopic examination of the esophagus, deep ulcers were noted in the upper third of esophagus; however, no active bleeding or perforation was noted. In addition, the foreign body had passed into the small intestine and no attempt was made to remove it. Given persistent tachycardia in the presence of anemia, the patient was transfused at the completion of the procedure. The patient's trachea was extubated and after an uneventful recovery period in the post-anesthesia care unit and she was transferred to the inpatient ward. The following day, an abdominal radiography demonstrated that the foreign body had passed into the sigmoid colon [Figure 2]. Oral intake was started and advanced without incidence and the patient was discharged home on hospital day 2 with a hemoglobin and hematocrit of 10 gm/dL and 30%, respectively. Three days after discharge, the patient presented to the ED with 2 episodes of hematemesis. On arrival, the patient appeared pale with a heart rate of 163 beats/minute, a blood pressure of 96/42 mmHg, and respiratory rate of 40 breaths/minute. Her hemoglobin and hematocrit were 7 gm/dL and 21%, respectively. Computed tomography of the chest showed a diverticulum at the distal aortic arch immediately distal to the origin of the left subclavian artery, which was presumed to be an AEF. After a multi-disciplinary discussion involving anesthesiology, radiology, general surgery, and cardiothoracic surgery, it was deemed that emergent surgical intervention was necessary. In preparation, two peripheral intravenous cannulas were placed followed by the administration of blood products to correct the existing anemia as the patient transitioned to the operating room. RSI was performed upon arrival to the OR with etomidate (0.4 mg/kg), rocuronium (1.5 mg/kg), fentanyl (5 μg/kg) and the trachea was intubated uneventfully. Anesthesia was maintained with a dexmedetomidine infusion and inhaled isoflurane with bolus doses of fentanyl and rocuronium. A right radial arterial catheter and an internal jugular catheter were placed. Following median sternotomy, cardiopulmonary bypass was instituted and the patient was actively cooled to 20°C. After

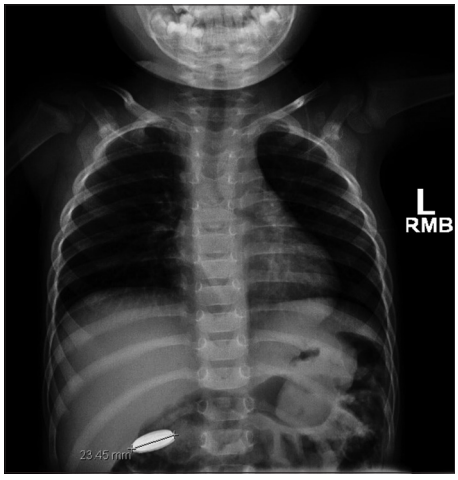

Figure 1: Admission chest radiograph showing radio-opaque foreign body suggestive of a button battery

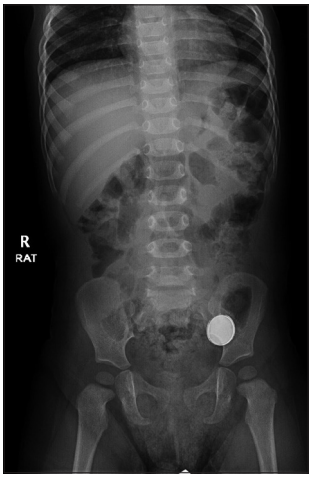

Figure 2: Abdominal radiograph on hospital day #2 showing radio-opaque foreign body has moved into the distal bowel

surgical exposure, a 5 mm ulcerative defect was found on the posterior wall of the descending aorta, with the esophagus effaced to the vessel. Patch angioplasty of the ulcerative defect in the aorta was performed followed by rewarming of the patient and uneventful separation from cardiopulmonary bypass. The patient's trachea was extubated in the OR and she was transferred to the PICU. After 3 days, the patient was returned to the OR for planned repair of the AEF by intercostal muscle flap advancement. Anesthesia included inhaled sevoflurane, a dexmedetomidine infusion, and intermittent bolus doses of fentanyl. Direct laryngoscopy with bronchoscopy was followed by rigid esophagoscopy to fully evaluate the extent of the airway and upper esophageal injuries. Left vocal cord paresis was noted, but there was no evidence of tracheal injury. The cervical esophagus was normal, but the mid-esophagus was injured anteriorly with healing granulation tissue noted, consistent with the negative pole of the button battery facing anteriorly. Rocuronium (1.5 mg/kg) was administered and the patient's trachea intubated. A median sternotomy was performed to establish cardiopulmonary bypass with cooling to 25°C. The patient was then positioned in left lateral decubitus for a posterior thoracotomy incision. The aorta was dissected off the esophagus revealing an 8 mm injury on the anterior wall of the esophagus. An intercostal muscle flap was opposed to the esophageal fistula site. The patient was warmed and then separated from bypass uneventfully. A gastrostomy was placed to allow for enteral nutrition during a prolonged period of *nil per os*. Her trachea was extubated and she was returned to the PICU. Oral intake was started 1 month after the last procedure and the patient was discharged home on hospital day 43. Approximately 1.5 years after the ingestion, the patient had only subtle left vocal cord paresis and has had her gastrostomy tube removed.

Discussion

Previous work has outlined the mechanisms of tissue injury caused by a button battery.[3,4] A button battery generates an electric current with hydroxide ions at the negative pole of the battery, which results in liquefication and necrosis of the adjacent tissue. Tissue damage is observed within 15 minutes of direct contact between the button battery and tissues. As the extent of tissue injury after ingestion is dependent on the length of time that the battery directly contacts the tissues, the most recent guidelines from the National Capital Poison Center recommend no more than a 2 hour window of time from diagnosis to removal of the button battery.[4,5] Ongoing alkali damage may continue for days to weeks after removal of the button battery, therefore extension of the injury to surrounding tissues, including the trachea and esophagus, may occur, resulting in delayed fatal complications including AEF, TEF, perforation, abscess formation, mediastinitis, and esophageal stricture.[4-6] Although many of these complications present acutely, delayed presentations are also common even for fatal complications such as AEF. In our review of the literature, the longest time from ingestion to a lethal hematemesis event was 32 days. Scarring and stricture formation generally occurs within a month of the initial event, but delayed stricture formation may occur up to several weeks after the ingestion.[3]

According to National Capital Poison Center, a total of 307 fatal or severe cases (62 fatal and 245 severe cases) of button battery ingestions have been reported since 1977. Among the 62 fatal cases, 25 (40%) cases were attributed to AEF, 12 (20%) to esophageal perforation or rupture, 11 (18%) to TEF, and 10 (16%) to bleeding, while no specific cause of death was noted in 4 (6%) cases. Of these 307 fatal and severe cases, 30 (9.8%) involved AEF, with only 5 reports of survival [Tables 1 and 2]. All of the reported patients with AEF were younger than 4 years of age with an average age of 26 months. More than half of the patients ingested a button battery that was larger than 20 mm and in the majority of cases, the battery lodged in the esophagus. Age younger than

Table 1: Demographic data of patients with aorto-esophageal fistula after button battery ingestion

Demographic data of 30 cases	Number
Age (month) (mean±SD)	26±12
Gender (male/female/not specified)	20/9/1
Battery diameter (millimeters)	
<20	2
20	19
>20	1
Not specified	8
Time to removal	
Less than 24 hours	6
More than 24 hours	13
Not removed prior to death	3
Not specified	8
Battery location (one case had two batteries)	
Upper esophagus	5
Mid-esophagus	9
Distal esophagus	7
Esophagus (location not specified)	6
Stomach	3
Cricopharyngeal membrane	1
Initial symptoms	
Hematemesis	12
Symptoms other than hematemesis	11
Not specified	1
Outcome	
Fatal	25
Non-fatal	5

SD=standard deviation

Table 2: Previous reports of aorto-esophageal fistula formation following button battery ingestion

Year	Author or source	Age (months)	Gender	Diameter (mm)	Type of battery	Time to removal	Battery location	Outcome	Days to normal feeding
1979	Shabino CL, *et al*.[7]	16	Female	23	MnO2	≥4 days	Upper esophagus	Death	Not applicable
1994	Sigalet DL, *et al*.[22]	36	Female	Unknown	Unknown	Unknown	Upper esophagus	Death	Not applicable
2004	National Battery Ingestion Hotline (NBIH)[1]	30	Male	20	Lithium	≥10 days	Upper esophagus	Death	Not applicable
2005	Hamilton JM[8] and NBIH[1]	19	Male	Unknown	Lithium	1 day	2 batteries: Stomach and mid-esophagus	Death	Not applicable
2008	Leinwand K, *et al*. (case 2).[9]	16	Female	20	Lithium	7-13 day	Mid-esophagus	Death	Not applicable
2009	Leinwand K, *et al*. (case 3).[9]	24	Female	20	Lithium	10 hours	Distal esophagus	Death	Not applicable
2009	NBIH[1]	13	Male	20	Lithium	10 days	Stomach	Death	Not applicable
2010	NBIH[1]	24	Female	20	Lithium	Not removed (unknown time of ingestion)	Mid-esophagus	Death	Not applicable
2010	Soerdjbalie- Maikoe V, *et al*.[10]	24	Female	20	Lithium	11 days	Mid-esophagus	Death	Not applicable
2010	Herrera CB, *et al*.[11]	36	Male	20	Lithium	1 day	Mid-esophagus	Death	Not applicable
2011	Pae SJ, *et al*.[12] and NBIH[1]	48	Female	20	Lithium	Unknown	Distal esophagus	Death	Not applicable
1998	MMWR[1]	16	Female	Unknown	Unknown	Unknown	Esophagus	Death	Not applicable
2002	MMWR[1]	15	Female	20	Lithium	≥24 hours	Upper esophagus	Death	Not applicable
2011	MMWR[1]	36	Male	Unknown	Unknown	Unknown	Esophagus	Death	Not applicable
2011	Spiers A, *et al*.[13] and NBIH	9	Male	20	Lithium	14 hours	Distal esophagus	Alive	Unknown
2012	MMWR[1]	48	Male	Unknown	Unknown	4 days	Mid-esophagus	Death	Not applicable
2012	CPSC (NBIH)[1]	24	Female	20	Lithium	≤8 days	Esophagus	Death	Not applicable
2013	Martinez SG, *et al*.[14]	23	Male	20	Lithium	Unknown	Upper esophagus	Death	Not applicable
2013	Taghave K, *et al*.[15]	48	Female	20	Lithium	≥2 weeks	Mid-esophagus	Death	Not applicable
2013	Connor L (News)[1]	12	Female	Unknown	Unknown	≤1 day	Esophagus	Death	Not applicable
2015	Chow J, *et al*.[16]	14	Female	20	Lithium	2-3 weeks	Distal esophagus	Death	Not applicable
2016	Nisse P, *et al*.[17]	48	Female	16	Lithium	3 days	Mid-esophagus	Death	Not applicable
2017	Kroll AK, *et al*.[18]	22	Male	20	Lithium	Not removed (Unknown)	Distal esophagus	Death	Not applicable
2017	Duell (News)[1]	24	Female	<20	Lithium	Unknown	Esophagus	Alive	Unknown
2018	CPSC (NBIH)[1]	22	Female	20	Lithium	Unknown	Distal esophagus	Death	Not applicable
2018	Mahajan S, *et al*.[19]	36	Female	Unknown	Unknown	Unknown	Distal esophagus	Alive	>7 months
2018	Granata A, *et al*.[20]	36	Female	Unknown	Lithium	≤8 hours	Esophagus	Alive	1 month
2019	Bartkevics M, *et al*.[21]	12	Female	20	Lithium	Unknown	Other	Alive	11 days

MMWR=morbidity and mortality weekly report; CPSC=Consumer Product Safety Commission; NBIH=National Battery Ingestion Hotline. MnO2=Manganese oxide

4 years and size of the battery (diameter of 20-25 mm) are the most important predictors of a clinically poor outcome, with an odds ratio of 3.2 and 24.6 respectively.[2] Merely based on size, larger batteries are more likely to lodge in the esophagus, especially in younger and smaller patients thereby increasing the duration of time that there is direct contact between the battery and the surrounding tissues. Although less likely to lodge in the esophagus, our review demonstrates that batteries smaller than 20 mm in diameter can also be associated with severe or fatal outcomes. Therefore, as noted by the most recent guidelines from the National Capital Poison Center, a button battery that lodges in the esophagus, regardless of its size and the age of the patient, should be urgently removed.[3,4] Given the high risk of morbidity and mortality, specific guidelines have been developed with recommendations for both home care prior to arrival to the hospital and for pathways to facilitate the rapid transport of these patients to the operating room [Table 3].

Following button battery ingestion, children may be asymptomatic or manifest non-specific symptoms, especially if a patient is non-verbal age and the ingestion was unwitnessed. These issues can lead to a delayed diagnosis and treatment. In reported cases, the most common signs and symptoms of AEF included hematemesis, vomiting, and abdominal pain [Figure 3]. Although hematemesis may not be a presenting sign, patients may return to the hospital with the abrupt onset of hematemesis following an apparent asymptomatic period after removal of the button battery. Delayed hematemesis has been noted at 2 to 32 days after battery removal. Patients with a history of button battery ingestion who present with hematemesis should be considered to have an AEF. Stabilization of the patient followed by radiologic imaging and upper endoscopy is needed to either confirm or rule out the diagnosis.[6,22] Diagnostic imaging may include CT or MR angiography to identify the presence of the AEF and its location. Effective care should include a multidisciplinary team including gastroenterology, radiology, general surgery, cardiac surgery, otolaryngology, and pediatric anesthesiology. Although clinically stable at the time of presentation, hematemesis or other presenting signs can be rapidly followed by massive hemorrhage and death.

Following a rapid and focused preoperative evaluation, preparations should be made to rapidly transport the patient to the operating room. Given the potential for hemorrhage, adequate venous access and blood products should be available in the operating room. Arterial access may be required for hemodynamically unstable patients and to allow for intermittent laboratory analysis as well as continuous blood pressure monitoring. Intraoperative evaluation of hemoglobin, platelet count, coagulation parameters, and acid-base status may be required. Rapid sequence induction is indicated, as these patients are considered to have a full stomach and may be at risk for aspiration during the induction of anesthesia. The choice of anesthetic agents is based on the patient's hemodynamic status. Surgical access for repair of an AEF generally requires a thoracotomy. Cardiopulmonary bypass may be required during repair of an AEF. Although endovascular aortic repair for an AEF is less invasive and has been reported in adults, to date, there remains only one report in a pediatric-aged patient.[23,20] Postoperatively, the patient should be monitored in a critical care setting as the ongoing alkali damage may continue for days to weeks.

In summary, although the majority of button battery ingestions in children are resolved uneventfully, severe outcomes including death or stricture formation have been reported. The potential for severe injury is greater

Table 3: Summary of triage and treatment guidelines for button battery ingestions

1. Nothing should be given orally if the time from battery ingestion is more than 12 hours due to the risk of underlying esophageal perforation.
2. Patients≥12 months of age with a possible lithium battery ingestion within 12 hours. Give honey 10 mL every 10 minutes (maximum of 6 doses) while en route to the hospital and prior to transport to the operating room. Honey should not be administered in children less than 12 months of age. Do not administer any other medications or fluids orally prior to battery removal. Neither treatment is a substitute for immediate removal of a button battery lodged in the esophagus.
3. Do not delay battery removal under general anesthesia because the patient has recently had any oral ingestion and is not *nil per os*. These cases are considered emergent and a process should be in place for rapid and efficient transport to the operating room for upper endoscopy.
4. Radiographs should be obtained to locate the battery and should include the entire neck, chest, and abdomen. Obtain both anterior-posterior and lateral radiographs for batteries in the esophagus to determine orientation of the positive and negative poles.
5. If the patient meets criteria for conservative management, consider outpatient observation, and confirm battery passage by inspecting stools. Conservative management criteria: The patient is more than 12 years of age, is asymptomatic, and has no history of esophageal pathology or previous esophageal surgery. The ingestion includes a single button battery <12 mm in diameter with no co-ingestion of a magnet. The patient and caregiver are cognitively able to report symptoms if they develop.
6. Coins and button batteries have a similar appearance on plain radiographs. Therefore, all patients should be presumed to have a button battery ingestion and be treated accordingly, unless the ingestion was known to be a coin.
7. Magnet co-ingestion: Immediate endoscopic removal. If this is not feasible, then proceed to surgical removal. If the patient is symptomatic, proceed with immediate endoscopic removal and assess the esophagus. If the button battery is beyond the reach of the endoscope, surgical removal may be indicated.

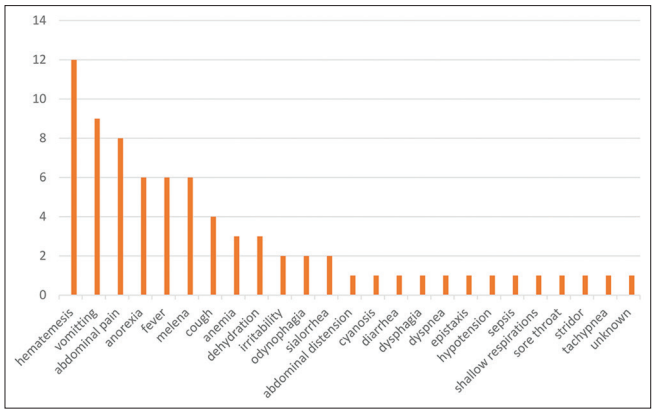

Figure 3: Literature review demonstrating initial symptoms among children who developed aorto-esophageal fistula following button battery ingestion. The x-axis demonstrates the specific symptom with case numbers listed on the Y axis

in patients less than 4 years of age and with ingestion of larger batteries (diameter greater than 20 mm). Tissue injury continues for days to weeks after removal of the button battery and fistula formation and fatal hemorrhage have been reported. As the majority of patients require anesthetic care during button battery removal, anesthesiologists should be familiar with the current guidelines. The reader is referred to references 3 and 5 for further recommendations and updates.[3,5] Care by a multidisciplinary team and prompt treatment interventions are key to a successful outcome.

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Conflicts of interest

There are no conflicts of interest.

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