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Battery ingestions in children: Variations in care and development of a clinical algorithm☆

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ABSTRACT

Purpose: To review current management and outcomes of ingested batteries and develop a clinical management algorithm.
Methods: Children <18 years old who ingested a battery between 1/2011 and 9/2016 at two tertiary care children's hospitals were reviewed. Demographics, imaging, management and outcomes were analyzed using descriptive statistics, Chi-square and Wilcoxon Rank-sum tests.
Results: There were 180 battery ingestions. The median age was 3.9 (range 0.7–18) years, with 78 (43%) males. The most common symptoms were abdominal pain (17%) and nausea/vomiting (14%). Diagnosis was confirmed with plain radiographs in 170 (94%) patients. Locations on imaging were: stomach (37%), small bowel (24%), esophagus (18%), colon (11%), and non-specific location past the gastroesophageal junction (9%). Treatment was dictated by five different subspecialties including surgery (35%), gastroenterology (25%), emergency medicine (19%), primary care/emergency with a consulting service (13%), and otolaryngology (8%).
All esophageal batteries (n = 33) had an intervention. Interventions included fluoroscopic balloon extraction (6 attempted, 33% retrieval rate), rigid esophagoscopy (26 attempted, 96% retrieval rate), and EGD (6 attempted, 83% retrieval rate).
For batteries distal to the gastroesophageal junction 16 (11%) patients had an intervention. Interventions included EGD (13 patients, 69% retrieval), colonoscopy (1 patient, successful retrieval), and abdominal surgery in two patients.
Conclusion: Isolated batteries that pass the gastroesophageal junction rarely require intervention and can be managed conservatively. Given the variability in managing these patients, we developed an evidence based algorithm.
Level of Evidence: Level 2.
Study Type: Retrospective Study.

Young children have a natural tendency to explore their environment by placing objects in their mouth. While a majority of ingested foreign bodies pass spontaneously through the gastrointestinal tract, batteries and magnets have an increased potential to cause damage. Over the past two decades' emergency room visits for battery ingestions have increased in frequency. According to the National Electronic Injury Surveillance System (NEISS) between 1990 and 2009 the incidence of emergency room visits for battery ingestions has doubled [1].

While there is agreement regarding the need for urgent removal of esophageal batteries, the management of batteries which lie beyond the gastroesophageal junction is controversial. An expert opinion-based guideline from the Endoscopy Committee of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) recommended endoscopic removal of button batteries in certain cases whereby the battery lies beyond the esophagus [2]. However, recommendations from the National Battery Ingestion Hotline (NBIH) and the National Capital Poison Center, suggest initial conservative management in asymptomatic children with postesophageal batteries [3,4]. The purpose of our study was to review the management and outcomes of battery ingestions from two tertiary-care academic children's hospitals and develop a standardized management algorithm.

1. Methods

1.1. Study design

Following approval by the Institutional Review Board (IRB) of Children's Mercy Hospital (IRB#16070546) and Texas Children's Hospital (IRB#H39198), medical records of all children less than 18-years-old with

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battery ingestions were retrospectively reviewed from January 2011 to June 2016. Patients were identified based on International Classification of Disease Ninth Revision (ICD-9) diagnosis coding. Patients diagnosed with foreign body ingestion, which included mouth, esophagus and stomach (935.0, 935.1, and 935.2), intestine and colon (936), and unspecified digestive system (938) were reviewed. Those with radiographic evidence of a battery ingestion were included and those with airway or other foreign body ingestions were excluded.

1.2. Data collection

Patient demographics including age, gender, and race were collected. Battery ingestion characteristics including location, symptoms, and diagnostic workup were recorded. Clinical management including procedures performed, hospital length of stay, and complications was included. Deidentified data from both institutions were used for data analysis.

1.3. Statistics

Data analyses were performed using STATA software version. 14.2 (STATACorp LLC., College Station, TX, USA). Patient characteristics and outcomes are described descriptively using counts and percentages for categorical variables and as median with interquartile range (IQR) for continuous variables. Comparative analysis was performed using the Wilcoxon rank test and Fisher's exact test or χ^2 square test, as appropriate. A $p < 0.05$ was used to determine significance.

2. Results

2.1. Patient Characteristics

There were 180 children with a confirmed battery ingestion. Hospital 1 contributed 94 patients (52%) and Hospital 2 contributed 86 (48%) to the total cohort. Overall, the median age was 3.9 years (range 0.7–18). There were 109 ingestions in children less than 5-years-old. The median weight was 16.9 kg (IQR, 12.4–28), and 43% were male. The most common symptoms were abdominal pain (17%) and nausea/vomiting (14%). At presentation the distribution of the battery location based on imaging was: esophagus (18%), stomach (37%), small bowel (24%), colon (11%), and a nonspecific location past the gastroesophageal junction (9%). The majority of patients presented less than one day after ingestion.

2.2. Clinical management

The diagnosis of a battery ingestion was confirmed with plain radiographs in 170 (94%) patients. The primary service managing the battery ingestion varied between five pediatric specialties: Surgery (35%), Gastroenterology (25%), Emergency Medicine (19%), Primary Care / Emergency Medicine with a consulting service (13%), and Otolaryngology (8%). Median hospital length of stay (LOS) for all patients was 0.1 days (range 0–20).

2.2.1. Esophageal batteries

There were 33 esophageal batteries, and 9 (27%) of the ingestions were witnessed. The median age was 1.8 years (IQR, 1.1–3.5). Twenty-four (73%) patients presented with symptoms: 18 (75%) with nausea or vomiting, six (25%) with respiratory symptoms, five (21%) with drooling, and two (8%) with abdominal pain. Diagnostic imaging identifying an esophageal battery included a chest radiograph in 18 (55%) patients, and a foreign body series (chest and abdominal radiograph) for 15 (45%) patients.

All esophageal battery patients had an intervention. Interventions included fluoroscopic balloon extraction, rigid esophagoscopy, and esophagogastroduodenoscopy (EGD). Fluoroscopic balloon extraction using a Foley catheter was only performed at Hospital 2 [5]. This technique was attempted on six (18%) patients, and was successful in two (33%). Both patients with successful removal had a postprocedure esophagram, and neither revealed a perforation. The time from ingestion to successful removal for this technique was less than 24 h. The four patients where the battery was unable to be removed with the fluoroscopic balloon extraction technique went on to uneventful removal by rigid esophagoscopy.

Rigid esophagoscopy was attempted in 26 (79%) patients, and the battery was successfully removed in 25 (96%). The one patient where the battery was not removed was followed-up with an EGD and fluoroscopy under the same anesthetic, and the battery was noted to have already moved past the Ligament of Treitz. On rigid esophagoscopy, 19 (73%) patients had evidence of mucosal irritation of the esophagus, and 20 (77%) subsequently underwent an esophagram. There were no perforations identified.

An EGD was attempted in six (23%) patients for esophageal battery removal, and the battery was successfully removed in five (83%). The one unsuccessful attempt was in the same patient as described above. On EGD four (67%) of patients had mucosal irritation of the esophagus and one was described as having a posterior esophageal burn. This patient underwent a computed tomography scan two days later, and was treated with nasogastric tube feedings owing to persistent dysphagia.

2.2.2. Gastric batteries

There were 67 batteries identified within the stomach, and 29 (43%) of the ingestions were witnessed. The median age was 5.7 years (IQR, 1.6–7.4). Seventeen (25%) patients presented with symptoms: 10 (59%) with abdominal pain, four (24%) with nausea or vomiting, two (12%) with throat pain, and one (6%) with drooling. Diagnostic imaging identifying a gastric battery included a foreign body series (chest and abdominal radiograph) in 41 (61%) patients, abdominal radiographs in 23 (34%) patients, and a chest radiograph in three (4%) patients.

The majority (84%, $n = 56$) of patients with a gastric battery were managed nonoperatively. Five patients were admitted for nonoperative management. Of the patients discharged home for outpatient management, four (6%) were placed on a bowel regimen, and 12 (18%) returned for serial radiographs. There were no complications in the nonoperative group.

An EGD was attempted in 11 (16%) patients. Five (45%) of these patients were symptomatic; three (60%) with abdominal pain, one (20%) with throat pain and two (40%) with nausea or vomiting. Of the asymptomatic patients, one underwent an EGD owing to ingestion of a battery and multiple magnets, a second owing to ingestion of 2 AAA batteries, the third swallowed a button battery 4 days prior which was still in the stomach, and the rest were prophylactic removal. Batteries were successfully retrieved in nine (82%) patients that underwent EGD. On EGD, four (36%) patients had gastric mucosal irritation. There were no perforations identified. The median time from ingestion to intervention was 1.5 days (IQR 0–4.5, $n = 8$). Of note, several patients in this review that arrived in the evening hours and were scheduled for a semielective EGD the next morning had the procedure canceled because the battery had already moved beyond the stomach by the next morning.

2.2.3. Small bowel batteries

There were 43 batteries identified in the small bowel, and 11 (26%) of the ingestions were witnessed. The median age was 5.1 years (IQR, 3.2–10.0). Nine (21%) patients presented with symptoms: nine (100%) with abdominal pain and one (11%) with additional nausea or vomiting. Diagnostic imaging identifying a battery in the small bowel included a foreign body series (chest and abdominal radiograph) in 27 (63%) patients, an abdominal radiograph in 15 (35%) patients, and a chest radiograph in one (2%) patient.

The majority (88%, $n = 38$) of patients with a battery in the small bowel were managed nonoperatively. Three patients were admitted

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