

# Endoscopic Retrieval vs Observation in Cylindrical Battery Ingestion

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**Background:** Battery ingestion, particularly in the pediatric population, has become more common since the development of button batteries. Consequently, formal recommendations regarding the management of this battery type have been developed. Larger cylindrical battery ingestion is less common, with fewer cases reported. As such, no clear practice guidelines have been developed for the management of cylindrical battery ingestion.

**Case Report:** We present a case of an incarcerated adult who ingested 2 AA batteries. One battery was retrieved endoscopically, but the second passed into the distal small bowel beyond endoscopic means of retrieval. The second battery passed spontaneously via the rectum after administration of laxatives and supportive care.

**Conclusion:** Our case and review of the literature demonstrate that nonsurgical, conservative management with close clinical monitoring is possible in a hospital setting after cylindrical battery ingestion. Cases with concerning clinical symptoms or a history of damage to the battery casing warrant endoscopic or surgical intervention.

**Keywords:** Endoscopy–digestive system, foreign bodies, ingestion, suicide–attempted

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## INTRODUCTION

Battery ingestion, particularly in the pediatric population, has become more common since the development of button batteries. Consequently, formal recommendations regarding the management of this battery type have been developed.<sup>1</sup> Larger cylindrical battery ingestion is less common, with fewer cases reported. As such, no clear practice guidelines have been developed for management of cylindrical battery ingestion. We present a case of an adult prison inmate who ingested 2 AA batteries in a suicide attempt, review the available literature and associated sequelae, and propose an approach to the management of patients presenting after the intentional ingestion of cylindrical batteries.

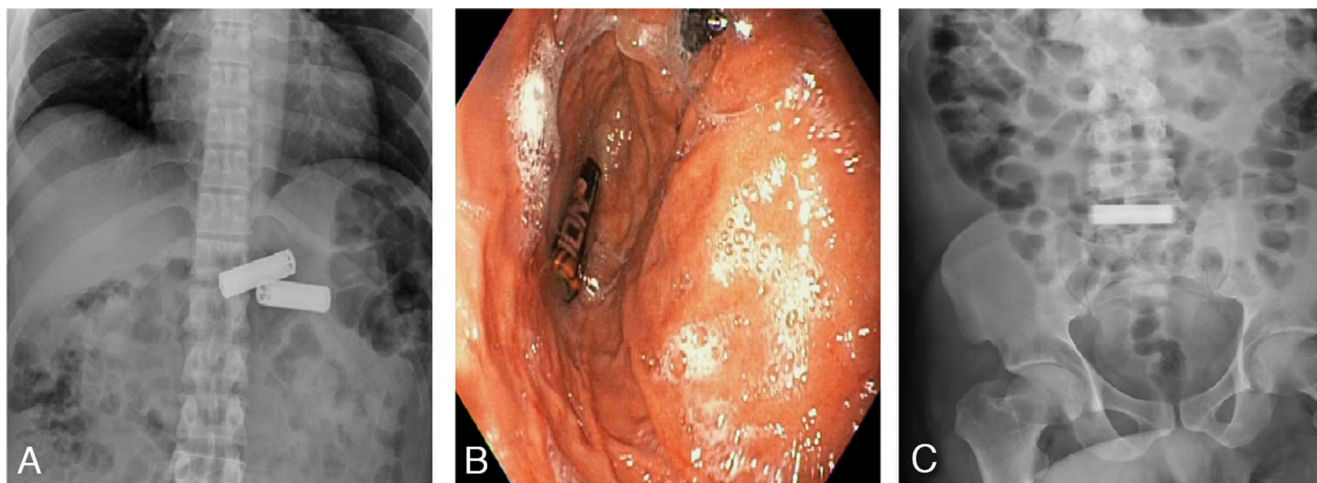
## CASE REPORT

A 36-year-old male was transferred to our facility from prison after reporting that he had ingested 2 AA batteries 2 days prior to admission. He had a history of schizophrenia and a previously reported suicide attempt by ingestion of AA batteries that were endoscopically retrieved. The patient had no complaints on admission; he denied abdominal pain, nausea, vomiting, and other gastrointestinal (GI) symptoms. His physical examination was without significant findings, including a nontender, nondistended abdomen and regular bowel sounds. Laboratory data were unremarkable. Abdominal x-rays revealed 2 cylindrical structures superimposed on

the mid upper abdomen consistent with the reported battery ingestion (Figure 1A).

Approximately 2 hours after the patient's presentation, upper GI endoscopy revealed one AA battery in the gastric fundus (Figure 1B). The second battery was not seen on endoscopic examination up to the third portion of the duodenum, and no mucosal damage was apparent. An overtube was placed. The first battery was captured with a snare and retrieved through the overtube. After retrieval of the first battery, a second examination with a pediatric colonoscope was conducted. The pediatric colonoscope was advanced deep into the jejunum, at least 80 cm from the ligament of Treitz, without success in locating the second battery.

Repeat abdominal x-rays revealed the second battery in the distal ileum or proximal colon (Figure 1C). Meanwhile, the patient's psychiatric medications were adjusted, and he was started on a regular diet that he tolerated well. Daily abdominal x-rays (Figure 2) demonstrated the battery progressing from the proximal colon to the descending colon. He was administered a 10-ounce bottle of magnesium citrate and started on 17 g daily of polyethylene glycol 3350 on hospital day 4, resulting in regular bowel movements the following day. The patient defecated the battery on hospital day 7. His hospital course was otherwise unremarkable, and he was discharged back to the correctional facility.



**Figure 1. A.** This supine anteroposterior view of the abdomen shows 2 cylindrical structures superimposing the right upper quadrant, likely in the gastric antrum (hospitalization day 1, prior to esophagogastroduodenoscopy [EGD]). **B.** Endoscopic image in retroflexion reveals an ingested battery in the gastric fundus. **C.** A cylindrical structure superimposing the mid lower abdomen represents the remaining ingested battery (hospitalization day 1, after EGD).

## DISCUSSION

Ingestion of batteries has been well documented in the medical literature and at poison control centers for decades. However, the majority of the literature concerning battery ingestion deals with button batteries rather than with cylindrical batteries. In a 7-year study from the National Capital Poison Center in Washington, DC, individuals swallowing button batteries greatly outnumbered those ingesting cylindrical batteries (2,320 vs 62).<sup>2</sup>

Button batteries are more likely to be swallowed either by accident or by a curious child.<sup>3</sup> Button batteries may cause liquefactive necrosis, and perforation can occur rapidly when the battery lodges in the esophagus, leading to severe and potentially fatal complications. As such, formal guidelines have been developed and emphasize emergent removal of button batteries from the esophagus.<sup>1</sup>

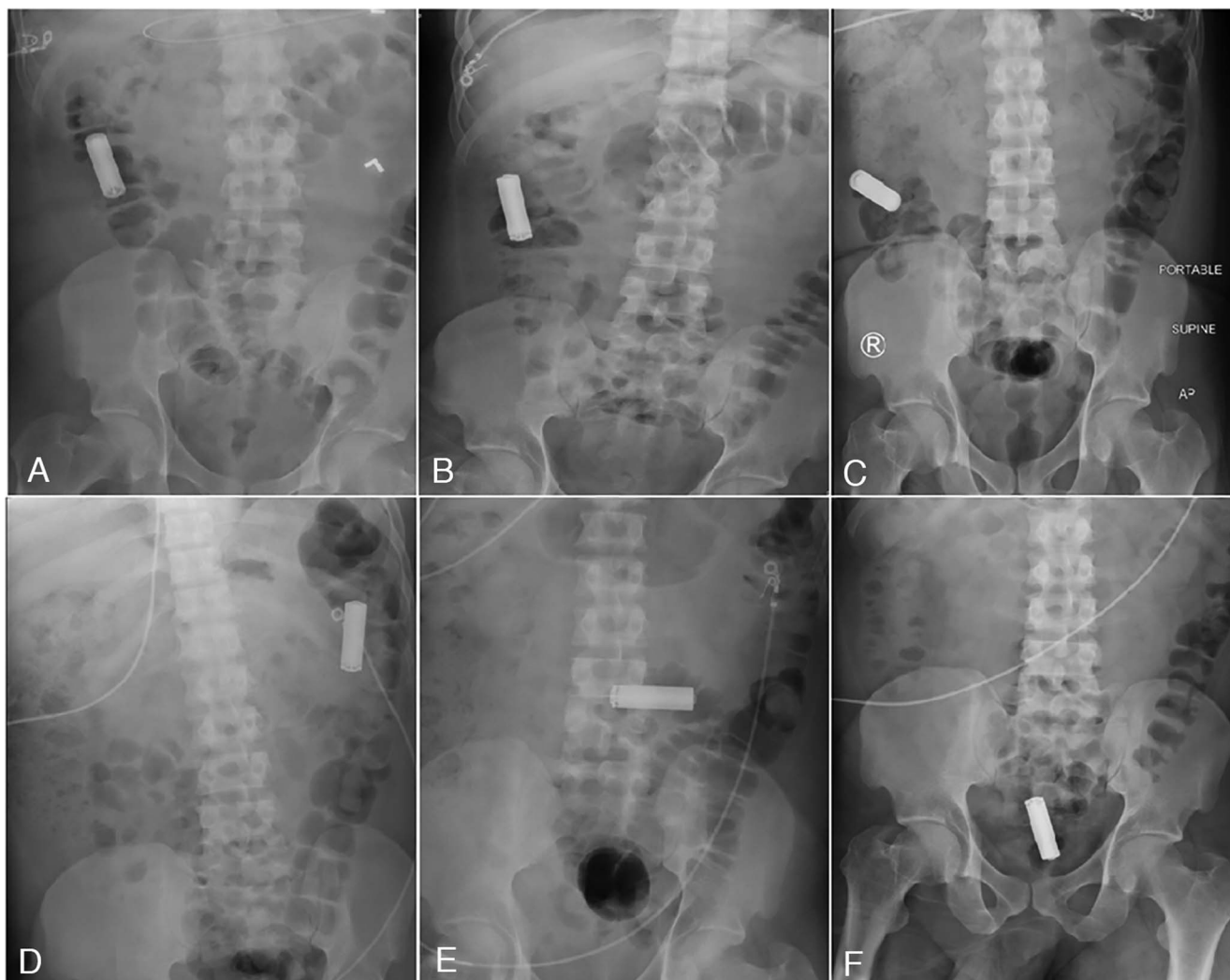
On the other hand, given the larger size of cylindrical batteries, they are commonly ingested deliberately in the psychiatric population and by prison inmates.<sup>4,5</sup> Most ingestions occur in patients 6–39 years of age.<sup>6</sup> Cylindrical cells are typically alkaline-manganese or nickel-cadmium (rechargeable) and when ingested can cause corrosive and toxic damage. Such damage can occur if the integrity of the battery casing is deliberately damaged and can also occur from sustained acid attack from gastric contents for a period of weeks, rather than days, or as a result of battery leakage. Untersweg et al reported the case of a 4-year-old boy who sustained grade II–III esophageal burns from putting a leaking cylindrical battery to his mouth and sucking the caustic solution.<sup>7</sup> The burns resulted in an esophageal stricture, necessitating frequent bouginages and placement of a jejunal tube for feeding.

The most comprehensive studies on battery-related exposures are based on cases reported to the National Battery Ingestion Hotline and US poison control centers. Litovitz conducted an 11-month review of the National Capital Poison Center at Georgetown University Hospital where 125 battery ingestions were reported.<sup>8</sup> Only 6 of the ingested

batteries were cylindrical; all passed through the GI tract spontaneously. Two cylindrical batteries were ingested by a 6-year-old and a 12-year-old child. Both children remained asymptomatic and passed the batteries in 36–38 hours. The other 4 batteries were ingested by a 30-year-old male convict who swallowed the batteries to avoid incarceration and subsequently reswallowed 3 of the excreted batteries with no reported adverse events. Litovitz and Schmitz next conducted a 7-year review.<sup>2</sup> Of the 2,383 reported battery ingestion cases, only 62 were reported as cylindrical battery ingestions: 33 patients ingested AA batteries, 26 patients ingested AAA batteries, 2 patients ingested N batteries, and 1 patient ingested a C battery. No other characteristics were reported. The Litovitz et al 18.25-year review reviewed 8,648 battery ingestion cases, 487 of which were cylindrical ingestions.<sup>9</sup> The researchers did not report individual characteristics of the cylindrical battery ingestions, but statistics showed that at least 43% of them were intentional, suicidal, or associated with a neuropsychiatric disorder; another 6% were by incarcerated individuals. Additionally, 37.8% of cylindrical cell ingestions involved multiple cells compared with 8.7% of button cell ingestions.

We conducted a literature search in PubMed, Scopus, and Cochrane Library for the terms cylindrical, battery, and ingestion from database inception until September 17, 2017 and identified 15 case reports and 1 case series (a case written in the Spanish language was not included). We summarize these cases in the Table.<sup>10–25</sup>

Most reported cases involved patients who were asymptomatic after ingestion. If symptoms did occur, they usually manifested as upper GI complaints or abdominal pain. Unusual presentations include ST segment abnormalities on electrocardiogram and a grand mal seizure.<sup>10,18</sup> All but one patient<sup>19</sup> with a history of prior abdominal surgery required either surgical or endoscopic intervention for battery retrieval, possibly related to adhesions or dysmotility preventing the passage of the batteries.<sup>11,12,13,22,24</sup>



**Figure 2.** Supine anteroposterior views of the abdomen demonstrate the single ingested cylindrical structure advancing through the gastrointestinal tract (hospitalization days 2, 3, 4, 5, 6, and 7, respectively). A. Within the right upper quadrant and either in the distal ileum or proximal colon. B. Within the region of the ascending colon. C. Within the region of the ascending colon. D. Within the left mid abdomen and in the region of the descending colon. E. Within the region of the sigmoid colon. F. Projecting over the pelvis in the region of the rectum.

Several patients spontaneously passed the cylindrical batteries via the rectum. In the Hindley et al case series, 3 psychiatric patients swallowed cylindrical batteries and passed them with conservative management within 1-2 weeks, a fourth patient passed ingested batteries within 3-4 months, and a fifth patient required surgical extraction. However, the patient who required surgery, unlike the other 4, had developed acute upper GI pain.<sup>13</sup>

Our review revealed that in all cases with evidence of corrosive changes, leakage, or damage to the battery casing, patients were symptomatic or had evidence of mucosal damage.<sup>10,11,13,14,21,22</sup> In 2017, Tien and Tanwar reported a case of a 3-battery ingestion that resulted in gastric ulcers and gastritis within 14 hours, despite the patient denying destruction of the battery cases.<sup>24</sup> Our review of the abdominal x-rays provided with the case suggested distortion of the battery casing that would have explained the gastric find-

ings. Two batteries were removed urgently from the stomach; the third had passed to the small bowel. Despite conservative management for 2 days with a laxative, urgent colonoscopy with planned terminal ileum intubation was attempted because of concern that the third battery would be impacted at the ileocecal (IC) valve. On endoscopy, the battery had passed the IC valve and was retrieved from the proximal right colon. Urgent colonoscopy may not have been indicated in this case, as the battery had passed the IC valve and therefore would have likely been passed without complication.

In a case from 2015, Hammad et al reported the case of a patient whose ingestion of 7 cylindrical batteries resulted in severe gastric ulcerations and erosions caused by the corrosive alkaline spilling from the eroded batteries, despite the patient being asymptomatic and the batteries being in his stomach for less than 12 hours.<sup>21</sup>

Table. Summary of Reported Cases of Patient Ingestion of Cylindrical Batteries

Case	Patient Age, years/Sex	Known Psychiatric Illness/Suicide Attempt	Interval Between Ingestion and Diagnosis		Number and Type of Batteries Ingested	History of Abdominal Surgery	Case Presentation, Course, and Outcome
			Diagnosis	Abdominal Surgery			
Levine et al, <sup>10</sup> 1984	31/Female	Yes/Yes	2 weeks	NR	1 C cell	NR	<ul style="list-style-type: none"> <li>• Grand mal seizure at presentation</li> <li>• Battery in stomach with mild diffuse gastritis could not be retrieved endoscopically; retrieved by gastrostomy; showed marked corrosive changes and was beginning to open</li> <li>• No further seizure activity; further workup for seizures unrevealing</li> </ul>
Young and Lubitz, <sup>11</sup> 1989	33/Male	Yes/Yes	6 hours	Laparotomy to remove razors ingested in a suicide attempt 7 years prior	5 AAA	NR	<ul style="list-style-type: none"> <li>• Mild epigastric pain at presentation</li> <li>• Batteries arrested at the pyloric sphincter and removed with Dormia basket one at a time</li> <li>• Undamaged gastric mucosa</li> </ul>
Kaplan and Totten, <sup>12</sup> 1993	24/Female	Yes/Yes	24 hours	Surgery for previous cylindrical battery ingestion	3 AA	NR	<ul style="list-style-type: none"> <li>• Left upper quadrant pain at presentation</li> <li>• Endoscopic removal unsuccessful (patient agitated and uncooperative); patient declined surgery and released to psychiatric facility; follow-up 48 hours later showed 1 battery in the stomach and 2 batteries lodged at the IC valve with continued abdominal pain</li> <li>• Batteries uneventfully removed via cecotomy and gastrostomy</li> </ul>
Hindley et al, <sup>13</sup> 1999	20/Male	Yes/Yes	NR	NR	1 alkaline cylindrical/2 alkaline cylindrical	NR	<ul style="list-style-type: none"> <li>• Immediately symptomatic with acute upper GI pain (patient bit casing prior to ingestion)</li> <li>• Emergent battery retrieval via laparotomy</li> <li>• After return to psychiatric facility, patient swallowed 2 batteries; repeat laparotomy for battery retrieval; course complicated by <i>Clostridium difficile</i> infection</li> </ul>
Hindley et al, <sup>13</sup> 1999	Late teens/Male	Yes/NR	NR	NR	2 alkaline cylindrical	NR	<ul style="list-style-type: none"> <li>• Asymptomatic at presentation</li> <li>• Abdominal x-ray showed undamaged batteries beyond the pylorus; passed via rectum a week later</li> </ul>
Hindley et al, <sup>13</sup> 1999	Late 20s/Male	Yes/Yes	NR	NR	2 alkaline	NR	<ul style="list-style-type: none"> <li>• Asymptomatic at presentation</li> <li>• Abdominal x-ray showed batteries with damaged casings beyond the pylorus; passed via rectum within 2 weeks</li> </ul>
Hindley et al, <sup>13</sup> 1999	20s/Male	Yes/Yes	NR	NR	2 alkaline	NR	<ul style="list-style-type: none"> <li>• Asymptomatic at presentation</li> <li>• Abdominal x-ray showed batteries beyond the pylorus; passed via rectum within 2 weeks</li> </ul>
Hindley et al, <sup>13</sup> 1999	30s/Male	Yes/Yes	NR	NR	4 alkaline	NR	<ul style="list-style-type: none"> <li>• Abdominal x-ray showed all batteries beyond the pylorus</li> <li>• Three passed via rectum in 1-2 months; fourth remained in cecum after 3 months</li> </ul>

Table. Continued

Case	Patient Age, years/Sex	Known Psychiatric Illness/Suicide Attempt	Interval Between Ingestion and Diagnosis	Number and Type of Batteries Ingested	History of Abdominal Surgery	Case Presentation, Course, and Outcome
Lim et al, <sup>14</sup> 2006	60/Male	NR/NR	NR	2 Duracell 3-volt	NR	<ul style="list-style-type: none"> <li>• Ten-day history of nausea, vomiting, and epigastric pain</li> <li>• Abdominal x-ray showed 2 metallic bodies in the stomach at the proximal greater curvature</li> <li>• Multiple deep ulcers noted on endoscopy; both batteries retrieved by Roth Net via an overtube; visible leakage from the copper tops and destruction of the grommet seals and positive terminals</li> </ul>
Lavon et al, <sup>15</sup> 2008	38/Male	No/No	6 years	2 pairs of cylindrical (each pair wrapped in plastic)	NR	<ul style="list-style-type: none"> <li>• Swallowed drug packets and 2 pairs of batteries to push drug packets down the GI tract; all drug packets and one pair of batteries expelled within several days; 6 years later, patient presented with intermittent diffuse abdominal discomfort and heartburn of several months</li> <li>• Abdominal x-ray showed radiopaque mass in the stomach; attempt to retrieve batteries with forceps failed because plastic began to tear and leakage was a concern; batteries removed laparoscopically; gastric biopsy revealed mild chronic inflammation</li> <li>• Postoperative course unremarkable; discharged 5 days later with resolution of presenting symptoms</li> </ul>
Nielsen et al, <sup>16</sup> 2010	27/Female	Yes/Yes	2 batteries ingested 24 hours prior to presentation	6 AAA and 4 button	NR	<ul style="list-style-type: none"> <li>• Decreased mental state (coingestion of mirtazapine) and stomach pain at presentation</li> <li>• All cylindrical and 2 button batteries discharged via rectum by day 3; CT showed 2 remaining batteries in the cecum and stomach</li> <li>• During EGD to retrieve stomach battery, small (mm size) erosions noted; retrieval unsuccessful; battery had passed the pylorus</li> <li>• Patient discharged and observed at psychiatric facility; no adverse outcomes reported</li> </ul>
Ribakovs and Uzoigwe, <sup>17</sup> 2011	56/Male	Yes/NR	7 days	2 AA	NR	<ul style="list-style-type: none"> <li>• Mild epigastric pain and vomiting progressed to debilitating global pain and refractory vomiting by day 7</li> <li>• Physical examination revealed rigid abdomen with peritonitis; abdominal x-ray showed 2 batteries in the ascending colon; CT revealed 1 battery in the cecum proximal to fecal loading in ascending colon and the second battery extraluminal</li> <li>• Laparotomy showed 1 battery protruding through ascending colon at hepatic flexure; hemicolectomy performed</li> <li>• Pathology of resected colon showed second battery impacted in a diverticulum 30 mm distal to the IC valve; site of distal perforation revealed cell necrosis and serositis consistent with chemical injury rather than pressure effect</li> </ul>
Chang et al, <sup>18</sup> 2012	36/Male	Yes/Yes	1 hour	6 AAA	NR	<ul style="list-style-type: none"> <li>• Pseudoinfarction pattern on ECG</li> <li>• Batteries removed endoscopically; ST segment abnormality resolved</li> </ul>

**Table. Continued**

Case	Patient Age, years/Sex	Known Psychiatric Illness/Suicide Attempt	Interval Between Ingestion and		Number and Type of Ingested Batteries	History of Abdominal Surgery	Case Presentation, Course, and Outcome
			Diagnosis	Diagnosis			
Malliwai and Bhattacharya, <sup>19</sup> 2013	54/Male	Yes/NR	3 days	5 AA	5 AA	Prior suicide ingestions, one requiring laparotomy	<ul style="list-style-type: none"> <li>Diffuse abdominal discomfort without clinical evidence of obstruction at presentation</li> <li>Serial images tracked battery progression along the gut; by day 5 all batteries transited to the large bowel</li> <li>All batteries passed via rectum</li> </ul>
Cyrany et al, <sup>20</sup> 2014	1/Female	NR/NR	26 hours	1 A23	1 A23	NR	<ul style="list-style-type: none"> <li>No symptoms at presentation</li> <li>Battery extracted by endoscopy and polypectomy snare; two 10-15 mm ulcers on the front and back walls of the stomach; several small erosions in the greater curvature</li> <li>Subsequent course uneventful</li> </ul>
Hammad et al, <sup>21</sup> 2015	31/Male	NR/Yes	2 hours	5 AAA and 2 AA	5 AAA and 2 AA	NR	<ul style="list-style-type: none"> <li>No symptoms at presentation</li> <li>Abdominal series showed 7 cylindrical batteries</li> <li>First EGD, 2 batteries visualized; retrieved by Roth Net; no mucosal damage</li> <li>Next morning, patient had mild abdominal pain and mild epigastric tenderness</li> <li>Second EGD in 12 hours, 3 batteries in the gastric body with 3 deep gastric ulcerations (2 in the antrum and 1 in the incisura) and multiple gastric erosions; superficial duodenal mucosal erosions; 1 battery beyond the ligament of Treitz; 4 batteries retrieved by Roth Net; seal of the batteries eroded with evident leakage of chemical contents</li> <li>Final battery passed via rectum 3 days later</li> </ul>
Dunphy et al, <sup>22</sup> 2015	37/Male	NR/NR	7 hours	6 AA and 2 AAA	6 AA and 2 AAA	Emergent laparotomy 12 months earlier for retrieval of ingested batteries	<ul style="list-style-type: none"> <li>Generalized midabdominal pain and self-inflicted laceration of left antecubital fossa (using the metal casing from one battery) at presentation</li> <li>Batteries failed to pass with conservative management; patient developed small bowel obstruction</li> <li>All batteries retrieved via laparotomy; superficial mucosal necrosis but viable mucosa otherwise; active leak of contents from 2 batteries observed</li> </ul>
Kayipmaz et al, <sup>23</sup> 2016	83/Female	No/Yes	25 minutes	3 AAA	3 AAA	NR	<ul style="list-style-type: none"> <li>No symptoms at presentation</li> <li>Batteries removed endoscopically by snare and overtube; piece of paper removed from duodenum; 3-4 cm distal esophageal laceration; edematous, erythematous, and stained with hematin gastric mucosa around the batteries; superficial ulcer</li> <li>Patient/family refused further care and left AMA from ED</li> </ul>

Table. Continued

Case	Patient Age, years/Sex	Known Psychiatric Illness/Suicide Attempt	Interval Between Ingestion and Diagnosis		Number and Type of Batteries Ingested	History of Abdominal Surgery	Case Presentation, Course, and Outcome
			Yes/No	14 hours			
Tien and Tanwar, <sup>24</sup> 2017	17/Female	Yes/No	14 hours	2 AA and 1 AAA	Yes (removal of prior battery ingestion)	<ul style="list-style-type: none"> <li>Abdominal pain at presentation</li> <li>Abdominal x-ray showed 3 radiopaque structures (2 in epigastrium and 1 in right iliac fossa); urgent EGD removed 1 AA and 1 AAA batteries by Roth Net; gastric ulceration and gastritis; normal esophagus and duodenum</li> <li>Remaining battery (in distal small bowel) monitored conservatively with laxatives and abdominal x-ray; 2 days later, x-ray suggested impaction at IC valve</li> <li>Battery removed via ileocolonoscopy from the proximal right colon by Roth Net</li> </ul>	
Paparoupa and Bruns-Toepler, <sup>25</sup> 2017	30/Female	Yes/No	1 hour	4 button and 2 AAA	NR	<ul style="list-style-type: none"> <li>No symptoms at presentation; patient violent in ED; administered sedatives and intubated</li> <li>Urgent EGD removal of 2 button batteries from stomach</li> <li>Colon preparation initiated; 12 hours later, abdominal x-ray identified a cluster of batteries in right lower quadrant; followed by immediate colonoscopy; 4 batteries (2 button, 2 AAA) visualized in large bowel;</li> <li>3 removed with Dormia basket</li> <li>Fourth battery (AAA) moved into small bowel and retrieved from terminal ileum with endoscopic loop</li> </ul>	

AMA, against medical advice; CT, computed tomography; ECG, electrocardiogram; ED, emergency department; EGD, esophagogastroduodenoscopy; GI, gastrointestinal; IC, ileocecol; NR, no record.

In an interesting report of delayed symptom presentation after battery ingestion, an individual who intentionally ingested 2 pairs of batteries wrapped in plastic to help move drug packets along the GI tract sought medical attention 6 years later because he was setting off alarms at the airport and had started having heartburn and intermittent abdominal pain.<sup>15</sup> He had expelled all drug packets and 1 pair of batteries a few days after ingestion, but 1 battery packet was not expelled. Upper endoscopy revealed a pair of batteries wrapped in plastic in the stomach, no sign of leakage was seen, and the stomach looked intact. Endoscopic retrieval was unsuccessful because the plastic began to tear, but the batteries were retrieved laparoscopically.

Current guidelines only briefly address cylindrical battery ingestion. Overall, intact cylindrical batteries pose a low threat for caustic damage after ingestion, but because of their length (>2.5 cm) they may become entrapped in the stomach in children and adults. The recommendation for retrieval of this battery type includes situations in which (1) the battery has remained in the stomach more than 48 hours, (2) the patient develops signs of injury to the GI tract, or (3) evidence indicates that the battery had an encasement defect prior to ingestion.<sup>1</sup>

In our case, the batteries were in the patient's stomach beyond the recommended 48-hour observation period. However, he remained asymptomatic, and no evidence indicated that the batteries were damaged or eroded. Based on our case and review of the literature, we conclude that if cylindrical battery swallowing is not accompanied by abdominal symptoms or abnormal physical examination findings, the battery cases were not damaged prior to ingestion, and the batteries are beyond retrieval with esophagogastroduodenoscopy, cylindrical battery ingestion can be managed conservatively with the aid of radiologic imaging, regardless of the timing of the observation period. Our case demonstrates that conservative management with close clinical monitoring is possible in a hospital setting.

Nonurgent upper endoscopy may be considered if the batteries are within reach of an upper endoscope. If upper endoscopic retrieval is not feasible, clinical monitoring and following battery progression through the GI tract with serial abdominal radiographs until batteries are discharged via the rectum can be achieved. However, in cases of prior abdominal surgery, history or evidence of damage to the battery, or any clinical symptoms, prompt endoscopy and battery retrieval are indicated. If retrieval fails, surgical consultation should be done for those cases.

Given the complexity of cylindrical battery ingestion, the lack of data on this subject, and the large variety of cylindrical batteries available, more reviews and specific guidelines on this topic seem indicated. In our review of the cases, most ingested cylindrical batteries were the AA and AAA type. However, other cylindrical battery shapes and sizes (ie, N, C, and AAAA, some of which resemble button batteries) may warrant different guidelines.

## CONCLUSION

Cylindrical battery ingestions are less common than button batteries, and data on the outcomes of these ingestions are limited. Based on our case and review of the literature, we conclude that if cylindrical battery swallowing is not accompanied by abdominal symptoms or abnormal physical exam-

ination findings, the battery cases were not damaged prior to ingestion, and the batteries are beyond retrieval with esophagogastroduodenoscopy, cylindrical battery ingestion can be managed conservatively with the aid of radiologic imaging. However, in the presence of prior abdominal surgery, history or evidence of damage to the battery, or any clinical symptoms, prompt endoscopy and battery retrieval should be done. If this is not possible, then surgical consultation should be done for those cases.

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