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ORIGINAL ARTICLE

Disc battery ingestion in paediatric age

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Abstract

Aim: The aim of the present study was to analyse clinical data of children referred for disc battery ingestion in order to assess short- and long-term reported injuries and to identify outcome predictors and trends, define the urgency of intervention and refine treatment guidelines.

Methods: The records of all children admitted to Santobono-Pausilipon Children's Hospital, Naples, Italy for disc battery ingestion from January 2016 to December 2020 were retrospectively reviewed. Odds ratio were computed to assess the association between the different study variables and the rate of complications.

Results: We enrolled 118 children. Mild to major complications related to the ingested disc batteries were reported in 12/118 (10.2%) patients. Disc battery oesophageal retention, disc battery diameter >20 mm, together with age below 1 year and symptomatic presentation were the most important factors associated with poor clinical outcome.

Conclusion: Our data confirm that ingested disc batteries are a serious health hazard and require a timely and qualified medical evaluation. We have identified three predictors of outcome severity: oesophageal retention, large-diameter cells and symptom onset. Disc batteries lodged beyond the oesophagus appear substantially harmless and we may support a more conservative approach.

KEYWORDS
disc batteries, endoscopic removal, oesophageal mucosal injury, site retention

1 | BACKGROUND

Among foreign body ingestions, disc battery ingestion is the most challenging clinical scenario. Despite industry progress in creating more secure battery compartments and making hazard warnings visible, cases of major morbidity and mortality continue to be reported.[1–5]

Given their local corrosive power, disc batteries pose an imminent health threat when ingested. Once retained in the gastrointestinal tract, they can shortly create a full-thickness erosion. Indeed, serious complications have been widely reported, including tracheoesophageal fistulas, fistulisation with periesophageal/thoracic vessels, exsanguination and even death. Possible long-term sequalae include oesophageal obstruction, tissue damage and stricture.[6]

The oesophagus has anatomically narrowed regions with increased likelihood of disc battery impaction, the most common being the area at the thoracic inlet.[7] If a disc battery is lodged in the oesophagus, it can cause initial tissue damage in only 15 min.[8,9] The mechanism of injury in these patients is primarily related to the generation of hydroxide radicals in the mucosa, resulting in a caustic

Abbreviations: CT, computed tomography; EGD, esophagogastroduodenoscopy; GI, gastrointestinal.

injury from high pH, instead of an electrical-thermal injury. The high degree of morbidity and mortality that has been observed with disc battery ingestions in children has led to renewed focus to determine the optimal management of these children.

Current international guidelines recommend to emergently (<2 h) remove disc batteries impacted in the oesophagus, further providing postremoval adequate management, in order to prevent possible dramatic complications. When disc batteries are retained in the stomach, endoscopic intervention is currently controversial. To date, very few fatalities have been reported in children with gastric disc batteries. In these cases, the cause of death was likely linked to oesophageal injury that occurred from the disc battery in transit. Gastric necrosis of uncertain clinical significance has also been reported by disc battery within the stomach in asymptomatic children.[10–13] Therefore, recommendations about the need and optimal timing for a prompt endoscopic removal of gastric disc batteries currently differ among different guidelines, leaving some discretion to the clinician regarding the appropriate management. Clinical presentation, age of the child, battery size and delayed diagnosis have been proposed as possible factors to be taken into account to drive the management.[3,14]

To date, no significant clinical data have been reported about disc battery ingestion except from raw data extrapolated from national registers.[1] Therefore, the principal aim of the present study was to analyse clinical data of children referred in the last 5 years to our tertiary paediatric centre for disc battery ingestion in order to assess short- and long-term reported injuries and to identify outcome predictors and trends, define the urgency of intervention and refine treatment guidelines.

Key Notes

- Despite industry progress in creating more secure battery compartments and making hazard warnings visible, morbidity and mortality continue to be reported.
- Our data confirm that ingested disc batteries are a serious health hazard and require a timely and qualified medical evaluation.
- We identified three main predictors of outcome severity: disc battery oesophageal retention, large-diameter cells and symptom onset.

2 | METHODS

The records of all children aged 0–14 years admitted for disc battery ingestion at the Santobono-Pausilipon Children's Hospital in Naples from January 2016 to December 2020 were retrospectively reviewed. No exclusion criteria were considered, except for the age range.

Data were systematically collected for all enrolled patients by medical chart review. Demographic and clinical data included the following: age, sex, pre-existing congenital or acquired diseases, ingestion modalities and possible signs and symptoms at admission. Moreover, we collected the results of the diagnostic imaging tests performed to detect the disc battery location along with laboratory tests, when available, and of esophagogastroduodenoscopy, eventually carried out for disc battery removal. Information about the nature and size of the ingested disc battery were registered, as well. Finally, short- and long-term (1- to 5-year follow-up) clinical outcomes were recorded for each patient.

Study data were entered into Excel spreadsheets (Microsoft Inc.) and analysed with GraphPad PRISM software 5.1 (GraphPad Software Inc.) and R 3.6.0 software environment for statistical computing. Quantitative variables were expressed as mean ± standard deviation while frequencies and percentages were used for categorical variables. Statistical analyses were performed by using the $X2$ test or the Fisher exact test, as appropriate, in order to analyse the difference in clinical presentation (symptomatic vs. asymptomatic). Odds ratio was computed to assess the association between the different study variables and the rate of complications. A p value of ≤0.05 was considered significant and odds ratio was calculated with a 95% confidence interval. All statistical analysis was performed using R software environment for statistical computing. The study was approved by the "Cardarelli-Santobono" Independent Ethics Committee and was conducted in accordance with the Declaration of Helsinki and Guidelines for Good Clinical Practice. In full compliance with the current privacy regulation, personal patient demographic data were not recorded.

3 | RESULTS

Over the study period 118 children were admitted for disc battery ingestion (M/F: 63/55; age range: 11–120 months; mean age ± standard deviation: 52.5 ± 26 months). Of these, 2/118 (1.7%) were infants, 30/118 (25.4%) were toddlers (1–3 years), 48/118 (40.7%) were preschool age children (3–5 years) and 38/118 (32.2%) were school age children (5–12 years) (Figure 1). Six/118 (5.1%) patients were affected by already known chronic diseases (3 by asthma, 2 by autism spectrum disorder and 1 by chronic nephropathy).

All ingestions were reported as accidental and all but two were witnessed or at least suspected by parents. At admission, only 8/118 (6.8%) patients were symptomatic: 5 complained of thoracic/abdominal pain, 2 of nausea and 1 of cough. The remaining 110/118 (93.2%) patients were asymptomatic.

A neck-chest-abdominal X-ray was performed in all patients to assess the disc battery presence and its retention site. Twelve/118 (10.2%) disc batteries were retained in oesophagus, 62/118 (52.5%) were retained in stomach and 44/118 (37.3%) in duodenum or beyond. Thirty/118 (25.4%) ingested disc batteries had a diameter >20 mm, whereas the remaining 88/128 (74.6%) had a diameter <20 mm. According to the latest national and international guideline

FIGURE 1 Number of DBs ingestions per age of the studied children

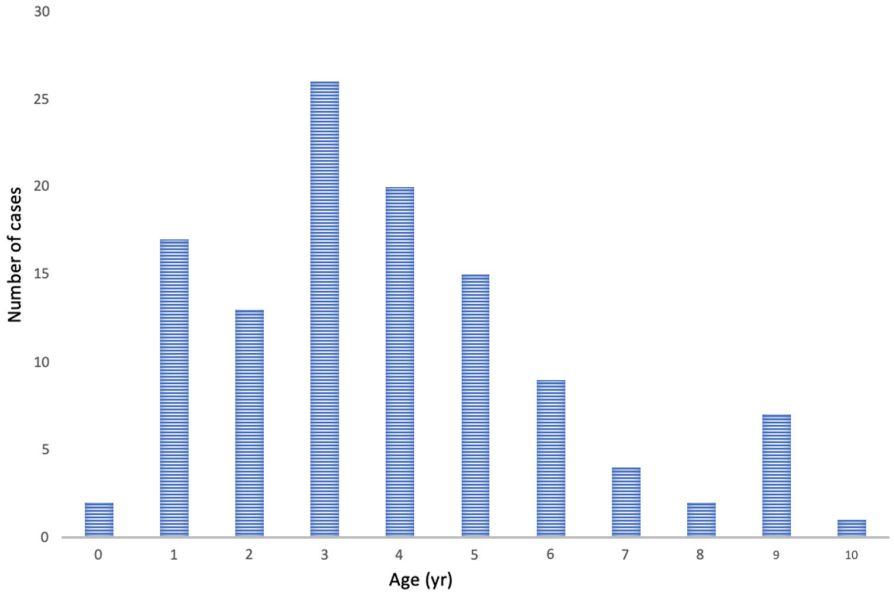

TABLE 1 Details of clinical cases of children with oesophageal disc battery retention

Age, months	Sex	Disc battery diameter	Site of impaction	Clinical presentation	Oesophageal mucosal lesions	Outcome
52	M	<20 mm	Proximal oesophagus	Asymptomatic	No	Full recovery
78	F	>20 mm	Proximal oesophagus	Asymptomatic	Mucosal necrosis	Oesophageal stenosis
71	F	>20 mm	Proximal oesophagus	Asymptomatic	Mucosal hyperaemia	Full recovery
108	F	>20 mm	Middle oesophagus	Chest pain, nausea	Mucosal hyperaemia	Full recovery
78	M	>20 mm	Proximal oesophagus	Asymptomatic	Mucosal necrosis	Full recovery
17	M	>20 mm	Proximal oesophagus	Asymptomatic	Mucosal necrosis	Full recovery
61	M	>20 mm	Distal oesophagus	Chest pain	Mucosal necrosis	Full recovery
93	M	>20 mm	Middle oesophagus	Asymptomatic	Mucosal necrosis	Oesophageal stenosis
11	F	>20 mm	Proximal oesophagus	Asymptomatic	Mucosal necrosis	Full recovery
25	M	>20 mm	Proximal oesophagus	Asymptomatic	Mucosal hyperaemia	Oesophageal stenosis
64	F	>20 mm	Distal oesophagus	Asymptomatic	Mucosal hyperaemia	Full recovery
12	M	>20 mm	Proximal oesophagus	Asymptomatic	Mucosal hyperaemia	Full recovery

recommendations, endoscopic removal of oesophageal disc batteries was performed immediately, while gastric disc batteries were promptly removed whenever the patients were symptomatic and/or in case the disc battery's diameter was >20 mm and the child <5 years of age. The remaining children were followed up by repeated X-rays and endoscopic removal was performed if developing GI symptoms or not passing stomach by 48 h. A variety of retrieval devices were used, including alligator and rat-tooth forceps and retrieval net or basket. No serious adverse events linked to the endoscopic or anaesthetic procedure were reported. Patients with intestinal retained disc batteries were followed-up until expulsion. Among these, 1/44 (2.3%) underwent surgical removal of the disc battery due to intestinal perforation while in the remaining 43/44 (97.7%) spontaneous passage and expulsion were observed.

Mild to major complications related to the ingested disc batteries were reported in 12/118 (10.2%) patients, 11 of which linked to oesophageal retained disc batteries. Fortunately, no fatality occurred.

Children with oesophageal retained disc battery were 7 boys and 5 girls (mean age 72.4 ± 18.4 months, range 30–108 months). The complete list, along with patients' data and clinical details, is reported in Table 1. Three/12 (25%) children were symptomatic (thoracic pain, epigastric pain, nausea). The remaining 8/12 (75%) children showed no sign or symptoms related to the ingestion. All disc batteries were easily detected through neck-chest-abdominal X-ray.

EGD was performed within 1–2 h from the arrival in the Emergency Department, yet the median time elapsed between ingestion and removal was 4 h (range 2–48 h). Disc battery endoscopic removal was successfully completed in all patients. Eleven/12 (91.7%) disc batteries had a diameter >20 mm, whereas only 1/12 (8.3%) had a diameter <20 mm. Oesophageal mucosal injury was reported in 11/12 (91.7%) children. Of these, 6/12 (50%) showed tissue necrosis while 5/12 (41.7%) a variable degree of mucosal hyperaemia. One/12 (8.3%) patient reported aortic wall oedema associated with the oesophageal mucosal injury, diagnosed by CT scan performed after endoscopy. At 1-year follow-up, 3/12 (25%) children still suffered from dysphagia due to a variable degree of oesophageal stenosis.

Children with disc batteries retained in stomach were 29 boys and 33 girls (mean age 52.2 ± 25.5 months, range 12–120 months). Among them, only 3/62 (4.8%) were symptomatic (abdominal pain, cough) at admission whereas 59/62 (95.2%) were not. Forty-two/62 (67.7%) gastric disc batteries were readily detected through neck-chest-abdominal X-ray through the halo or double ring sign while in the remaining cases the disc battery ingestion was reported by parents. A total of 10/62 (16.1%) children underwent upper GI endoscopy, out of which 6/10 (60%) were found to have evidence of variable gastric mucosal injury and 4/10 (40%) no gastric mucosal injury. None of them showed oesophageal mucosal lesions. Moreover, at 1- and 6-month follow-up visit none of them reported having complained of GI symptoms.

Finally, children with intestinal disc battery retention were 27 boys and 17 girls (mean age 50.4 ± 26 months, range 11–108 months). Among them, only 2/44 (4.5%) were symptomatic (abdominal pain) at admission whereas 42/44 (95.5%) were not. Only 10/44 (22.7%) disc batteries had a diameter >20 mm, whereas the remaining 34/44 (77.3%) had a diameter <20 mm. No children underwent endoscopic removal, while all were followed-up until disc battery expulsion. Unfortunately, 1/44 (2.3%) child (boy, 108 months old, disc battery diameter >20 mm) underwent disc battery surgical removal due to lack of intestinal progression.

The overall mean time between disc battery accidental ingestion and rectal expulsion (whenever not endoscopically removed) was 29 ± 18 h. Chronic constipated children were given faecal softeners in order to fasten the disc battery transit.

Correlation among disc battery diameter, disc battery retention site, child's age and clinical outcome is shown in Table 2. Logistic regression was used to identify disc battery ingestion outcome predictors. Disc battery oesophageal retention, disc battery diameter >20 mm, together with infantile age range and symptomatic presentation were the most important factors associated with poor clinical outcome.

TABLE 2 Rate of mild to major complications according to disc battery diameter, disc battery retention site, age range and clinical presentation

	Rate of complications	OR (95% CI)	*p*value
Disc battery diameter			
<20 mm	1/88 (1.1%)	-	-
>20 mm	11/30 (36.7%)	48.2 (6.3; 2163)	<0.001
Disc battery retention site			
Oesophagus	11/12 (91.7%)	701(53; ∞)	<0.001
Stomach	0/62 (0%)	0 (0; 0.26)	<0.001
Duodenum or beyond	1/44 (2.3%)	0.13 (0.01; 0.99)	0.03
Age range			
Infants	1/2 (50%)	9.2 (0.11; 750)	0.194
Toddlers	2/30 (6.7%)	0.56 (0.6; 2.9)	0.728
Preschool age	1/48 (2.1%)	0.12 (0.01; 0.85)	0.026
School age	8/38 (21%)	5.0 (1.22; 24.4)	0.018
Clinical presentation			
Symptomatic presentation	3/12 (25%)	6.5 (0.88; 40.7)	0.034
Asymptomatic presentation	5/106 (4.7%)	-	-

Note: The risk of complications for each variable was evaluated using odds ratio and related 95% confidence interval.

4 | DISCUSSION

Our data confirm that disc battery ingestion is a current health issue, with about 10% of children ingesting disc batteries reporting a variable degree of mucosal injury. We identified 3 significant outcome predictors: oesophageal retention, large-diameter cells and symptom onset.

Of 12 severe outcome cases, 11 (91.7%) involved disc battery retained in the oesophagus. According to our data, oesophageal disc batteries were 97.6 time more likely to be associated with clinically significant outcomes compared with disc batteries retained anywhere else in the digestive tract. This finding was widely expected and strengthens a large body of scientific evidence already available. Almost all of the major effects worldwide reported so far involved oesophageal disc battery injuries.[3] Impaction at this site represents the highest risk for injury since the oesophagus is the only anatomical site that allows the battery to tightly adhere to 2 mucosal layers, thus inducing the passage of direct low voltage electric flow. As a result, oesophageal disc batteries have emerged as the most critical indication for emergent endoscopy in children.

Large-diameter disc batteries (>20 mm) accounted for all but one severe outcome cases befallen. According to our data, large-diameter disc batteries were 33.4 time more likely to be associated with clinically significant outcome cases compared with small-diameter disc batteries (<20 mm). A similar finding was recently reported and may be easily explained since the larger diameter results in increased likelihood of oesophageal impaction and consequent mucosal injury.[1]

Disc battery retention site and diameter are promptly available parameters which drive the management of these children. In our series, a neck-chest-abdominal X-ray was always able to assess the presence of the disc battery, with an accurate image inspection, avoiding the possible confusion with coins when there was no direct witnessing. Radiographs usually overestimate battery diameter unless magnification is corrected, therefore, the actual diameter should be obtained with the help of radiologists.

Clinical presentation of children ingesting disc batteries was mainly silent, with few children complaining of thoracic pain and nausea related to the retained disc battery. Nevertheless, a symptomatic clinical presentation was significantly related to the subsequent onset of complications. According to our data, children complaining of any symptoms related to disc battery ingestion were 5.3 times more likely to report severe outcome compared with asymptomatic children. Therefore, although rare, symptoms related to disc battery ingestion should always be considered as red flags for a worst outcome since the onset of symptoms (thoracic pain, nausea) could be related to initial oesophageal mucosal injury (in children able to adequately verbalise). To date, no similar finding was reported. Indeed, main guideline recommendations focus on the rare occurrence of active or "sentinel" (acute anaemia, hemodynamic instability) bleeding, which requires a more invasive management including the evaluation by vascular surgeons and an eventual exploratory thoracotomy followed by an intraoperative endoscopy in order to evaluate oesophageal lesions before removing the disc battery.[1,2]

Age was an important predictor of severity as well, being infantile and school-age range significantly related with worst outcome. While in infants the reason probably lies in the smaller size of the oesophagus, in school-age children the higher frequency of larger diameter disc battery ingestion probably plays the major role.

Our data provide scientific evidence contributing to the current controversial about the need and optimal timing for a prompt endoscopic removal of gastric retained disc batteries. Once spontaneously passed through the oesophagus, the need for disc battery removal from the stomach may be linked to the assessment and treatment of a very unlikely but potentially dramatic transit oesophageal damage or to prevent possible injuries during gastric and intestinal crossing. Overall, about half of the ingested disc batteries we have reported were retained in the stomach at the time of first evaluation, raising the issue about the optimal clinical management. Only 5% of children with gastric retained disc batteries showed related symptoms. According to the current international guideline recommendations, one out of six patients underwent endoscopic removal among which just over half had a variable degree of gastric mucosal injury of poor clinical significance. None of them showed oesophageal mucosal lesions and no one reported gastric symptoms at follow-up.

According to our experience, we may support a less invasive approach with a wait and see strategy that could avoid unnecessary invasive procedures. The recommendation about the need for endoscopic intervention should take into account the reported occurrence of few fatalities in children with disc batteries diagnosed beyond the oesophagus, very likely linked to oesophageal injury caused by disc batteries before reaching the stomach.[15] Unfortunately, this suggests that passage of a disc battery to the stomach alone cannot be used as a criterion that the child is free from potentially catastrophic underlying injury. Therefore, the onset of possible disc battery-related symptoms, active or sentinel bleeding, multiple disc battery ingestion or magnet co-ingestion, should always imply the need for a prompt endoscopic removal and assessment of a possible oesophageal mucosal injury. Conversely, in asymptomatic children with a single gastric retained disc battery in our opinion a timely endoscopic intervention may be considered only in the concomitant eventuality of early age child, large ingested battery size and long time elapsed since ingestion. However, factors supporting observation alone, without endoscopic removal of gastric batteries, are confirmed short time elapsed since ingestion (<4 h), battery diameter <20 mm, the absence of clinical symptoms and a child 5 years of age or older.

Our data have some acknowledged limitation, mainly including the lack of data concerning disc battery chemistry and discharge state which has been reported being able to possibly affect the outcome. Indeed, lithium disc batteries and new cells are more likely associated with the development of mucosal injury.

In conclusion, we have reported one of the largest paediatric case series of disc battery ingestions. Our data confirm that ingested disc batteries are a serious health hazard and require a timely and qualified medical evaluation. By a thorough data analysis, we have identified 3 predictors of outcome severity: oesophageal retention, large-diameter cells and symptom onset. In order to prevent life-threatening complications, it is worldwide acknowledged that oesophageal retained disc batteries have to be emergently removed. Less agreement exists on the management of gastric retained disc batteries. Our data showed a substantial harmlessness of batteries lodged in the stomach. Thus, we may support a more conservative approach, except should symptoms develop, should multiple disc batteries ingestion or a magnet co-ingestion occur, or in the concomitant eventuality of early age child, large ingested battery size and long time elapsed since ingestion.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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