International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Button Battery Ingestion in Children - A Tertiary Center Experience in Endoscopic Management and a Brief Review of the Literature

Uma Devi Malladi M. D, D. M[1], Suraj Kumar Chimata M. D[2], Ramesh Kumar Bhashyakarla M. D, D. M[3], Sahitya Reddy Lingampally M. D, D. M[4], Vikas Reddy Venkannagari M. D[5], Rithwik Chandra Chanda M. D[6], Sai Kumar Pippiri M. D[7]

[1]Professor and Head of the Department, Department of Medical Gastroenterology, Osmania General Hospital, Hyderabad
Email: *umadevimalladi_66[at]yahoo.co.in*
ORCID id: 0000 - 0001 - 7800 – 3333

[2]Postgraduate in Gastroenterology, Department of Medical Gastroenterology, Osmania General Hospital, Hyderabad
Corresponding Author Email: *surajkumarcsk6[at]gmail.com*
ORCID id: 0009 - 0004 - 9261 – 0574

[3]Professor, Department of Medical Gastroenterology, Osmania General Hospital, Hyderabad
Email: *bhashyakarla_rk[at]yahoo.co.in*

[4]Assistant Professor, Department of Medical Gastroenterology, Osmania General Hospital, Hyderabad
Email: *sahityareddy21[at]gmail.com*

[5]Postgraduate in Gastroenterology, Department of Medical Gastroenterology, Osmania General Hospital, Hyderabad
Email: *vikas.venkannagari[at]gmail.com*
ORCID id: 0009 - 0000 – 7664

[6]Postgraduate in Gastroenterology, Department of Medical Gastroenterology, Osmania General Hospital, Hyderabad
Email: *rithu24rithwik[at]gmail.com*
ORCID id: 0009 - 0009 - 7569 - 8996s

[7]Postgraduate in Gastroenterology, Department of Medical Gastroenterology, Osmania General Hospital, Hyderabad
Email: *pippirisaikumar[at]gmail.com*

Running Title: *Button battery ingestion in children*

Abstract: ***Background*: Button battery ingestion is an emerging hazard due to its use in toys and easy accessibility, posing unique challenges in the pediatric population. *Clinical Description*: Young children often present with non - specific symptoms, making diagnosis difficult. Common symptoms include drooling, coughing, chest pain, fever, and hematemesis. *Management*: Radiographs are essential for diagnosis. While ingestion of honey and sucralfate may reduce injury severity, outcomes have worsened recently, with a significant increase in major or fatal cases. *Conclusions*: The increased battery size and capacitance are linked to more serious complications. Multi - disciplinary management is crucial for reducing mortality and long - term complications.***

Keywords: Button battery, Coagulative necrosis, Double Halo sign, Lithium battery, Sucralfate

1. Introduction

Button batteries are round, flat batteries named for resembling the button on clothing. They are sometimes referred to as disc batteries or coin cells which are used in watches, calculators, toys, small electronic devices, musical greeting cards, and hearing aids. It is a unique foreign body emergency that requires timely removal. Button battery ingestions (BBI) account for 2% of all foreign body ingestions in children [1]. Between 1999 and 2019 The United States National Poison Data System reported a 66.7% increase in yearly ingestion of button batteries and a 10 - fold increase in complications (0.77% to 7.53%) [2]. The dangers associated with BBI have been recognized for decades but have been evolving in recent years. Although batteries may pass through the gastrointestinal tract uneventfully, they can cause severe or even fatal complications, especially in younger children if lodged in the esophagus. Mucosal ulcerations, perforation, and fistula formation are the possible complications of the impacted button battery. If the button battery causes erosion into adjacent major blood vessels, then the outcome is mostly fatal.

Clinical Description of Cases

We report here a series of eight cases of BBI in children seen over 4 years (2018 to 2022) (details are mentioned below in Table 1). The mean age at presentation is 4 years and 3 months. All of the batteries retrieved were Lithium - ion based. We had successfully removed the button battery in all of them, and three were removed from the stomach while five of them were removed from the esophagus. The mean diameter of the battery was 10mm with a range of 5 - 15mm. The average duration of presentation to us after ingestion of the battery is 18 hours. The average time taken to intervene

from the point of ingestion of the battery is 40 hours. Two cases had the battery impacted in the post - cricoid region and upper esophagus respectively, one of them had it impacted in the mid esophagus and three of them had the foreign body lodged in the stomach. Rat - toothed forceps were used in 5 cases where it was lodged in the esophagus and a Roth net was used in 3 cases for retrieval from the stomach.

Table 1: Details of children with button battery ingestion managed at our center

Age/Gender	Diagnosis (in hours)	Time to intervention (in hours)	Anatomic location	Used/ Unused battery	Diameter of the battery (in mm)	Severity of Injury	Endoscopic accessory used for retrieval	Immediate Outcome	Complications on follow - up
4 years/Male	12	36	Upper esophagus – 15cms from incisors	Unused	15mm	Non - circumferential ulceration with white Eschar	Rat Toothed forceps	Good	None
4 years/Male	24	36	Stomach - Antrum	Used	10mm	Hyperemia and multiple superficial ulcers	Roth Net	Good	None
3 years/Male	12	24	Upper esophagus - 12cms from incisors	Unused	15mm	Few erosions superficial ulcerations	Rat Toothed forceps	Good	None
6 months/Male	1	12	Post Cricoid	Used	10mm	No mucosal Injury	Roth Net	Good	None
10 years/Male	12	48	Post Cricoid	Used	10mm	Few superficial ulcerations	Rat Toothed Forceps	Dysphagia - 1week	None
5 years/Female	12	72	Mid - esophagus - 18cms from incisors	Used	10mm	Deep ulcerations and sloughing Escher	Rat Toothed forceps	Dysphagia, Respiratory distress	None
3.5 years/Male	12	20	Stomach - Proximal part of the body of the stomach	Used	5mm	Hyperemia and erosions	Roth net	Abdominal pain	None
4 years/Female	60hrs	72hrs	Stomach - Proximal part of the body of the stomach	Used	5mm	Large gastric ulcers with adherent clots	Passed spontaneously	Upper GI bleed	None

Figure 1: Pictures demonstrating the endoscopic image of case 1 (4 - year male child with BBI) - large non - circumferential ulceration with overlying whitish eschar noted in the esophagus on the left, and the image of the extracted button battery on the right.

2. Discussion

Disk batteries are formed by compacting metals and metal oxides on either side of an electrolyte - soaked separator as depicted in Figure 2. The unit is then placed in a 2 - part metal casing held together by a plastic grommet. The grommet electrically insulates the anode from the cathode. The metal undergoes oxidation on one side of the separator, while the metal oxide is reduced to the metal on the other side, producing a current when a conductive path is provided. Disk batteries contain mercury, silver, zinc, manganese, cadmium, lithium, sulfur oxide, copper, brass, or steel. These are the components of the anode, cathode, and case containing the battery. Disk batteries also contain sodium hydroxide or potassium hydroxide to facilitate the electrochemical reaction through the separator. The negative terminal (anode) is the narrow portion of the battery where the electric current flows into the tissue and usually creates the most damage.

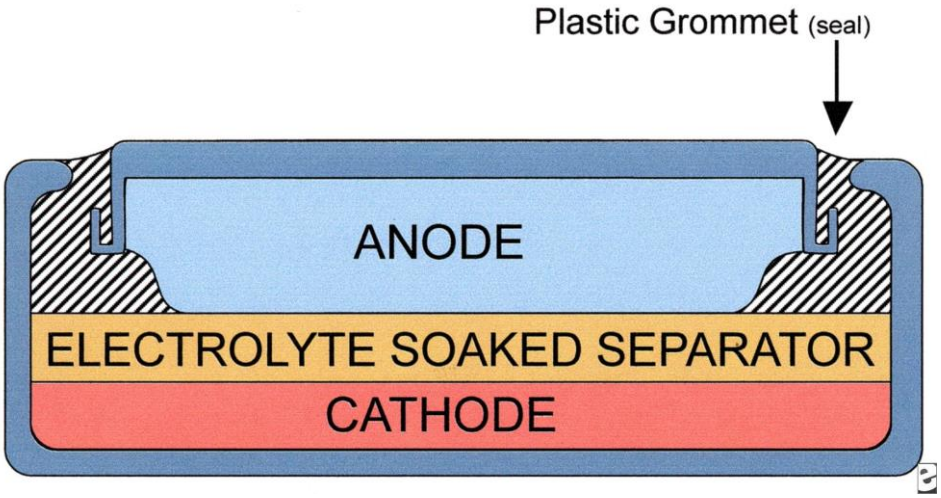

Figure 2: Cross - sectional image of a typical button battery depicting the components

The chemical content, diameter, and height of the battery can be determined from the imprinted code found on the battery case as determined by the International Electrotechnical Commission. The first letters in the code give the identification of the chemical composition of the positive terminal (cathode) of the battery (e. g., CR indicates Lithium/manganese dioxide; S indicates silver oxide). A battery with a four - number code has the diameter given by the first two numbers (e. g., CR2032 is 20 mm in diameter). The last two numbers give the battery height in tenths of millimeters (e. g., CR2032 is 3.2 mm in height). Mentioned below is Figure 3 which demonstrates the positive (cathode) and negative (anode) poles of the button battery

Figure 3: Image showing the positive and negative pole of the button battery. The flat surface of the positive battery pole (black arrow) is on the left. The negative battery pole (white arrow) is shown on the right with a step - up to the narrower flat surface

Litovitz et al described in series of 56, 535 battery ingestions from 1985 - 2009 in which the type of battery was known in 57.7% of the cases, 42% were manganese dioxide, 32% were zinc - air, 13% were silver oxide, and 9% were lithium (up from 1.3% in 1900 - 1993) [3]. In 2008, 24% of the batteries ingested were lithium cells; an upward trend that started in the late 1990s with a corresponding drop in the number of mercuric oxide cells.

Button batteries that become lodged in the mucosa of the gastrointestinal (GI) tract cause caustic injury, mucosal ulceration, and, if impacted long enough, cause perforation. The severity of esophageal damage after button battery ingestion depends upon the length of time that the battery is lodged in place, the amount of electrical charge remaining, and the size of the battery. Damage to the esophagus may be seen as early as two hours after ingestion, with more severe damage after 8 to 12 hours [4]. As the duration of impaction increases, the mucosa becomes edematous and the battery adheres tightly to the mucosa. If the battery remains in place, ulceration and perforation can occur.

Mechanisms of injury from battery ingestion include electrical discharge, pressure necrosis, and leakage of battery contents (such as the alkaline substances causing liquefactive necrosis, and absorption of heavy metals from broken or fragmented batteries causing injury), each of which contributes to corrosive damage when the battery is in contact with a mucosal surface for a sufficient period [5]. Electrical discharge seems to be the predominant mechanism of the injury and even discharged batteries retain enough voltage and storage capability to generate an external current. Thus, ingestion of "dead" button batteries is still a major concern.

In a PubMed literature review of 31 publications on BBI from 1995 - 2015 by Ágnes Varga et al [6], 136, 191 patients from 4 months to 19 years old were included of which 75% were aged <6 years. In 6262, the diameter of the battery was documented. Batteries of 20 mm or greater in size were more prone to complications (n = 226). Ulceration or perforation of the gastrointestinal tract was found to be the most frequent. There were 61 fatal outcomes reported due to massive hemorrhage because of fistula formation to the great vessels or suffocation secondary to aspiration of blood and bronchopneumonia. Rare complications were also reported, such as bilateral vocal cord palsy or spondylodiscitis. About the anatomy, BBI caused complications mainly in the esophagus (38.94%), stomach (7.08%), small intestine (1.33%), and pharynx (0.88%); however, the nasal cavity (15.93%) led the list in the respiratory manifestation, followed by trachea (0.44%). The time required for passing the battery with stool spontaneously was documented only in 4903 patients of which three - quarters of the ingested batteries passed spontaneously within 4 days. Table 2 mentioned below depicts the various complications associated with BBI.

Table 2: List of possible complications with button battery ingestion

RESPIRATORY TRACT	GASTROINTESTINAL TRACT	OTHERS
Nasal septal perforation	Esophageal perforation	Aortoesophageal or other major arterial branch fistula
Intranasal synechiae	Esophageal stenosis	Massive hemorrhage
Tympanic membrane perforation	Stomach perforation	Mediastinitis
Facial nerve paralysis	Small intestine perforation	Spondylodiscitis
Recurrent laryngeal nerve injury		Periorbital cellulitis
Thyroid hemorrhage		
Tracheoesophageal fistula		
Battery aspiration		
Pulmonary hemorrhage		
Bronchial stenosis		
Pneumonia		

Symptoms vary and can be non - specific in children. Drooling of saliva, coughing, pain in the chest and abdomen, fever, hematemesis, and change in voice are encountered in BBI. In healthy toddlers with acute onset of severe hematemesis, BBI should be suspected [7].

Two views of radiographs should be taken immediately, anteroposterior and lateral views of the neck, and chest with anteroposterior view of the abdomen and pelvis. The cardinal signs of a button battery are a double ring/double rim in AP view and a step - off bilaminar appearance in a lateral view, to distinguish it from a coin which has a single ring and a more uniform appearance. The negative terminal side of the battery is also narrower when viewed laterally [8]. These findings may also aid in determining the likely risk of complications if esophageal erosion were to occur by noting the level of the battery in the esophagus and its orientation. The “3 Ns” mnemonic (negative, narrow, necrotic) may be useful in anticipating potential risk since the negative pole is the narrow side of the battery on the lateral radiograph where an increase in local pH and tissue necrosis is most likely to occur. [9] For example, if a button battery is located in the proximal esophagus with the negative pole facing anteriorly toward the adjacent trachea, there is a greater risk of developing a tracheoesophageal fistula. It is also important to note that a button battery under the diaphragm does not exclude transient impaction in the esophagus. Figure 4 mentioned below describes the characteristic radiographic findings in patients with BBI

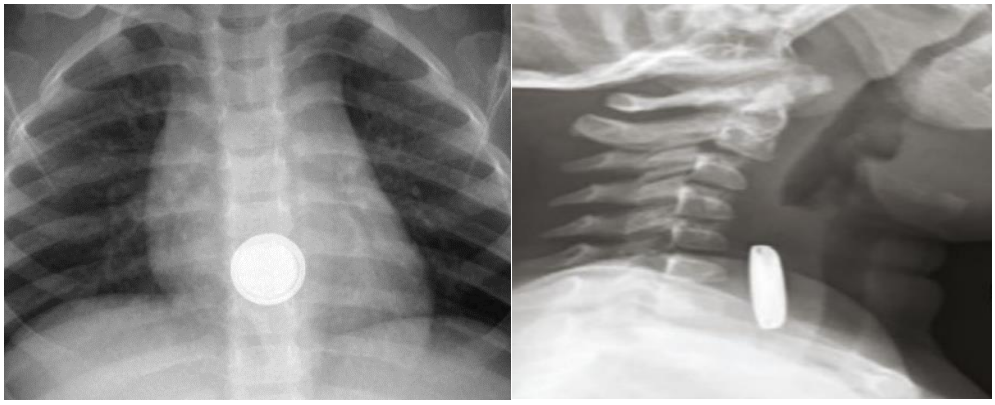

Figure 4: X - ray taken in anteroposterior view which suggests the presence of a button battery in the lower esophagus as indicated by the “Halo sign” (left - sided image) and X - ray taken in lateral view suggestive of the “Step - off sign” which indicates the presence of a button battery likely in the post - cricoid area (right - sided image)

Multidisciplinary involvement between physician/pediatrician and otolaryngologist, gastroenterologist, and emergency physicians is recommended to assist in expediting transfer and management. While delays to surgical removal result in worse outcomes, prehospital management guidelines have changed to mitigate the injury. Ingestion of honey and sucralfate may have a role in reducing the severity of the injury. Animal studies have shown that these treatments result in fewer full - thickness injuries. Honey can be administered before the patient reaches the hospital. Sucralfate can be initiated when in the hospital and within 12 hours of ingestion to mitigate tissue injury while waiting for possible definite management. Honey can be given as 10 ml every 10 minutes for children >1yr (with a maximum of 6 doses) while sucralfate can be given as 1 gram every 10 minutes (with a maximum of 3 doses) [10]. Use of 50 - 150 ml of 0.25% acetic acid irrigation after BBI reduces injury. Patients should otherwise be kept nil per os. Sucralfate is preferred in children less than 1 year of age as honey carries a risk of botulism. Another exception to the administration of honey in BBI apart from age <1 year is the duration of BBI which is more than 12 hours (due to the higher risk of esophageal perforation).

The injury - free window in which a button battery can be removed with no or minimal complications is <2 hours [11]. In animal studies, perforation was seen after 12 hours [12]. It is thought that the alkaline liquefaction necrosis continues to occur hours after the battery has been removed. Although mucosal damage can occur within 2 hours after ingestion, development of complications such as perforation can occur within 2 days though it is rare before 12 hours. Fistulas can develop up to 4 weeks after ingestion. Immediate and long - term respiratory tract complications are also described with BBI. Recurrent laryngeal nerve Injury, spondylodiscitis, and esophageal stricture may take weeks and months after BBI.

Immediate localization of the button battery is important, and the Endoscopy Committee of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition NASPGHAN recommends endoscopic assessment and removal in certain cases of BBI where the battery lies beyond the esophagus [13]. This procedure should be performed under general anesthesia after intubation of the patient thereby protecting the airway during the procedure. During endoscopy, the mucosa should be inspected for the extent, depth, and location of the injury, and the direction of the negative pole side without the + sign and the imprint should be determined as this is commonly the most damaged site. In case of severe mucosal injury cardiothoracic surgeon should be consulted and a joint approach may be necessary. In case of esophageal impaction, it should be removed instantly (preferably within 2 hours). In the case of BB in the stomach according to the NASPGHAN guidelines removal is advised after 2 - 4 days. For a battery lodged in the small intestine that causes symptoms or that does not pass spontaneously, surgical evaluation may be necessary. The battery in the colon will almost always pass without intervention.

The National Button Battery Task Force (BBTF) recommended that if there is co - ingestion of a magnet, it has to be removed even in asymptomatic patients. In case of delayed diagnosis after 12 hours and esophageal impaction, a CT scan is to be performed to evaluate for vascular injury. If the button battery has passed the esophagus, endoscopy can be considered to screen for esophageal damage as seen in cases where even after the passage of the battery into the stomach, necrosis of the esophagus and surrounding tissues is an ongoing process that can lead to fistulization and serious outcomes. In asymptomatic patients, and if the button battery is beyond the esophagus, monitoring with X - rays in 7 - 14 days can be done. Emesis should not be evoked as it causes more damage and aspiration.

After battery removal, the scope should be reinserted into the esophagus, and another careful examination of the mucosa performed to better assess the severity and location of any injury as well as to determine the most likely complications (Table.2). Trauma to the anterior aspect of the esophagus prompts greater concern for vascular and tracheal injury, whereas posteriorly oriented inflammation has been associated with the development of spondylodiscitis. Anterior injury in the proximal esophagus should prompt concern for thyroid artery involvement or tracheoesophageal fistula as well as vocal cord injury. Location in the mid - esophagus should evoke the greatest concern for aorto - esophageal fistula [14]. Circumferential involvement in particular should increase concerns about long - term complications of stricture or stenosis. After re - examination of the esophagus, the passage of the endoscope into the stomach and proximal duodenum to exclude additional foreign bodies is prudent, presuming that this is not hampered by esophageal trauma and/or edema.

Admission and close monitoring are necessary for children with BBI. A second look at endoscopy after 2 - 4 days may be considered as it could provide prognostic information. A clear liquid diet may be started and a soft diet may be continued over 4 weeks depending on the severity of the injury and on a case - to - case basis. Broad - spectrum antibiotics need to be given in patients with mucosal injury. Morbidity and mortality associated with BBI are not strictly limited to vascular injury and bleeding events but also include vocal cord palsy and bowel perforation.

Once the battery is removed, however, management is highly variable depending on the institution, provider experience, and the clinical picture. Additional tests or procedures may include repeat endoscopy, bronchoscopy, esophagogram, and occasionally cross - sectional imaging. The North American Society for Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN), for example, recommends follow - up imaging with CT angiography or MRI but gives no specific recommendations on timing, repeat imaging window, or technique. [13]

MRI can provide valuable information in button battery ingestion patients. Sagittal T2, axial T2, and short tau inversion recovery (STIR) sequences are most useful in the evaluation of edema and inflammation. The T1 mDixon GRE sequence is optimal for demonstrating blooming artifacts centered at the level of battery lodging. Edema and blooming artifacts decreased over time on serial follow - up MRIs. The axial and sagittal post - contrast mDixon sequences were also believed to be the most useful in evaluating severe complications, such as TEF, fluid collections, and

spondylodiscitis. In a retrospective study by Grey et al, the MRI finding of a preserved fat plane between the trachea and esophagus had a negative predictive value of 100%; however, the finding of loss of a fat plane only had a positive predictive value for TEF of 50%. [15]

3. Conclusions

Accidental button battery ingestion in children is not uncommon, and timely diagnosis, prompt endoscopic removal, close monitoring, and follow - up with MRI imaging are essential. Unwitnessed cases with button battery ingestion require a high index of suspicion. Plain radiograph of the chest and abdomen is to be advised in all cases with suspected foreign body ingestion and button battery ingestion is no exception. With the increasing use of button batteries in household items and toys, they have become a major cause of foreign body ingestion after coins. Parents need to be educated about the hazards related to button batteries and the safe disposal of them.

Lessons Learnt

1) Need to always keep a differential of unwitnessed button battery ingestion, especially in children with symptoms of feeding intolerance or hematemesis
2) Localization of button battery in the stomach does not exclude esophageal injury because even transient contact of the battery with the esophageal mucosa can lead to erosions or ulcerations and rarely fistulization leading to grave outcomes
3) Every attempt must be made to expedite the process of endoscopic retrieval of the button battery because injury to mucosa can occur even with a shorter duration of contact with mucosa

Author contributions: Uma Devi Malladi has conceptualized manuscript writing and made critical contributions in terms of management of the cases and revision of the manuscript. Suraj Kumar Chimata has contributed to manuscript writing and editing, compilation of the data, and literature review. Sahitya Reddy Lingampally and Bhashyakarla Ramesh Kumar contributed to the manuscript's revision and management of cases. Vikas Reddy Venkannagari, Rithwik Chandra Chanda, and Sai Kumar Pippiri have contributed to data collection and management of cases.

Acknowledgments: None

Source of Support and Funding: None

Conflict of Interest Statement: All the authors state that they have no disclosures to make and have no conflict of interest in relevance to the current abstract

Patients' consent form: Written informed consent was taken to perform the diagnostic and therapeutic procedures that were essential in making the diagnosis which include the endoscopic and radiology - based procedures.

References

[1] Lorenzo C, Azevedo S, Lopes J, Fernandes A, Loreto H, Mourato P and Lopes AI (2022) Battery Ingestion in Children, an Ongoing Challenge: Recent Experience of a Tertiary Center. Front. Pediatr.10: 848092. doi: 10.3389/fped.2022.848092

[2] Button Battery Ingestion Statistics; Washington DC National Capital Poison Center https: //www.poison. org/battery/stats

[3] Litovitz, T., Whitaker, N., Clark, L., White, N. C., & Marsolek, M. (2010). Emerging battery - ingestion hazard: clinical implications. Pediatrics, 125 (6), 1168–1177. https: //doi. org/10.1542/peds.2009 - 3037

[4] Leinwand, K., Brumbaugh, D. E., & Kramer, R. E. (2016). Button Battery Ingestion in Children: A Paradigm for Management of Severe Pediatric Foreign Body Ingestions. Gastrointestinal endoscopy clinics of North America, 26 (1), 99–118. https: //doi. org/10.1016/j. giec.2015.08.003.

[5] Park, S. J., & Burns, H. (2022). Button battery injury: An update. Australian journal of general practice, 51 (7), 471–475. https: //doi. org/10.31128/AJGP - 03 - 21 - 5873

[6] Varga, Ágnes MD*; Kovács, Tamás MD, PhD*; Saxena, Amulya K. MD, PhD, DSc, FRCS (Glasg) †. Analysis of Complications After Button Battery Ingestion in Children. Pediatric Emergency Care 34 (6): p 443 - 446, June 2018. | DOI: 10.1097/PEC.0000000000001413

[7] Rao PVR, Pedada RK, Sekhar VC, Kumar PA. Button battery ingestion - case report and review. IP Int J Forensic Med Toxicol Sci 2020; 5 (3): 107 - 110

[8] Semple T, Calder AD, Ramaswamy M, McHugh K. Button battery ingestion in children—a potentially catastrophic event of which all radiologists must be aware. Br J Radiol 2018; 91: 20160781

[9] John B. Eck, Warwick A. Ames; Anesthetic Implications of Button Battery Ingestion in Children. Anesthesiology 2020; 132: 917–924 doi: https: //doi. org/10.1097/ALN.0000000000003121

[10] Anfang, R. R., Jatana, K. R., Linn, R. L., Rhoades, K., Fry, J., & Jacobs, I. N. (2019). pH - neutralizing esophageal irrigations as a novel mitigation strategy for button battery injury. The Laryngoscope, 129 (1), 49–57. https: //doi. org/10.1002/lary.27312

[11] Jatana, K. R., Litovitz, T., Reilly, J. S., Koltai, P. J., Rider, G., & Jacobs, I. N. (2013). Pediatric button battery injuries: 2013 task force update. International journal of pediatric otorhinolaryngology, 77 (9), 1392–1399. https: //doi. org/10.1016/j. ijporl.2013.06.006

[12] Tanaka, J., Yamashita, M., Yamashita, M., & Kajigaya, H. (1998). Esophageal electrochemical burns due to button - type lithium batteries in dogs. Veterinary and human toxicology, 40 (4), 193–196.

[13] Kramer, R. E., Lerner, D. G., Lin, T., et al. North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition Endoscopy Committee (2015). Management of ingested foreign bodies in children: a clinical report of the NASPGHAN Endoscopy Committee. Journal of pediatric gastroenterology and nutrition, 60 (4), 562–574. https: //doi. org/10.1097/MPG.0000000000000729

[14] Mortensen, A., Hansen, N. F., & Schiødt, O. M. (2010). Fatal aortoesophageal fistula caused by button battery ingestion in a 1 - year - old child. The American journal

of emergency medicine, 28 (8),. https: //doi. org/10.1016/j. ajem.2010.01.007.

[15] Grey, N. E. O., Malone, L. J., Miller, A. L., Carroll, H. F., Khalaf, R. T., Kramer, R. E., & Browne, L. P. (2021). Magnetic resonance imaging findings following button battery ingestion. Pediatric radiology, 51 (10), 1856–1866. https: //doi. org/10.1007/s00247 - 021 - 05085 - w