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Current guidelines for treatment after button battery ingestion

Aktualne zasady postępowania u dzieci w przypadkach połknięcia baterii guzikowych

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Abstract

Aim: Button battery ingestion is one of the most dangerous forms of foreign body ingestion commonly seen in paediatrics. It poses a serious threat to both the health and life of children. The extent of the damage depends on the duration of contact between the battery and the oesophageal mucosa, the pressure exerted by the foreign body on the oesophageal wall, the local electric current flow, and the potential leakage of toxic substances. Complications following battery exposure include oesophageal burns and perforation, oesophageal-tracheal fistula, oesophageal-aortic fistula, mediastinitis, gastric perforation, intestinal perforation, and peritonitis. Long-term complications are oesophageal strictures, while rare complications include vocal fold paralysis and spinal injury. The aim of this study is to establish updated guidelines for the management of children in cases of button battery ingestion. **Materials and methods:** A comprehensive literature search was performed for the years 2018–2023. **Results:** A total of 1,057 children treated after for button battery ingestion were included in the study. Among the patients, 309 were found to have a button battery lodged in the oesophagus, while in the remaining 748 children, the foreign body was located in the stomach, duodenum, or small intestine. The patients' epidemiological data, clinical manifestations, radiological findings, treatment, complications, and long-term outcomes were analysed. Current management guidelines based on National Capital Poison Center recommendations and literature data from recent years were presented. **Conclusions:** Button battery ingestion is one of the most dangerous forms of foreign body ingestion commonly seen in the paediatric population. The longer the foreign body is lodged in the oesophagus, the higher the risk of complications. Once the battery is removed from the oesophagus, the injury may continue to develop for up to several weeks, causing distant complications. Preventive measures to reduce the risk of battery ingestion incidents are essential.

Keywords: button battery ingestion, oesophageal foreign body, oesophageal burn

Streszczenie

Wprowadzenie i cel: Połknięcie baterii guzikowej jest jedną z najniebezpieczniejszych form połknięcia ciała obcego w populacji pediatrycznej. Stanowi poważne zagrożenie dla zdrowia i życia dziecka. Rozległość uszkodzeń zależy od czasu kontaktu baterii z błoną śluzową przełyku, ucisku ciała obcego na ścianę przełyku, lokalnego przepływu prądu i ewentualnego wycieku substancji z baterii. Na skutek działania baterii na ściany przełyku mogą wystąpić groźne dla życia powikłania, takie jak perforacja przełyku i zapalenie śródpiersia, a długotrwała ekspozycja może wytworzyć przetoki w kierunku tchawicy, dużych naczyń i kręgosłupa. Odległe następstwa połknięcia baterii to przede wszystkim zwężenia przełyku, a do rzadkich powikłań zalicza się porażenia fałdów głosowych i uszkodzenie kręgosłupa. Celem badania było opracowanie aktualnych zasad postępowania w przypadku połknięcia baterii guzikowych przez dziecko. **Materiał i metody:** Korzystając z baz danych PubMed i Cochrane Library, przeprowadzono przegląd piśmiennictwa obejmującego lata 2018–2023. **Wyniki:** Znaleziono 11 artykułów, w których oceniono 1057 dzieci. U 309 z nich bateria guzikowa była zaklinowana w przełyku, a u pozostałych 748 stwierdzono jej obecność w żołądku bądź w jelicie cienkim lub grubym. Analizie poddano dane epidemiologiczne pacjentów, główne dolegliwości, wyniki badań obrazowych, leczenie oraz powikłania wczesne i odległe. Przedstawiono sposób postępowania w oparciu o zalecenia National Capital Poison Center oraz dane z piśmiennictwa z ostatnich 5 lat. **Wnioski:** Połknięcie baterii guzikowej jest najniebezpieczniejszą formą połknięcia ciała obcego, powszechnie spotykaną w populacji pediatrycznej. Ryzyko powikłań rośnie wraz z czasem

zalegania ciała obcego w przełyku. Po usunięciu baterii z przełyku uraz może rozwijać się nawet tygodniami, powodując odległe powikłania. Ważne są działania prewencyjne polegające na zapobieganiu incydentom połknięcia baterii.

Słowa kluczowe: połknięcie baterii guzikowej, ciało obce przełyku, oparzenie przełyku

INTRODUCTION

Young children are the most common victims of accidental battery ingestion. Over the past decade, the frequency of these incidents has been increasing steadily due to the widespread use of batteries in various devices and toys. In recent years, larger lithium-ion batteries, known as button batteries (diameter: 20–22 mm), have become more common. Such batteries, due to their larger diameter, are at a greater risk of becoming lodged in the oesophagus[1–3]. Foreign bodies in the oesophagus are most likely to become stuck at one of three physiological strictures: the upper oesophageal sphincter (most often, in 60–70% of cases), the middle section of the oesophagus at the junction with the aortic arch (10–20%), or above the lower oesophageal sphincter (20%)[2]. Most cases of foreign body ingestion (80%) involve children between the ages of 6 months and 3 years. Young children frequently put objects in their mouths, and the small diameter of their oesophagus allows a foreign body to become lodged in its lumen[3,4]. The main symptoms of a foreign body in the oesophagus include dysphagia, painful swallowing, drooling, and vomiting, with accompanying symptoms of general restlessness and irritability, choking, coughing, respiratory distress, and fever. In young children, a foreign body in the oesophagus may not initially cause symptoms[5–10]. When a battery is lodged in the oesophagus, symptoms occur in 57% of cases, whereas in the lower gastrointestinal tract, they occur in 24%[3]. Due to the immediate life-threatening nature of the condition, any case of suspected battery ingestion requires prompt diagnosis and treatment. Diagnosis is established on the basis of an X-ray with anteroposterior and lateral projection covering the neck and chest, and if necessary, the abdominal cavity. Button batteries are round and coin-like in appearance. In a radiographic image, the "double ring" ("halo") sign is characteristic of a battery, while the "step" sign on the battery is visible in the lateral view[4,11,12]. The negative pole of the battery is located on the narrower ring, which is important because the greatest tissue damage occurs on the side of this pole. Determining its location is therefore important for assessing which structures are most at risk[11,12]. In a battery, which consists of an anode (negative pole), a cathode (positive pole), and compartments containing electrolytes, a chemical reaction occurs in which electricity is generated. The walls of the digestive tract can be damaged by four different mechanisms. The first involves pressure exerted by the foreign body on the oesophageal wall. This direct pressure results in ischaemia and the formation of initial pressure sores, followed by necrosis and perforation. The second and most significant mechanism is the formation of liquefactive necrosis due to the electrical activity of the battery. Its tight adhesion to the walls of the oesophagus closes the circuit between the two poles of the battery, allowing current to flow. The wall most vulnerable is the one in direct contact with the negative pole of the battery, where the production of hydroxide ions, electrolysis of tissues, and elevation of pH to 12–13 cause softening and liquefactive necrosis of the gastrointestinal wall[10,14–16]. The third mechanism involves leakage of the battery's electrochemical composition, leading to extensive tissue damage. Depending on the type, batteries contain manganese, cobalt, nickel, lithium ions, and compounds of aluminium, cadmium, chromium, iron, mercury, lead, and barium[14]. The humid environment of the throat is ideal for the leakage of electrolytes. The last mechanism is poisoning of the body through the absorption of toxic substances (mainly mercury compounds) by the intestinal wall into the bloodstream[14,16].

The time of contact between the battery and the oesophageal wall remains the most significant factor affecting the extent of injury[7,8,16]. Visible damage to the mucous membrane of the oesophagus appears as early as 15 minutes after exposure to the battery, and necrosis of the oesophageal wall is typically observed 12 hours after the battery is swallowed[7,8]. Severe complications develop in 12% of children <6 years of age[8].

The damage to the oesophageal wall poses a risk of fistula formation between the oesophagus and its surrounding tissues (trachea, aorta, and other large vessels), leading to a number of potentially life-threatening conditions. Such dangerous complications include oesophageal perforation, mediastinitis, large vessel haemorrhage, oesophageal-tracheal fistula, vocal fold paralysis, and spinal injury[5,7,10,17–20]. Fatal cases have been described, including death after swallowing a camera battery, which caused rapid haemorrhage from the inferior thyroid veins due to deep necrosis of the oesophageal wall[17]. Long-term complications have also been reported in the literature, such as bilateral vocal fold paralysis, which occurred one month after a button battery was removed from a child's oesophagus[21]. An interesting case involved a patient with cardiac arrhythmias and ECG abnormalities (ST-segment elevation, higher amplitude of leads, biphasic T-wave, QT interval prolongation) caused by swallowing electrically active batteries during a suicide attempt[22]. Extensive oesophageal wall injury should always raise concern about an airway fistula; therefore, bronchoscopy is recommended[7]. The most common remote complication is an oesophageal stricture, which

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occurs in 5–41% of children[1,3,16,18,23,24]. Its incidence, however, appears to be underestimated because routine follow-up endoscopies are not performed for several weeks after the event[23]. The main factor that increases the risk of oesophageal stricture is the length of time the battery remains lodged in the oesophagus[1,18,24]. The occurrence of strictures after caustic burns to the oesophagus depends on the severity of the burns – most develop in second- and third-degree mucosal burns. In contrast, complications after exposure of the lower gastrointestinal tract to the battery include necrosis and perforation of the stomach, duodenum, small intestine, as well as haemorrhage and peritonitis[1,5,6].

In the present study, an analysis of research was conducted to present updated guidelines for managing button battery ingestion in children.

MATERIALS AND METHODS

A literature review was conducted using PubMed and Cochrane Library databases, with the search terms: "button battery" AND "battery ingestion" AND "esophageal foreign body" AND "child(ren)" AND "English (language)". Papers published between 2018 and 2023 were analysed. The inclusion criteria for publications in the analysis comprised data on the type of battery, clinical course, duration of oesophageal foreign body ingestion, diagnostic examinations performed, treatment modalities, complications, and long-term consequences. The retrieved articles were subjected to full-text review. Retrospective studies were eligible for analysis; one was a cohort study. Current management guidelines based on National Capital Poison Center recommendations and literature data from recent years were presented.

RESULTS

Eleven studies from 2018 to 2023 were eligible for analysis[1,3,5,6,10,15,18–20,24,25], evaluating 1,057 patients. The male-to-female ratio was 51% to 49%, and the mean age at diagnosis was 2.6 years (range: 0.1 years – 17 years). A total of 309 children were found to have a button battery lodged in the oesophagus, while the remaining 748 had it in the stomach or small or large intestine. The main complaints were drooling (30%), dysphagia (28%), nausea and vomiting (28%), refusal to feed (25%), sore throat (18%), chest pain (18%), fever (11%), abdominal pain, hoarseness, respiratory distress, stridor, hemodynamic abnormalities, and pallor. In 42% of patients, the course was asymptomatic. Complications after swallowing a button battery included oesophageal perforation, oesophageal-tracheal fistulas, unilateral and bilateral vocal fold paralysis, mediastinitis, gastric or duodenal perforation, oesophageal-aortic fistulas, peritonitis, formation of a retropharyngeal abscess, and C7–T2 spondylitis. In 5% of children, oesophageal lumen narrowing occurred. Antibiotic therapy was prescribed in 7% of children who developed fever or perforation of the gastrointestinal tract during the course of the disease. Antireflux treatment with proton pump inhibitors was used in only two hospitals[1,3]. Five patients passed away (0.5%).

The location of the battery in the gastrointestinal tract, along with a summary of the main clinical manifestations and early and long-term complications in the publications, is shown in Tab. 1.

The updated guidelines were developed based on reports from recent years and the recommendations of the National Capital Poison Center[26].

DISCUSSION

The lodgement of a battery in the gastrointestinal tract is suspected in two situations – regardless of the presence of symptoms, when its ingestion is noticed by a parent or caregiver, or when a child presents with distressing symptoms such as drooling, reluctance to eat, choking, vomiting, as well as wheezing, coughing, or shortness of breath. In both situations, inducing vomiting is ill-advised. An X-ray of the neck, chest, and abdomen in AP and lateral projections is recommended in the emergency department (Fig. 1). Further management depends on the X-ray findings and the location of the battery[26].

TREATMENT IN CASE OF OESOPHAGEAL BATTERIES

When a caregiver notices that a child >1 year of age has swallowed a battery, the National Capital Poison Center recommends administering honey (10 mL, or 2 teaspoons) every 10 minutes (up to 6 doses). Alternatively, sucralfate (1 g/10 mL suspension) can be administered orally at 10 mL (2 teaspoons) every 10 minutes (up to 6 doses). These substances are not recommended if the oesophageal battery has been retained for >12 hours. Consuming honey or taking sucralfate does not affect the patient's fasting status for planned general anaesthesia[27,28]. Once a battery is found lodged in the oesophagus, it should be removed as soon as possible, regardless of whether the patient is fasting or after a meal. The risk of complications increases with the duration of direct contact between the battery and the oesophageal mucosa. Immediate intervention is required, even if the patient is initially asymptomatic. If the battery remains lodged in the oesophagus for >12 hours, it is considered a delayed diagnosis. The first visualisation of the battery on an X-ray or its removal >12 hours after swallowing is followed by a computed tomography scan to assess damage to the vessels and adjacent structures[4]. A rigid endoscopy method is recommended. In addition to removing the foreign body, it is necessary to evaluate the mucosa after contact with the battery, determine the extent and depth of the burn, and assess the location of the wall in contact with the negative pole of the battery. After excluding visible features of an oesophageal wall burn, it is recommended to rinse exposed tissues with 50–150 mL of

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	Number of patients (*N*)	Number of patients with oesophageal battery	Number of patients with battery outside the oesophagus	Main symptoms	Early complications	Patients with oesophageal strictures
Krom et al., 2018[10]	16	16	0	Vomiting, dysphagia, fever	Oesophageal-tracheal fistula, vocal fold paralysis	5
Dörterler, 2019[24]	17	17	0	Drooling, vomiting	Vocal fold paralysis, oesophageal-tracheal fistula	7
Duan et al., 2020[25]	34	34	0	Sore throat, dysphagia, vomiting, drooling, hoarseness, stridor	Oesophageal-tracheal fistula, vocal fold paralysis	0
Akilov et al., 2021[20]	122	26	96	Drooling, nausea, vomiting, cough, fever	Oesophageal perforation, mediastinitis, oesophageal ulceration	1
Shafiq et al., 2021[6]	56	18	38	Dysphagia, cough, vomiting, abdominal pain	Perforation of the stomach, peritonitis	2
Bettadahalli et al., 2022[15]	100	100	0	Vomiting, dysphagia, fever, cough, sore throat, stridor	Oesophageal-tracheal fistula, oesophageal perforation, retropharyngeal abscess	0
Quitadamo et al., 2022[5]	118	12	106	Chest pain, nausea	Bowel perforation	3
Lorenzo et al., 2022[3]	35	14	21	Vomiting, drooling, fever, refusal to feed, abdominal pain, melenas, coughing	Infection, mediastinitis, sepsis, subglottical constriction, acute respiratory distress	6
Scalise et al., 2023[18]	143	36	107	Vomiting, cough, abdominal pain, fever, drooling, dyspnoea	Oesophageal perforation, mediastinitis, oesophageal-tracheal fistula, oesophageal-vascular fistula	9
Afshari et al., 2023[19]	1	1	0	Haematemesis, weight loss	Spondyloarthritis C7–T2	0
Labadie et al., 2023[1]	415	35	380	Refusal to feed drooling, dyspnoea, fever, haemodynamic abnormalities, pallor, pain	Duodenal perforation, peritonitis, oesophageal-tracheal fistula, oesophageal-aortic fistula	24

Tab. 1. Number of analysed patients, location of the battery in the gastrointestinal tract, main clinical symptoms, and early and long-term complications after battery ingestion

a 0.25% acetic acid solution to neutralise remaining hydroperoxides and inhibit the progression of the caustic burn process[8,26,29]. After rinsing the oesophagus, excess fluid should be aspirated. Patients with visible changes to the oesophageal wall should be hospitalised and monitored due to the high risk of local oedema and dyspnoea. An X-ray of the oesophagus with contrast (using a water-soluble contrast agent) is performed 1–2 days after battery removal. Analgesic treatment is very important. Broad-spectrum antibiotic therapy is recommended in cases of severe damage to the gastrointestinal wall (second- and third-degree burns) or confirmed perforation, and in patients with associated fever[13,30]. However, a regimen for antibiotic therapy has not yet been established. At the hospital in which the authors of the article work, amoxicillin with clavulanic acid is used (for 7 days). Although the efficacy of antireflux drugs in minimising oesophageal wall damage has not been confirmed in studies, proton pump inhibitor therapy seems reasonable[1,13]. At the institution where the authors work, patients are given intravenous omeprazole throughout their hospitalisation. It is necessary to monitor the child for potential complications (oesophageal perforation, mediastinitis, oesophageal-tracheal fistula, haemorrhage, pneumonia, and spondylitis). Notably, 98% of oesophageal fistulas and strictures are diagnosed many weeks after battery removal[16,23]. Patients who have had a battery removed from the upper oesophagus should be closely monitored for

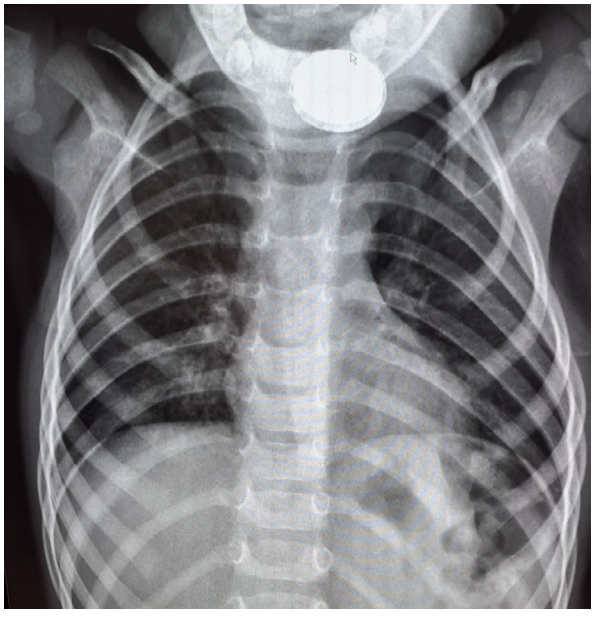

Fig. 1. Button battery in the oesophagus images on chest X-ray

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changes in voice tone, respiratory distress, or stridor, as the occurrence of these symptoms is an indication for laryngeal endoscopy. A potential complication of battery ingestion is unilateral or bilateral vocal fold paresis/paralysis due to damage to the inferior laryngeal nerve. A lodged battery (especially if in contact with its negative pole) at the junction of the oesophagus with the aorta or other large blood vessels is strongly associated with the risk of life-threatening haemorrhage. A computed tomography scan or magnetic resonance imaging is recommended to confirm whether there is at least 3 mm of healthy tissue between the oesophageal injury site and adjacent vessels. Minor asymptomatic bleeding is also possible. If oesophageal-vascular fistula formation is suspected, the child should be monitored in a hospital with a cardiac surgery unit. The timing of returning to oral nutrition depends on the local condition and accompanying symptoms. In asymptomatic children with no lesions on the oesophageal mucosa, a liquid diet is recommended 24 hours after surgery. If food intake is normal, the child can be discharged. After a few days, the diet may be adjusted to include mushy foods, while soft foods should be maintained for 28 days in all children after oesophageal battery removal to prevent mechanical damage to the healing oesophagus. In cases of damage involving the muscular layer of the oesophagus (stage II and III injuries), feeding is administered through a gastric probe, which should be inserted during endoscopy immediately after battery removal. In children who have had the probe removed, a "0" diet is implemented, and a follow-up X-ray of the oesophagus is taken using a water-soluble contrast agent. In cases of deep oesophageal wall injury, control esophagoscopy for potential structures is performed no earlier than 4 weeks after the injury[7,13], as earlier endoscopy increases the risk of iatrogenic perforation[16].

TREATMENT IN THE CASE OF BATTERIES LOCATED BELOW THE OESOPHAGUS, IN THE LOWER GASTROINTESTINAL TRACT

If a single battery <12 mm in diameter has passed beyond the oesophagus (into the stomach and further along), observation at home with a normal diet and unrestricted physical activity is recommended for children >12 years of age, provided there is no history of symptoms or gastrointestinal disease. The child requires observation until confirmation of battery passage through stool inspection[26]. Batteries typically pass through the intestines within 24–48 hours, and intervention is rarely required.

If a foreign body is not found in the stool within 7–14 days and the child is asymptomatic, a repeat gastrointestinal X-ray and endoscopic removal of the battery are required[26]. NASPGHAN (North American Society for Pediatric Gastroenterology, Hepatology and Nutrition) guidelines recommend endoscopic removal of the battery if it remains in the stomach for 2–4 days. Surgical removal is necessary if the battery becomes lodged in the small intestine and causes symptoms. If the battery enters the colon, it is almost always expelled without surgical intervention[3,4]. Complications in cases where the battery is present outside the oesophagus are rare, occurring in 7% of cases when located in the stomach and 1.3% when in the intestine[4]. It is important to note that the presence of a button battery in the stomach or further in the gastrointestinal tract does not exclude the possibility of concomitant oesophageal damage[4].

Prevention measures play a very important role in reducing the incidence of button battery ingestion. These strategies include raising public awareness and collaborating with the industry to widely introduce safety features on commercially available batteries. Current precautions include protective stickers on batteries, double plastic packaging that can only be opened with scissors, or coating button batteries with a layer of a very bitter, repulsive, non-toxic substance that is harmless when ingested. Key preventive measures also include widespread education of parents and caregivers of young children on the safe use, storage, and disposal of batteries. It is also important to educate general practitioners on the early diagnosis and proper rapid intervention in cases of battery ingestion by a child. In the United States, for example, there is a National Battery Ingestion Hotline providing information and guidance on battery ingestion treatment aimed at both the public and healthcare professionals, while in Australia, educational posters are displayed in the waiting rooms of doctors' offices.

CONCLUSIONS

Button battery ingestion is one of the most dangerous forms of foreign body ingestion commonly seen in the paediatric population. The risk of complications increases with the length of time the foreign body remains lodged in the oesophagus. Once the battery is removed, the injury can develop for up to several weeks, causing distant complications. Preventive measures to avoid battery ingestion incidents are essential.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organisations which might negatively affect the content of this publication and/or claim authorship rights to this publication.

Author contribution

Original concept of study: AG, IB. Collection, recording and/or compilation of data; analysis and interpretation of data; writing of manuscript: AG. Final approval of manuscript: IB.

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