Device for the Removal of Button Batteries

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Abstract

Objective **There is an increasing number of accidents by erroneous ingestion of button batteries in recent years; the batteries arouse the interest of infants because of their attractive shape and luster. The batteries remaining in the gastrointestinal tract and discharging electric current over a long period of time may induce ulceration or perforation, thus must be carefully considered the selection of appropriate treatment.**

Methods **We remove erroneously ingested button batteries with two tubes with ferrite magnets nearly the same size as the button batteries themselves.**

Patients **Four cases of erroneous ingestion of button batteries.**

Results **We easily removed button batteries from the stomach within 5 minutes in all cases with two magnet-attached tubes.**

Conclusion **We present this battery removal device together with a literature review,because it seems convenient and useful.**

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Key words: acute medicine, foreign body, erroneous ingestion

Introduction

The use of button batteries in small appliances is gaining popularity. This tendency is associated with an increasing number of accidents of erroneous ingestion of the button batteries in recent years because the batteries are liable to arouse interest in infants because of their attractive shape and luster. The batteries remaining in the gastrointestinal tract and discharging the electric current over a long period of time may induce ulceration or perforation, urging physicians to take mature considerations about selection of an appropriate treatment.

In this study, we present the point of our contrivance that we have developed in our hospital to remove erroneously ingested button batteries together with a literature review.

Subject

While playing with an alarm clock on May 26, 1999, a 10-month-old girl swallowed a button battery (Mitsubishi alkaline button battery model LR44) by mistake and she was then brought to a clinic in the neighborhood. As the presence of the battery within the stomach was confirmed by X-ray examination of the abdomen, the patient was referred and admitted to our hospital. On admission her height was 71 cm, weight 8.0 kg, and body temperature 37.6°C, with regular pulses at 120/min with mild pharyngeal reddening but nothing unusual at the thoracoabdomen. X-ray examination of the abdomen on admission (Fig. 1) revealed the erroneously ingested battery at a site which was supposedly within the stomach.

Post-admission progress: The erroneously ingested battery (Mitsubishi alkaline button battery model LR44 with a diameter of 11.6 mm, a weight of 1.9 g, and a magnetic flux density of 0 Gauss) was made of iron with a potential risk of inducing ulceration or perforation. Thus, we tried to remove it 3 hours after ingestion using two tubes carrying 700 Gauss ferrite magnets nearly the same size as the button batteries (diameter: 12 mm) (Fig. 2). First of all, two magnet-attached tubes were inserted from the mouth into the stomach under X-ray fluoroscopy without anesthesia in the same fashion as for insertion of the stomach tube, and then the patient's posture was changed to a different one. When the battery was caught by one of the two magnet-attached tubes, it was pulled up to the cardia (Fig. 3). As we feared that continued pulling would easily cause falling of the battery into the stomach or coming-off from the magnet at the physiological stricture of the esophagus, we pulled the battery by holding it supportively with the other magnet-attached tube of the anal side and succeeded in letting the battery pass through the orifice without difficulty.

The battery came off from the magnet-attached tube inserted

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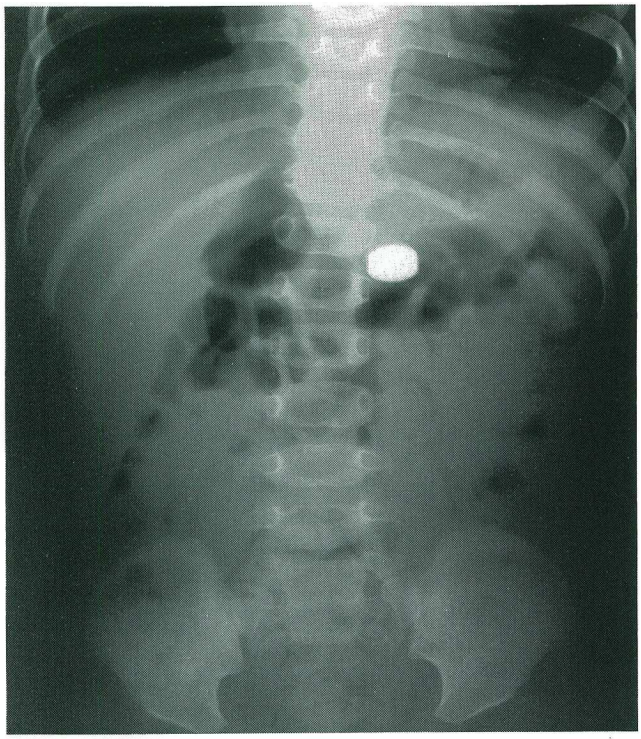

Figure 1. X-ray examination of the abdomen on admission. An erroneously ingested button battery is identified at a site of the upper abdomen that may be considered the inside of the stomach.

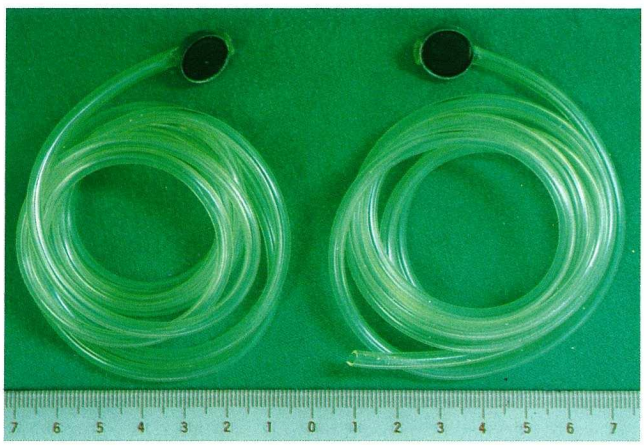

Figure 2. Magnet-attached tube. Prepared by fastening a stationary 700 Gauss ferrite magnet measuring 12 mm in diameter to a polyvinyl tube for infusion measuring 4 mm in diameter with an instantaneous adhesive for medical use.

from the mouth at the physiological stricture of the esophagus, but it was easily removed as it was sticking to the magnet-attached tube of the anal side (Fig. 4).

The removed battery was found to be discolored black be-

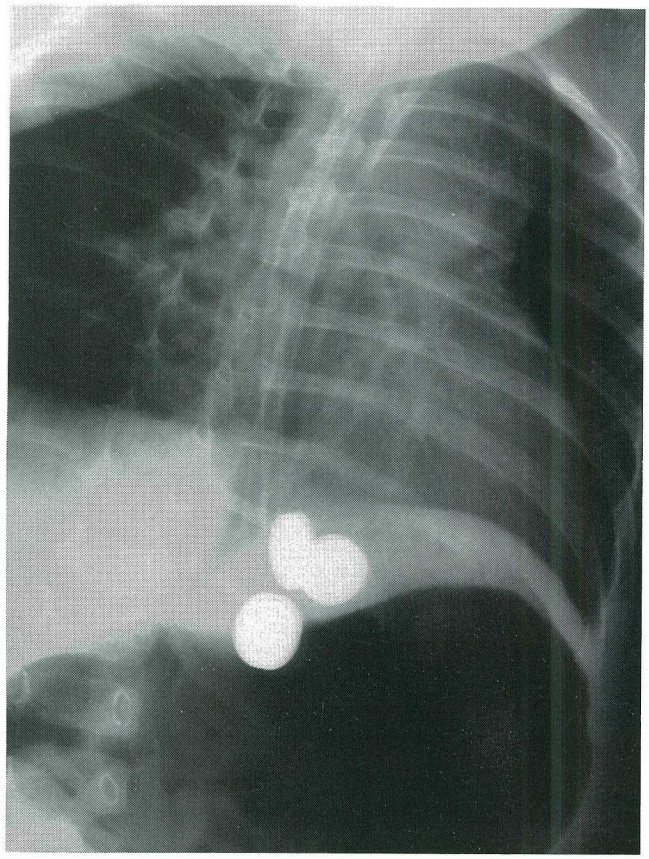

Figure 3. X-ray examination of the thoracoabdomen. The magnet-attached tube catching the battery was pulled up to the cardia.

cause of the metallic elution on the anode side (Fig. 5, left). On the cathode side, on the other hand, there was electrolysis-induced alkaline deposition which might have potentially caused ulceration or perforation.

The patient was discharged on May 28 without any complication.

Discussions

In association with the recent trend to make electric appliances much smaller with higher performance, it has become common to install button batteries not only in toys such as game machines but also in clocks, desk calculators and remote controllers (1). Button batteries are likely to attract interest from infants because of their size and luster, resulting in a higher incidence of erroneous ingestion in recent years. Endo et al classified 125 cases of such erroneous ingestion according to the button battery-installed devices and found that toys ranked the top in the list of such devices, followed by various types of clocks and toy-like key holders making sound or light (2). We suggested that these devices should be structured in such a way that the battery might not be easily taken out.

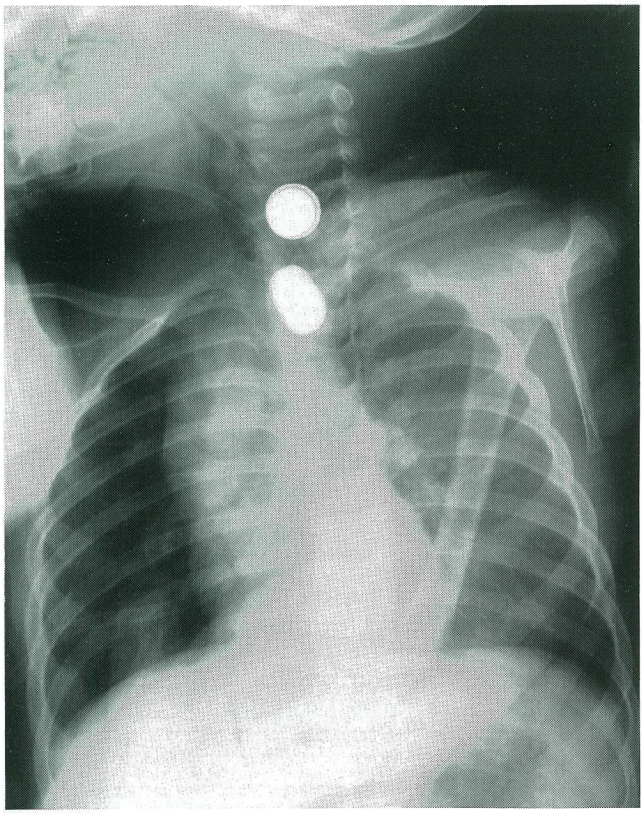

Figure 4. X-ray examination of the chest. The battery was successfully removed as it adhered to the magnet-attached tube of the anal side.

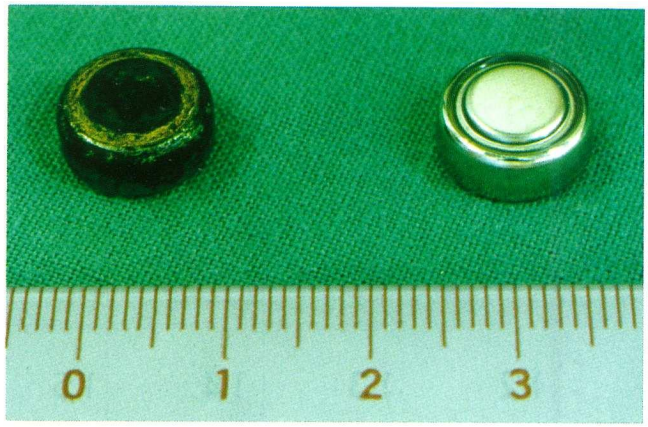

Figure 5. Mitsubishi alkaline button battery model LR44 (diameter 11. 6 mm, weight 1. 9 g, and magnetic flux density 0 Gauss, made of iron). Left: removed battery, Right: new battery. The removed battery on the left is discolored black.

Benson and Lloyd suggested that an erroneously ingested foreign body remaining below the level of the stomach can be left as it is for 2 weeks in expectation of its spontaneous evacuation, provided that there is no immediate risk of complications (3). However, if the button battery remains within the gastrointestinal tract and continues to discharge the electric current over a long period of time, then alkaline deposit is formed due to electrolysis on the cathode side (1, 4, 5) while a metallic elution occurs on the anode side, leading to destruction of the capsule and leakage of contents with a potential risk of ulceration or perforation (1, 4). Thus, physicians must pay careful consideration regarding the selection of appropriate treatments. Kost and Shapiro (6) and Temple and McNeese (7) suggested that tissue impairment by batteries might be caused by necrosis resulting from their oppression on tissues, erosion due to outflow of their contents, or chemical damage produced by electric current.

Fujishima et al (8) conducted experiments using rabbits, and reported that the electric resistance is 8 KΩ for artificial gastric fluid and ranges from 100 to 500 KΩ for stomach tissues of the rabbit, and that if button batteries come into contact with the gastrointestinal wall, most of their electric current flows within the gastric fluid running over the mucosal surface with a lower resistance, causing only a negligible effect on the tissues. Therefore, they suspected that the tissue-damaging effect by the batteries might be due to alkali produced around the cathode. Meanwhile old batteries without any electromotive force may just be left as they are until they are spontaneously excreted. However, they also report that measurement of the electromotive force on 100 used-up old batteries demonstrated a residual voltage of 1.5 V on about 1/4 of them (8). Ito et al also found a residual voltage of over 1.3 V in more than 69% of alkaline batteries recovered from the stomach (9). These findings suggest that even old batteries should be treated carefully.

Regarding the potential risk of chemical substances contained in batteries, Gosselin emphasized that all sorts of button batteries contain KOH and NaOH at levels of 6 to 10 N, at which the gastrointestinal tract could be eroded in several tens of seconds (10). In experiments on battery destruction within the dog stomach, Katz and Cooper noted that the pH within the stomach changed between 12 and 13 within several minutes (11). Yamashita (12) noted that due attention must be paid to the eroding effect and the possible anaphylactic reaction due to iron, although there may be no possibility of metallic poisoning with those amounts of the substances contained in the batteries. Mant et al reported a case in which mercury concentrations in the blood and urine became abnormally high as a result of collapse of an erroneously ingested mercury battery within the gastrointestinal tract (13).

Erroneous ingestion of a battery might cause no safety problem, if it is designed in a way that it may have an electronic conduction flowing through the leading wire but no ion conduction. In this connection, Tanaka and Yamashita reported that Hitachi-Maxell has recently marketed an alkaline button with safety measures by utilizing the fact that iron and nickel induce electronic conduction or ion conduction at a voltage of 1.5 V whereas stainless steel button batteries cause neither types of conduction unless it is plated with nickel; more specifically, the battery is capsulated with stainless steel and plated with a

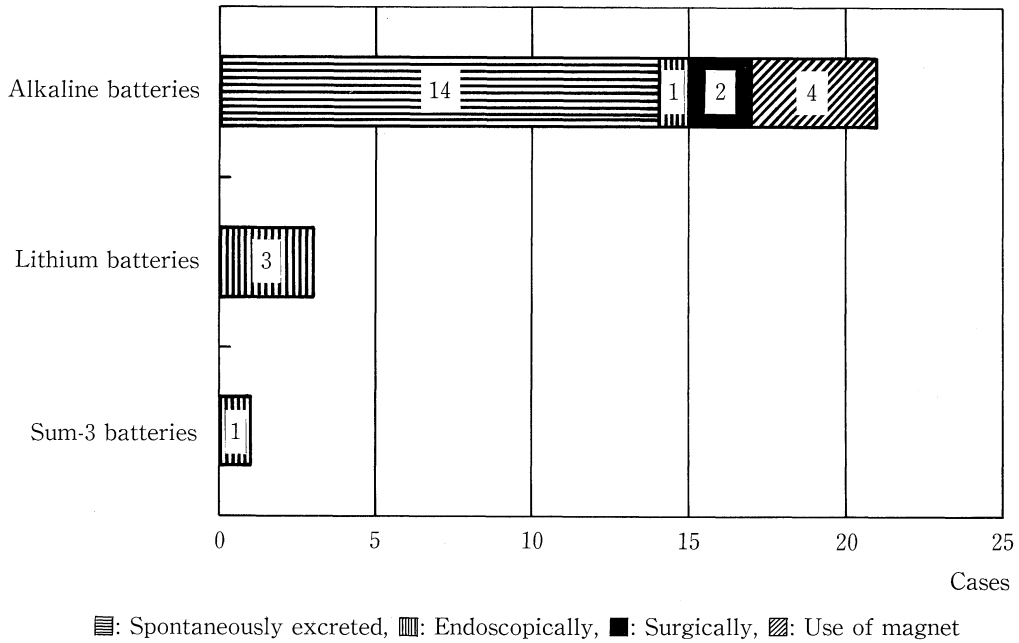

Figure 6. Treatments of cases with erroneous ingestion of batteries in Japan (1990–1999).

small amount of nickel to such an extent that even if the battery is swallowed by mistake, the nickel may be lost through elution before it takes a damaging effect on tissues (14). However, other makers unfortunately have not as yet implemented any safety measures. Meanwhile the lithium battery has a voltage of 3 V, causing ion conduction even if it is capsulated with stainless steel. Therefore, no lithium batteries with effective safety measures have yet been marketed (14).

To our knowledge, cases of erroneous ingestion of batteries for which treatments are specified during the last decade amount to 25 in Japan, four of which are from our hospital (Fig. 6). Erroneous ingestion of alkaline button batteries was the most common, accounting for 21 cases (84%). Since lithium batteries and Sum-3 batteries are so large that they are apt to remain in the esophagus and stomach, thereby often causing complications. All of those batteries were thus removed endoscopically. Alkaline button batteries, which are small in size, were spontaneously excreted in 14 cases (67%), but there were two cases treated surgically due to complications. In foreign countries, in addition, three deaths (15–17) and one cardiac arrest (18) have been reported. In all of these cases ending in serious complications, more than 24 hours had passed before the erroneously ingested batteries were recovered.

Litovitz and Schmitz reported that they monitored patients with erroneous ingestion of batteries without any special treatment, since batteries are destined to be spontaneously excreted once they drop into the stomach unless they are over 15 mm in diameter, patients are under 6 years of age, and the retention time within the stomach is over 48 hours (19). However, they also described a case of esophageal mucosal damage which occurred 4 hours after erroneous ingestion of a battery, with perforation occurring after 6 hours (19). Yamashita et al reported that a 1.5 V mercury battery erroneously ingested into dog esophagus caused discoloration of the mucosal membrane after 2 hours, followed by ulceration after 8 hours, with inflammation reaching the mucous layer at that time and as far as the bronchial muscle after 24 hours (1). Thus, they recommend that the battery should be removed with a magnet or by other means while it is within the stomach, since necrosis extending to the mucous layer may occur, if the battery strays off into, for instance, the diverticulum to become fixed there for over 8 hours, followed by collapse of the battery more than 72 hours after, resulting in a possible alkaline leakage (1). Votteler et al, who inserted a 1.5 V battery into dog esophagus, noted ulcer formation after 2 hours (20). These findings thus suggest that batteries should be quickly recovered if they are located within the esophagus or stomach.

Endoscopic procedures for removal of batteries aim at avoiding long-term monitoring of progress, risk of complications, or bloody surgical removal. Although such procedures have the advantage of permitting removal of batteries under direct view, if the battery is present in the midst of residual food, it may be difficult to achieve removal even with endoscopic procedures. For such procedures, fasting, intrabronchial intubation and general anesthesia and endoscopic facilities (21) and physicians skilled in infantile endoscopy are required. Litovitz succeeded in removing batteries in only three (37.5%) of their eight cases (22). Endo et al suggested the use of a magnet at the time of endoscopic removal of batteries, since a higher rate of removal may be achieved with its use (2). If removal is difficult to achieve or the battery is located within the intestines, the patient must be treated with laxatives, followed by moni-

toring of progress. However, there have been some reported cases of the battery straying into Meckel's diverticulum, and eventually resulting in perforation. In this connection, Willis and Ho suggested that batteries with poor movability should be forced to move under X-ray fluorosocpy (23). In such cases, progress should be monitored with frequent repetition of radiographic examination.

Equen developed a method to recover foreign bodies from within the gastrointestinal tract with a magnet in 1944 (24), and a large number of reports of the usefulness of this method have since been published (9, 25–27). Given parental anxiety, the requirement of several repetitions of radiographic examination, hospitalization or difficulty in removal with endoscopic procedures in cases of non-evacuation from the stomach (22), we believe that recovery of alkaline batteries from the stomach using a magnet at the time of first consultation is a much safer and more reliable method. Some authors have tried the use of electromagnets (28), but these have the disadvantage of generating heat. We thus think it better to use small-sized permanent magnets such as ferrite magnets or rare-earth magnets which do not dissolve in the acid of the stomach. Recovery with magnets does not require anesthesia or special techniques, and may be achieved even in the presence of residual food. Hirata et al pointed out the possibility that an erroneously ingested foreign body may occasionally come off from the magnet catheter. In such cases, they recommend the combined use of a basket catheter (29). In our hospital, we easily removed button batteries from the stomach within 5 minutes in all cases with two tubes with ferrite magnets nearly the same size as the button batteries themselves. We report this procedure because it seems convenient and useful.

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