

Perforation of Meckel's diverticulum by an alkaline hearing aid battery

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With recent advances in electronic technology, a large number of miniature cell batteries are in daily use. These batteries generally consist of an outer nickel-plated can (the cathode) and a gold-plated top (the anode) joined by a plastic seal. They usually contain approximately 40% to 45% potassium hydroxide, mercury salts and zinc; some also contain silver oxide.

Small foreign bodies are not infrequently ingested by children, and most pass uneventfully through the gastrointestinal tract. Three cases, two fatal, of accidental ingestion of small alkaline batteries by young children have been reported.¹⁻³ Leakage of the highly caustic potassium hydroxide from the battery produced liquefaction necrosis and subsequent perforation of the esophagus in each of the fatal cases. While perforation of Meckel's diverticulum by a foreign body has been described, the following is the first report of such a perforation after an alkaline hearing aid battery was swallowed.

Case report

Clinical course

A 2½-year-old boy was first seen on the evening of June 6, 1979 at the emergency room of Langley Memorial Hospital, 2 days after swallowing possibly two Ray-O-Vac 675 RP hearing aid batteries (Ray-O-Vac division, E.S.B. Inc., Madison, Wisconsin). The child had been complaining of intermittent "stomach ache" the previous day and had vomited once. The mother had been searching the child's stools but had not recovered either battery. However, the child had had a bowel movement in his mother's absence the day following the ingestion and could have passed either one or both of the batteries at that time.

When examined, the boy was in no distress. His abdomen was soft, with no

guarding or gross tenderness; plain roentgenograms showed a round metallic foreign body in the lower abdomen, possibly in the terminal ileum or the colon. Owing to incomplete information on the nature and contents of the battery, and because the physical findings were essentially unremarkable, a further period of observation was decided upon and the child sent home.

Next morning the child was brought back to the hospital. He had had abdominal pain throughout the night, had not slept well and had had loose bowel movements; no battery had been found in the stools. The child was somewhat apprehensive. There was tenderness in the mid-abdomen and some guarding, but the bowel sounds were normal. Plain abdominal roentgenograms showed that the foreign body had not changed position, and a Gastrografin (meglumine and sodium diatrizoate) enema demonstrated that it was not in the colon.

At this time, information obtained from the B.C. Drug and Poison Information Centre suggested that the battery could contain potassium hydroxide and a mercury salt, which could be dangerous if leakage occurred. The battery's manufacturer confirmed that the battery contained 40% potassium hydroxide and approximately 1 g of mercury as mercuric oxide.

Laparotomy was performed immediately. There was a moderate amount of thin, turbid fluid in the peritoneal cavity. A Meckel's diverticulum, measuring 2 × 3 cm, was present about 28 cm from the ileocecal junction. It was edematous, indurated and hemorrhagic. There was necrosis along its base, and perforation and leakage on one side. A battery was lodged in the diverticulum. About 8 cm distally along the small bowel there was an area of superficial necrosis, measuring 1 × 2 cm, that probably represented an area of contact with the Meckel's diverticulum. A segment of small bowel about 17 cm long, including the diverticulum and the area of superficial necrosis, was resected. The removed battery was approximately 1.5 cm in diameter and 8 mm thick. It appeared to be intact, although its outer surface was pitted. The battery was not cleaned before being forwarded to the manufac-

turer for analysis. Microscopic examination of a section of the Meckel's diverticulum revealed an area of transmural necrosis but no areas of ectopic gastric mucosa.

The child's postoperative course was uneventful. Urinalysis and renal function tests, including measurement of the blood urea nitrogen and serum creatinine levels, gave normal results. No mercury was detected in a 24-hour urine collection.

Laboratory analysis of battery

The battery's manufacturer reported that the gold-plated top of the cell, the anode, showed only minor pitting after being cleaned. In contrast, the nickel plating of the can, the cathode, was largely missing, and in some places the base metal was also missing, so that the inside plating was revealed. There appeared to be some cracks in the inside plating. The surface of the can-grommet interface was badly corroded; however, there was just enough metal to hold the can together (Fig. 1).

The cell was taken apart, and the weights of its metal parts and components were compared with those of two undischarged batteries of the same make. The data obtained are presented in Table I.

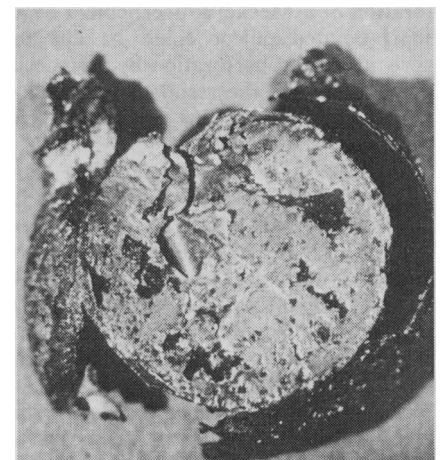


FIG. 1—Bottom view of ingested Ray-O-Vac 675 RP battery after being cleaned and taken apart, showing loss of nickel plating, marked pitting, and corrosion of surface of can-grommet interface.

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Discussion

The loss in weight of the can of the ingested battery, 0.184 g, was probably due to the loss of the nickel plating and base metal. The loss of 0.022 g of potassium hydroxide could be attributed to leakage due to a loss of integrity of the plastic seal or to cracks in the inside plating of the cell, or both. The presence of a small amount of chloride indicates some transmission from the gastrointestinal tract to the inside of the battery cell. The increased weight of the electrolyte would be due primarily to conversion of the zinc in the anode to zinc oxide.

Approximately 90% of ingested foreign bodies pass uneventfully through the gastrointestinal tract, regardless of their size, shape or composition.^{4,5} The ingestion of foreign bodies is rarely associated with intestinal perforation. In a series of 800 cases of such ingestion reported by Henderson and Gaston,⁶ perforation occurred in less than 1%. The time taken for all types of foreign bodies to pass through the gastrointestinal tract has averaged 5 to 6 days and ranged from 1 day in an infant who swallowed a pin to 37 days in a child who swallowed a nail.^{4,6}

A Meckel's diverticulum is present in 1% to 2% of individuals and is three times more common in males than in females.⁷ Perforation of Meckel's diverticulum by a foreign body is rare: only 42 cases have previously been reported.⁷⁻¹⁵ The objects responsible for these perforations were a fish bone in 23 cases, a wood splinter in 6 cases, a needle or pin in 4 cases, a rolled tomato skin in 2 cases, and a prune pit, a grape seed, a chicken bone, bone and wood, a cabbage stalk, metallic costume jewelry, and a toothbrush bristle in 1 case each.

Ward-McQuaid⁹ suggested that perforation of a Meckel's diverticulum by a sharp-pointed object could be due to peristalsis, and perforation by a smooth object could be the result of inflammation and ulceration due to pressure on the diverticular wall.

Ingestion of a miniature alkaline battery proved fatal in two children when it resulted in perforation of the esophagus.^{1,2} The battery, lodged in the esophagus for 24 hours in one patient and for 3 days in the other, was surgically removed and appeared intact in each case. Microscopic examination of esophageal tissue from both patients revealed liquefaction necrosis similar to that seen with alkali burns produced experimentally in animals by the application of a strong solution of potassium hydroxide to the esophagus; the findings in the patients were felt not to be consistent with those seen in pressure necrosis.²

A third case of ingestion of a small alkaline battery was reported by Reilly.³ The battery was in the stomach for approximately 25 hours before being removed by gastrotomy. It was found to be heavily corroded and fell into two sections during removal. The patient experienced no untoward effects, and no mercury was detected in the urine. After being immersed in a solution of hydrochloric acid of pH 1.5 for 5 hours a similar battery was discoloured and bubbling vigorously, Reilly noted.

In three cases unreported in the literature alkaline batteries were ingested by children but caused no symptoms before being passed. No marked changes were noted in the battery recovered after 1.5 days; however, those present in the gastrointestinal tract for 3.5 and 4 days showed marked pitting and a loss of the nickel plating. None showed a loss of seal integrity, and little or none of the contents was lost from the cells (Ray-O-Vac; personal communication, 1979).

In the case we have reported, analysis of the battery suggested leakage of the contents due to corrosion of the cell and possibly also to loss of integrity of the seal. The necrosis, hemorrhage and perforation of the Meckel's diverticulum and the superficial necrosis in an adjacent area of the bowel 3 days after ingestion of the battery indicate that the alkaline contents, not pressure necrosis, caused the perforation.

In all cases of ingestion of an alkaline battery serial roentgenography should be performed. If the battery becomes arrested in the esophagus, remains in the stomach for 24 hours or longer, or fails to negotiate the entire gastrointestinal tract in 48 hours, or if the patient exhibits signs of peritoneal irritation, surgical intervention is strongly indicated.

Table 1—Weights of metal parts and cell components of ingested Ray-O-Vac 675 RP battery, and differences from those for two undischarged batteries of the same make


Part or component	Weight (g)	
	Ingested battery	Average difference from that for undischarged batteries
Top (anode)	0.386	-0.012
Retaining ring	0.122	-0.066
Can (cathode)	0.215	-0.184
Anode		
Dry weight	0.334	+0.028
Cathode		
Dry weight	0.949	-0.116
Mercury	0.747	-0.076
Electrolyte		
Total weight	0.270	+0.106
Potassium hydroxide	0.050	-0.022
Zinc oxide	0.037	+0.034
Chloride	0.001	+0.001

The ingestion of small alkaline batteries can cause serious complications and death; health professionals and parents should be aware of the danger.

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