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Miniature Battery Foreign Bodies in Auditory and Nasal Cavities

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A series of cases involving button batteries lodged in the ear or nasal cavity is presented. All produced tissue destruction. Injuries were generally severe, and included tympanic membrane perforation (three patients) or total destruction (three), marked necrosis of dermis of the external ear canal with exposed bone (seven), documented further impairment of hearing (three), destruction of ossicles (two), facial nerve paralysis and chondritis (one), nasal septal perforation (one), and superficial burns of nasal mucosa (one). Otic and nasal drops must be withheld as they provide an external electrolyte bath for the battery, enhancing leakage and generation of an external current, with subsequent tissue electrolysis and hydroxide formation. Instead, batteries lodged in the ear or nose must be removed promptly.

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SINCE the introduction of miniature cell batteries in watches, calculators, hearing aids, photographic equipment, and children's toys, more than 225 ingestions have been reported in the medical literature.[1-7] These reports focus on the effects of batteries on the esophagus and gastrointestinal tract and present divergent assessments of the hazard of battery ingestion. Esophageal perforation has been reported as early as six hours after ingestion, and animal studies by Maves et al[8] have demonstrated esophageal perforation in eight to 12 hours in cats with batteries suspended in the esophagus. Most authors agree that esophageal lodgment is an indication for expedient endoscopic removal,[1-8] whereas a more distal gastrointestinal location usually implies a favorable prognosis. Watchful waiting is advocated when batteries pass through to the stomach spontaneously. Ninety percent of 111 disk battery ingestions described by Litovitz[7] remained asymptomatic, and only one patient had severe symptoms or complications (an 11-month-old child with esophageal lodgment and perforation).

Little has been written about battery lodgment in other orifices. This study focuses on a series of reports to the National Button Battery Ingestion Hotline involving impaction of batteries in the external auditory canal or nasal cavity.

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Methods

Cases were reported to the National Button Battery Ingestion Hotline in the National Capital Poison Center at Georgetown University Hospital, Washington, DC, between September 1983 and May 1985. (Patient 1 is a patient of one of us [K.T.K.].) Reports were primarily

Clinical Outcome of Patients With Batteries Lodged in Ear or Nose

Patient/ Age, yr	Intended Use of Battery	Battery Diameter, mm	Chemical System	Clinical Outcome
Batteries lodged in ear				
1/7	Watch	7.9	Silver oxide	Entire TM* and 75°/ of skin of external canal sloughed; 75% of manubrium blackened; exposed bone over 25% of canal wall; TM reformed over 4 wk; residual 15-dB conductive hear ing loss
2/7	Unknown	7.9	Unknown	Otalgia and otorrhea with swelling, red ness, and fever; marked necrosis of canal skin with exposed bone; TM intact; slight conductive hearing loss
3/82	Hearing aid	Unknown	Unknown	Diffuse pain and edema in left ear; blackish discharge; skin eroded, patches of exposed bone; TM perfo ration; hearing deteriorated from 60 to 85-dB loss
4/54	Hearing aid	Unknown	Unknown	Excoriation of canal with much black debris; TM and portion of ossicles destroyed
5/70	Hearing aid	11.6	Mercuric oxide	Prior mastoidectomy; patient presented with facial nerve paralysis, nystag mus, and vertigo; alkaline burns of inner ear and canal and chondritis
6/84	Hearing aid	Unknown	Unknown	Two batteries removed from ear canal; blackish purulent discharge; large central perforation of TM remained; hearing deteriorated
7/80	Hearing aid	7.9	Mercuric oxide	TM completely destroyed; erosion of 75% of dermis of external canal into mastoid bone; mercury droplets vi sualized in external canal; profound hearing loss (unknown if worsened)
8t/6	Watch	Unknown	Unknown	Swollen, pus-filled canal; treated with otic drops; battery expelled sponta neously; subsequent examination re vealed large perforation of TM and erosion of canal
Batteries lodged in nose				
9/2	Unknown	11.6	Silver Oxide	2- to 3-mm superficial oval burn on right inferior turbinate with bloody drainage
10/2	Hearing aid (child's own)	7.9	Mercuric Oxide	Large septa) perforation; frequent nose bleeds, crusting, impaired smell

* TM indicates tympanic membrane.
t Case reported by Rachlin.[9]

generated by health care providers aware of this information resource through announcements to poison centers, notices in newsletters, journals, and toxicologic resources, and warning labels on battery packaging. The hotline functions as a 24-hour emergency consultation service as well as a case registry. Detailed histories are obtained on each case reported, and follow-up calls are placed to the patient or physician until the final medical outcome can be determined. After removal (or passage if ingested), batteries are sent to the poison center for determination of the extent of corrosion by visual assessment of the degree of crimp area dissolution and pitting. One additional case (Table, case 8) was retrieved from the medical literature[9] and is included in our analysis to allow a comprehensive assessment of the problem.

Results

Eight patients presented with button batteries lodged in the ear (including one patient [No. 6]with two batteries in the ear, and another [No. 4] with a history of prior removal of another button battery from the ear). Two patients presented with batteries lodged in the nares. The age distribution, battery type, and clinical outcome for each of these cases is outlined in the Table.

A delay in battery removal occurred inmost cases. Four patients were treated initially with antimicrobial/corticosteroid ear drops for foreign-body presence (case I), otalgia, otorrhea, and edema (cases 2 and 8), or otalgia alone (case 4). In other cases, a presumably lengthy delay preceded discovery of the impacted foreign body because of patient confusion or memory loss secondary to advanced age or concurrent disease. As a result, the precise interval between battery insertion and removal could not be documented in any of the adult cases.

Battery retrieval, even with direct visualization through an operating microscope, proved difficult in several cases. In case 2, the battery was removed with difficulty under general anesthesia, using Rosen needles to lever it anteriorly. The battery casing was punctured by the instrumentation and removed in pieces. In case 1, initial attempts to grasp the battery with alligator forceps were unsuccessful. Subsequently, cup forceps were demonstrated to easily perforate the battery casing. Removal was finally accomplished with ease by passing a 1-mm 90° pick in the plane between the battery and the tympanic membranes. Once the end of the pick was medial to the battery, it was rotated 90° and used to retract the button cell.

Comment

Mechanism of Tissue Injury.-Two diverse mechanisms are presently believed to cause the local tissue injury induced by disk batteries. The first involves battery leakage, either spontaneous or enhanced by instrumentation or corrosion of the crimp area. Crimp area corrosion occurs at a more rapid rate when the battery is immersed in an electrolyte solution (such as the fluid of the gastrointestinal tract or otic drops) and external currents develop across the crimp region. Spent batteries generate less electric potential for this process, but are not completely discharged. Batteries immersed in an acid medium (acetic acid-based otic drops) undergo corrosive reactions that result in dissolution of the steel can and formation of soluble iron, facilitating disassembly. Batteries in an alkaline or neutral medium form iron oxide and hydroxide precipitates, reducing can dissolution.[10]

The second mechanism involves the production of chlorine gas and sodium hydroxide from the electrolysis of the surrounding saline solution. This mechanism, proposed by Yamashita et al,[11] is supported by the work of

Votteler et al,[5] who noted gas bubbles, a black precipitate, and elevation of pH after in vitro battery placement in saline.

Mercury or other heavy metal poisoning is now known to be an unlikely consequence of button battery ingestion. Despite the presence of a potentially lethal amount of mercuric oxide within many button cells, both battery discharge and gastric acid (in the presence of iron dissolved from the steel can) convert these toxic oxides to nontoxic elemental mercury.[12]

Case Analysis.-The observation of significant complications in all eight patients with batteries lodged in the ear and one of the two patients with a battery lodged in the nose contrasts dramatically with the typically benign clinical outcome observed when button batteries are ingested. The implication of smaller-diameter batteries (7.9 or 11.6 mm vs 23.0 mm in esophageal impactions) correlates with the smaller aperture of the orifices involved.

All eight cases of battery lodgment in the ear produced complications, including tympanic membrane perforation (three) or total destruction (three), marked necrosis of dermis of the external ear canal with exposed bone (seven), documented further impairment of hearing (three), destruction of ossicles (two), and facial nerve paralysis with chondritis (one). One of the two cases of nasal impaction produced a septal perforation: a severe consequence in a 2-year-old because of the danger of midfacial growth inhibition.

Three factors are responsible for the severity of the injuries noted in these cases. The first, impaction, results in the continuous exposure of a localized tissue area to any damage caused by the battery. The second factor, delayed patient presentation or definitive removal, prolongs this local effect. The third factor is the immersion of the battery in an electrolyte-rich liquid medium, resulting in electrolysis and hydroxide production. The nasal mucosa can produce approximately a liter of secretions per day, which is more than enough for this latter process to occur. In the ear, impaction of the battery causes edema, weeping, and eventual infection. Once weeping occurs, electrolysis will commence and a severe alka line burn will result. In a dry canal, this process may be delayed. However, it will be hastened by the instillation of otic drops, an unfortunate reflexive therapy for the painful or draining ear. A battery foreign body is an absolute contraindication for the use of otic solutions and mandates an adequate physical examination and working diagnosis in all patients with otalgia and otorrhea.

The majority of the reported cases occurred in the very old or young. Of the nine batteries lodged. in ears (one patient had two batteries in the same ear), six were intended for hearing aid use. Elderly, hearing-impaired patients must be cautioned against inadvertent insertion of hearing aid batteries in the external ear canal rather than the aid. Pediatric hearing aids should be manufactured with child-resistant closures on the battery compartments, and battery access should be rendered more difficult in all products available to toddlers, especially toys and children's watches. Prevention also mandates storage of replacement batteries and disposal of discharged cells out of the reach and view of children.

Patient Management and Method of Foreign-Body Removal.-All otologic and nasal battery foreign bodies should be removed immediately. Unlike a gastrointestinal foreign body, there is little chance of spontaneous passage. A battery impacted in the nasal cavity can be removed under general anesthesia, using standard sinus instruments. Removal from the ear can be difficult unless proper technique is utilized. A disk battery that has a very tight fit in the external auditory canal can only move in two directions: medially and laterally. A 1-mm 90° pick can be passed in the plane between the drum and the battery. Once the end of the pick is medial to the battery, it is rotated 90° and used to pull the battery out of the canal. An alligator forcep will not grab the battery's convex surface. Biting instruments (cup forceps, etc) should be avoided because they can easily perforate the already corroded thin battery casing. This occurred in cases 1 and 2, both involving batteries impacted in the relatively small ear canal of a child. After removal of the battery, the impaction site should be thoroughly irrigated to remove any precipitate and foreign material. The importance of irrigation must be emphasized in light of the alkaline nature of the battery contents and the need to prevent possible continued alkaline injury. Close patient follow-up is indicated for debridement of necrotic tissue, which will continue to slough over the ensuing weeks. During this time, the patient should be treated with otic drops. Subsequent follow-up is important to prevent impending stenosis or nasal synechia by placing ear canal or nasal stents.

Summary of Recommendations.-(1) All batteries in the external auditory canal and nasal cavities should be removed immediately. (2) In otologic impaction, a 90° pick will easily remove the battery. (3) Nasal or otic drops **must be avoided** before battery removal. **After** removal, the canal should be irrigated to remove the precipitate and any foreign material as completely as possible. (4) Close patient follow-up is indicated to debride necrotic tissue and monitor healing.

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References

1. Mofenson HC, Greensher J, Caraccio TR., et al: Ingestion of small flat disc batteries. *Anr Emerg Med 1983;12:88-90.*

2. Litovitz TL: Button battery ingestions: A review of 56 cases. *JAMA 1983;249:2495-2500.*

3. Janik JS, Burrington JD, Wayne ER, et al: Alkaline battery ingestion. Colo *Med 1982; 79:404-405.*

4. Kulig K, Rumack CM, Rumack BH, et al: Disk battery ingestion: Elevated urine mercury levels and enema removal of battery fragments. *JAMA 1983;249:2502-2504.*

5. Votteler TP, Nash JC, Rutledge JC: The hazard of ingested alkaline disk batteries in children. *JAMA 1983;249:2504-2506.*

6. Beyer P, Muhlendahl KE, Krienke EG: Ingestion von kleinen queck-silberbatterien (Knopfbatterien): Mogliche Komplikationen. *Padiatr Prax 1981;24:455-460.*

7. Litovitz TL: Battery ingestions: Product accessibility and clinical course. *Pediatrics 1985; 75:469-476.*

8. Maves MD, Carithers JS, Birck HG: Esophageal burns secondary to disc battery ingestion. *Ann Otol Rhinol Laryngol 1984;93:364-369.*

9. Rachlin LS: Assault with battery, N *Engl J Med 1984;311:921-922.*

10. Litovitz T, Butterfield AB, Holloway RR, et al: Button battery ingestion: Assessment of therapeutic modalities and battery discharge state. *J Pediatr 1984;105:868-873.*

11. Yamashita M, Saito S, Koyama K, et al: Chemical burns due to low voltage direct current: Button type battery. *Igaku no Ayumi 1983;126:957-959.*

12. Barber TE, Menke RD: The relationship of ingested iron to the absorption of mercuric oxide. *Am J Emerg Med 1984;2:500-503.*