Letter to the Editor

In Response to Letter to the Editor Regarding: pH-Neutralizing Esophageal Irrigations as a Novel Mitigation Strategy for Button Battery Injury

In Reply:

We would like to thank Dr. Labadie et al. for their inquiries related to our recent publication.1

In the United States, organized collaborative efforts to reduce button battery (BB) injuries have been implemented through a National Button Battery Task Force.2 We completely agree that replicating the clinical scenario of human BB ingestion in an animal model is difficult and note that randomized controlled human studies are not feasible. Mitigating a severe hazard such as an esophageal BB, anything to potentially reduce the rate of injury in a child who can swallow liquids should be considered. In our study, laboratory conditions were standardized to be able to simply compare an intervention to a control. The laboratory conditions with anesthetized animals and direct placement of the anode face on the esophageal mucosa created an ideal environment for injury typically not observed in clinical settings. Thus, the faster rate of injury progression and increased incidence of perforation is not unexpected. This brings the question—when directly compared, even in idealized conditions, is any intervention better than nothing? We believe so because a statistically significant improvement in several parameters for honey or sucralfate (Carafate) was noted relative to control.

To directly answer the suggestion of saline acting as an accelerant for injury, we did not find an overall statistically significant difference between saline and artificial saliva when compared in vitro (P < 0.001). Importantly, sterile saline is a commercially available and can act as a stable and consistent control solution between separate experimental trials with less potential variability than artificial saliva.

The 60-minute BB exposure in vivo testing duration created enough damage for injury characterization and the opportunity for histopathological assessment of any treatment efficacy after ~7 days of healing. Preliminary testing with a 180-minute BB exposure resulted in injury beyond a full-thickness perforation; due to distress, the animal was euthanized prematurely in compliance with Institutional Animal Care and Use Committee protocol (IACUC) protocol.

The primary mechanism of BB injury results from hydroxide ions at the anode to cathode step-off, leading to liquefactive necrosis.1,4 Our group has previously tested sterile water in vitro and does not provide any protective barrier or pH neutralization properties.3 Thus, the use of sterile water would be ineffective for injury mitigation. Lemon juice was a nonviscous solution tested that had protective effects, which is not a palatable option for children.3 Our most recent study established the need for the dual action of barrier protection and pH neutralization, which was accomplished using higher viscosity weakly acidic liquids.1 Honey and sucralfate (Carafate)4 not only halted the injury progression at the time of development but also improved tissue architecture 7 days out by promoting a more robust healing response in severely injured areas.1 These findings correlate with the observed reduction in delayed esophageal perforations, which is also suggestive of their potential to help reduce the likelihood of late-stage complications such as massive fatal hemorrhage from aorto-esophageal fistulas. In addition to pre-removal mitigation strategies, 0.25% acetic acid irrigations after BB removal may blunt injury progression to more severe complications.3,4 This 0.25% acetic acid irrigation technique was recently cited as the reason for improved short- and long-term outcome in a severe circumferential esophageal injury in a 15-month-old patient with two lithium esophageal BBs.5

A proximal esophageal location was studied because: 1) a majority of esophageal BB are proximally located, and 2) to ensure in vivo experimental standardization. This location facilitated the ease of BB placement/removal, intervention delivery, in situ endoscopic visualization of the injury site, and tissue pH testing. Given the use of 10 mL repeated esophageal irrigations, there is potential for protective effects anywhere in the esophagus. A vertically oriented BB anywhere in the esophagus typically does not cause complete esophageal obstruction and can allow liquids to flow around it. We agree that additional studies with varied volumes and time intervals could help optimize and assess treatment efficacy for mid/distal esophageal BBs. Nevertheless, esophageal location is determined by X-ray, and there may be variable, unavoidable delays with transport to a pediatric facility, internal hospital transport, and operating room or endoscopist availability. Based on these uncertainties.

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and the statistically significant potential to attenuate injury severity during this period before BB removal, it is appropriate to recommend prompt treatment initiation with honey or sucralfate (Carafate®) for known or suspected ingestions. Creating favorable environmental conditions for any duration can have a positive impact, even if mitigation treatments do not span the entire interval from BB ingestion to removal. It should be noted that prior to our work, no potential pre-removal mitigation strategies existed. We plan to track outcomes and collect data for patients who utilize these pre-removal strategies.

It is clear that the esophageal BB hazard is severe and can lead to debilitating long-term complications and death. The risks and potential benefits of these pre-removal interventions must be weighed against rapid development of BB injury. Most children going to the operating room with an esophageal BB are not NPO by standard anesthesia guidelines, as removal is considered an emergency. Nationally recognized pediatric anesthesia specialists and organizations have reviewed our data and determined that anesthetic-related risks such as aspiration are low with rapid sequence induction techniques. The period from ingestion to removal is a critical time when interventions may provide the maximal benefit and should be exploited as a potential target to improve patient outcomes. According to human data, there is an extremely low probability for an existing perforation or early-stage mediastinitis that would limit oral intake within 12 hours of BB ingestion.6 After independent review of our data, the National Capital Poison Center updated their guidelines to recommend honey and sucralfate (Carafate®) within this window for children who can safely swallow.4

For additional information on the latest National Capital Poison Center Button Battery Triage and Treatment Guidelines: https://www.poison.org/battery/guideline.

Rachel R. Anfang, MA
Sidney Kimmel Medical College, Thomas Jefferson University, Philadelphia, Pennsylvania, U.S.A

Kris R. Jatana, MD*
Department of Otolaryngology–Head and Neck Surgery, Nationwide Children’s Hospital and Wexner Medical Center at Ohio State University, Columbus, Ohio, U.S.A

Rebecca L. Linn, MD
Division of Anatomic Pathology, Department of Pathology and Laboratory Medicine, Children’s Hospital of Philadelphia (CHOP), Philadelphia, Pennsylvania, U.S.A

Keith Rhoades, BS and Jared Fry, BS
Intertek Product Intelligence Group Inc., Arlington Heights, Illinois

Ian N. Jacobs, MD
Department of Otorhinolaryngology–Head and Neck Surgery, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, Pennsylvania, U.S.A

*Send correspondence to Kris R. Jatana, MD, Pediatric Otolaryngology, Nationwide Children’s Hospital, 555 South 18th Street, Suite 2A, Columbus, OH 43205. Ph: 614-722-6600; Fax: 614-722-6609. E-mail: Kris.Jatana@nationwidechildrens.org

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