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Original Article

Clinical features, management, and complications of paediatric button battery ingestions in Canada: an active surveillance study using surveys of Canadian paediatricians and paediatric subspecialists

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Abstract

Background: Button battery ingestions pose a serious threat to paediatric health and are on the rise worldwide. Little is known about Canadian data. This study described the type of button battery ingestions Canadian paediatric physicians have observed, including treatment and complications.

Methods: A Canadian Paediatric Surveillance Program (CPSP) survey was sent to paediatricians and paediatric subspecialists. The questions were developed through a literature review and consultation with 19 CPSP members, before piloting with 5 paediatric physicians. Descriptive analyses were conducted.

Results: The response rate was 39% (n = 1067/2716). Few were aware of treatment options with honey (n = 189/1067, 18%) and sucralfate (n = 118/1067, 11%). Two hundred and ninety-nine physicians (28%) had been involved in a case in the past 1 year (n = 132 case details). Children < 3 years were most affected (n = 67/132, 51%). In unwitnessed ingestions (n = 41/132, 31%), the most common symptoms were dysphagia (n = 14/41, 34%) and coughing (n = 10/41, 24%). When it was known where the child found the battery, it was most commonly loose in the environment (n = 34/132, 26%). Seventy per cent of patients (n = 92/132) presented within 6 h following the ingestion. Six per cent (n = 8/132) reported the battery eroding into important adjacent structures (eg, aorta and trachea).

Interpretation: A high degree of suspicion for button battery ingestion is needed in young children presenting with dysphagia and coughing. Prevention efforts should be aimed at battery disposal and security. There is a need for dissemination of guidelines to physicians caring for paediatric patients, since modifiable patient factors, such as honey and/or sucralfate administration while awaiting definitive treatment, can improve outcomes.

Key words: button battery; ingestion; foreign body

Introduction

Button battery ingestions pose a serious threat to paediatric health. Tissue damage occurs in as little as 15 min, and carries high morbidity and mortality.[1–3] Ingestions are most dangerous when the battery becomes lodged in the oesophagus; smaller-sized patients (ie, paediatric patients) are at the highest risk. The battery can erode into adjacent structures such as large blood vessels and the airway, via liquefactive and pressure necrosis, and corrosive injury. There have been recent efforts aimed at the creation and dissemination of guidelines to assist in the diagnosis and management of button battery ingestions given the increasing frequency of these events and their adverse outcomes.[4,5]

In the United States, the rate of button battery ingestions increased by over 1500% from 1995 to 2015, with a corresponding nearly 10-fold increase in complications.[6,7] The British Paediatric Surveillance Unit[8] and Australian Paediatric Surveillance Units[9] have similarly recently launched surveillance studies to gather more information on these ingestions in their respective countries. Little is known about rates in Canada. The objective of this study was therefore to describe button battery ingestion cases that Canadian paediatricians and paediatric subspecialists had recently observed, including treatments employed and ingestion complications.

Methods

Materials

The Canadian Paediatric Surveillance Program (CPSP) one-time survey (Appendix A) was developed after a review of the current literature and in conjunction with both general paediatricians and subspecialists through the CPSP (n = 19 members of the CPSP scientific steering committee, which includes members of the Canadian Paediatric Society, Immunization Monitoring Program ACTive (IMPACT),

the Paediatric Chairs of Canada, the Canadian College of Medical Geneticists, and the Canadian Association of Child Neurology). The CPSP (established in 1996) gathers information on rare conditions in Canadian children from members each month and disseminates between 1 and 4 one-time surveys each year. Each year CPSP enrols all newly certified practicing general paediatricians and paediatric subspecialists in Canada (yearly list sent to the CPSP by the Royal College of Physicians and Surgeons of Canada). CPSP is a voluntary program, and physicians can opt-out if they don't want to participate. At the time of this study survey, CPSP members included 2716 paediatricians and paediatric subspecialists. The CPSP reported their average survey response rate in 2022 to be 50%-100% across all 10 provinces, with 97% of their members signed up to respond to surveys electronically.[10] The survey questions were designed to be able to be completed in less than 5 min. After the survey questions were developed and revised, they were piloted with paediatricians and paediatric subspecialists ($n = 5$ total from 2 provinces) working in community practice, hospital medicine, and emergency medicine. Feedback was incorporated and the final survey was approved by the CPSP steering committee.

All individuals who opened the survey link (whether or not they had ever been involved in a button battery ingestion case) were asked to specify the number of children they had observed and/or treated for a button battery ingestion in the past 12 months, the type of paediatric medicine they practised, the location of their practice, and if they were aware of general button battery ingestion clinical care pathways regarding the timing of endoscopic removal of a battery, honey administration, and sucralfate administration. Those who had not observed or treated any child with problems related to button battery ingestions in the past 12 months then exited the survey. Those who had been involved with a case were asked to complete the rest of the survey, which asked case detail questions including age, presenting complaint, if the ingestion was witnessed and how the child accessed the button battery, if there was a co-ingestion, location of the battery, treatment received, injuries, and complications. The case details could be provided for up to 3 cases, and if the physician had additional case details they were asked to contact the CPSP for another survey. The survey questions were not randomized or adaptive and a completeness check was not done before the questionnaire was submitted. IP addresses and/or cookies were not used to identify if the individual opening the link was a unique visitor.

Procedure

The survey was programed online using the Canadian Network for Public Health Intelligence platform. The online survey was emailed out to the CPSP members on August 31, 2022 and closed on October 31, 2022. Two email reminders were sent when the survey was open. Once closed, the results were downloaded into a Microsoft Excel (2022) spreadsheet for analysis. A small proportion of CPSP participants still receive hard-copy surveys. Those that were returned were scanned and manually entered into the Excel spreadsheet.

Analysis

Each detailed patient case described (ie, completed the questionnaire case details, Appendix A Question #6) was screened for potential duplication. Cases within the same city or nearby cities were screened for similarities in case of details (eg, patient age, presenting symptoms, location of battery, and complications) and duplicate cases were removed. For physician responses that specified the number of button battery cases seen but did not provide patient details, these cases were unable to be screened for duplication. Survey responses were analyzed using descriptive statistics, including median and interquartile ranges for continuous variables, and frequency and percentage for categorical variables. There were no statistical corrections done to adjust for a potentially nonrepresentative sample. All analyses were done in SPSS Version 20 (IBM SPSS Statistics).

Results

Physician demographics

The response rate was 39% ($n = 1067/2716$; all electronic responses), with responses from all Canadian provinces. Two hundred and ninety-nine paediatric physicians (28%) had observed or were involved in, a total of 815 button battery ingestion cases in the previous 12 months, resulting in an average of 2.7 cases/physician/year. Of the physicians that identified their area of practice ($n = 145/299$, 48%), these physicians included both general paediatricians ($n = 46/145$, 32%) and subspecialists ($n = 99/145$, 68%). Of those that identified their subspecialty ($n = 94/99$, 95%), the most common were paediatric emergency medicine ($n = 32/94$, 34%), paediatric gastroenterology ($n = 12/94$, 13%), and paediatric intensive care ($n = 12/94$, 13%). Other subspecialties were less common, including developmental paediatrics ($n = 7/94$, 7%), endocrinology ($n = 7/94$, 7%), and cardiology ($n = 4/94$, 4%). Physicians involved in a button battery case predominantly worked in an urban environment ($n = 126/131$ respondents, 96%) and in academic practice ($n = 95/111$ respondents, 86%).

Guideline knowledge

Of all 1067 survey respondents, few were aware of general recommendations for pre-removal administration (<12 h since battery ingestion) of honey (10 mL every 10 min, maximum 6 doses) ($n = 189$, 18%) and sucralfate (10 mL every 10 min, maximum 3 doses) ($n = 118$, 11%) for button battery patients (Figure 1). Forty-six per cent ($n = 493$) knew about endoscopy removal recommendations (removal of the battery within 2 h if in the oesophagus). Of the 299 physicians who had seen or been involved in a button battery case, guideline knowledge was similar for honey ($n = 54/299$, 18%) and sucralfate ($n = 33/299$, 11%), but worse for endoscopic removal recommendations ($n = 99/299$, 33%). For physicians who work in the Emergency Department (generalists and subspecialists, $n = 178/299$, 60%), there was improved awareness of endoscopic removal recommendations ($n = 142/178$, 80%), but still low knowledge of honey ($n = 65/178$, 37%) and sucralfate ($n = 48/178$, 27%) administration.

All cases

Provincial demographics were provided for 308 patient cases ($n = 308/815$, 38%). The provinces with the most reported cases were Ontario ($n = 142/308$, 46%), Alberta ($n = 63/308$, 20%), and Quebec ($n = 46/308$, 15%). However, these were also the top 3 provinces that had the most survey respondents:

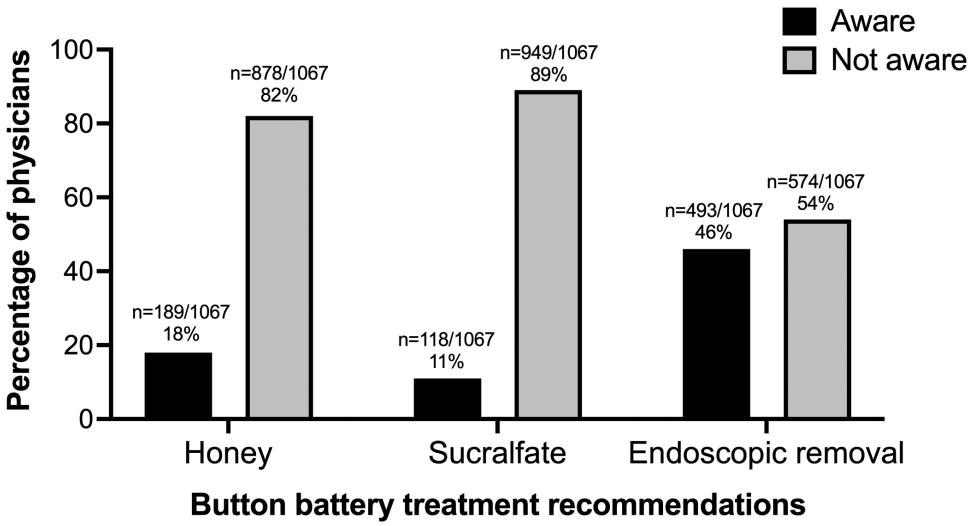

Figure 1. Physician (*n* = 1067) button battery treatment knowledge.

Ontario (*n* = 266/1067, 25%), Quebec (*n* = 150/1067, 14%), and Alberta (*n* = 91/1067, 9%).

Patient presentation

Of the 815 patient cases, patient details were provided for 133 patients (16%). One duplicate case was identified and excluded, resulting in a total of 132 patient case details included in the final analysis (Table 1). Only 4 cases (3%) were reported to Health Canada. The most affected age group was children between 1 and 2 years (*n* = 60/132, 46%), with the majority of cases (*n* = 111/132, 84%) being under the age of 5 years. Fifty-six per cent (*n* = 74/132) of ingestions were witnessed, with 31% (*n* = 41/132) unwitnessed and 13% (*n* = 17/132) unknown. Dysphagia (24%), coughing (12%), and pain (11%) were the most common presenting symptoms in all patients. For unwitnessed ingestions, the most common symptoms were the same as for all patients: dysphagia (*n* = 14/41, 34%), coughing (*n* = 10/41, 24%), and pain (*n* = 7/41, 17%). Asymptomatic unwitnessed ingestions came to healthcare attention due to caregiver concern for ingestion (*n* = 8/41, 20%) or the child telling their caregiver about the ingestion (*n* = 7/41, 17%). Haematemesis was rare overall (*n* = 2/132, 2%) but occurred only in unwitnessed ingestions. Three patients (2%) had co-ingestions, with another button battery (*n* = 1/132, 1%) or magnet (*n* = 2/132, 2%). Seventy per cent of all patients (*n* = 92/132) presented acutely to healthcare assessment, within 6 h of ingestion.

Battery access and ingestion intent

In 56% of cases (*n* = 73/132) it was unknown where the child obtained the button battery (Table 1). In 26% of ingestions (*n* = 34/132), the battery was found lying around or on the ground. In 86% of patients (*n* = 113/132), the ingestion was accidental, occurring in a developmentally appropriate child.

Patient interventions and outcomes

Few patients received honey (*n* = 32/132, 24%), sucralfate (*n* = 9/132, 7%), or both (*n* = 1/132, 1%). For patients where it was known, it was less than 6 h since ingestion (*n* = 92/132, 70%), 32% (*n* = 29/92) received honey, and 7% (*n* = 6/92) received sucralfate. Information about the button battery size or voltage was not collected, so it is unknown how this factor affected honey and/or sucralfate administration.

The battery was endoscopically removed in 77 patients (58%). This included 69 patients (53%) who had the battery lodged in their oesophagus at the time of assessment. It is unknown if acetic acid was administered during endoscopy as this question was not asked. Of those who did not have endoscopic removal (*n* = 55/132, 42%), 3 patients had initially presented with the battery in the oesophagus.

Injuries and complications secondary to the ingestion are displayed in Figure 2. Of the known injuries, oesophageal or gastric burns/mucosal injury (*n* = 38/132, 29%) was the most common. Eight patients (6%) had the battery erode through tissue into adjacent structures, including oesophageal perforation (*n* = 4/132, 3%), aortoesophageal fistula (*n* = 2/132, 2%), tracheoesophageal fistula (TEF) (*n* = 2/132, 2%), and nasal septum perforation (*n* = 1/132, 1%). Five patients (4%) developed oesophageal strictures. There were 2 reported patient deaths (2%), which included 1 patient with an aortoesophageal fistula and 1 patient with an oesophageal perforation. Haematemesis as a presenting symptom (*n* = 2/132, 2%) was associated with significant complications (*n* = 1 death, *n* = 1 oesophageal stricture). All significant injuries and complications occurred with both witnessed ingestions (*n* = 2/74, 3% oesophageal perforation; *n* = 1/74, 1% TEF; *n* = 1/74, 1% oesophageal stricture; *n* = 1/74, 1% death due to oesophageal perforation) and unwitnessed ingestions (*n* = 2/41, 5% oesophageal perforation; *n* = 2/41, 5% oesophageal strictures; *n* = 2/41, 5% aortoesophageal fistula; *n* = 1, 2% death due to aortoesophageal fistula).

Discussion

To our knowledge, this is the first study to report Canadian paediatric physicians' experiences with paediatric button battery ingestions. Nearly a third of participating physicians had been involved in, or observed, a case within the last year, including individuals from general paediatrics, multiple paediatric subspecialties, and both academic and community

Table 1. Patient presentation details (n = 132) of reported paediatric button battery ingestions in the previous 12 months.

Age (years)	Frequency (percentage)
<1	7 (5)
1-2	60 (46)
3-4	44 (33)
5-9	15 (11)
≥10	2 (2)
Not specified	4 (3)
Witnessed ingestion	
Yes	74 (56)
No	41 (31)
Unknown	17 (13)
Co-ingestion	
None	127 (96)
Magnet	2 (2)
Unknown	2 (2)
Another button battery	1 (1)
Location of battery at time of assessment	
Oesophagus	69 (52)
Stomach	42 (32)
Intestine	14 (11)
Unknown	6 (5)
Nose	1 (1)
Time from ingestion to healthcare assessment	
<2 h	42 (32)
2-6 h	50 (38)
>6 h	17 (13)
>24 h	13 (10)
Unknown	10 (8)
Presenting concerns/symptoms[a]	
Witnessed ingestion	74 (56)
Dysphagia	32 (24)
Coughing	16 (12)
Pain	14 (11)
Told their parents about the ingestion	9 (7)
Concern for ingestion of unknown object	7 (5)
Haematemesis	2 (2)
Vomiting	1 (1)
Access to button battery	
Unknown	74 (56)
Found on the ground/lying around	34 (26)
Inside a household product (eg, car keys)	13 (10)
Inside a toy	10 (8)
Inside a medical device (eg, hearing aid)	1 (1)
Ingestion intent	
Accidental, no developmental delay	113 (86)
Unknown	14 (11)
Accidental, developmental delay	3 (2)
Impulsivity	1 (1)
Self-harm	1 (1)

[a]Able to select more than 1 answer.

practice locations. Button battery ingestions were, unfortunately, a problem across the entire country, demonstrating the pervasiveness of this important public health issue.

The most commonly affected population was those under the age of 5 years, particularly those under the age of 3, who may not be able to verbalize symptoms or details of the ingestion. Compared to the previously published US data, we identified a larger percentage of patients in this younger age category, with under the age of 6 years accounting for 84% (vs. 62%[6]). This is important, as younger age at the time of ingestion has been identified as a significant predictor of resultant major complications.[6] This is likely related to the smaller size of the patient (and oesophageal lumen), which increases the likelihood of oesophageal impaction of the swallowed battery.

Only half of button battery ingestions in this study were witnessed, highlighting the importance of a high degree of suspicion even in the absence of a history of foreign body ingestion. Combining this with the very young age of most presenting patients highlights how easily this type of ingestion can be missed. A previous review of button battery ingestions in the United States also found that most ingestions were unwitnessed, including nearly all the fatalities and over half of the patients who developed major complications.[6]

Clinical symptoms were not identified as the main presenting complaint in nearly half of patients. In those that did have symptoms, dysphagia, coughing, and pain were the most common. These were the most common symptoms in both witnessed and unwitnessed ingestions. The presence of any symptoms at the time of clinical assessment has been identified as an important predictor of more severe outcomes following a button battery ingestion.[11,12] Gastrointestinal bleeding was a rare initial presenting symptom in our study. Vascular injuries may have a delayed presentation, as opposed to the initial presentation, and can develop even after a battery has been removed. Patients re-presenting with haematemesis have been described even 1 month post-discharge.[11–13] A recent large review of vascular complications after button battery ingestions in children found a higher risk of death in those who developed vascular injury, with over 80% of complications being lethal.[13] Although rare, any GI bleeding, including in those with a previous/remote history of button battery ingestion, needs to be taken very seriously. This is even important in those with no history of a witnessed ingestion, as our study identified 2 cases of aortoesophageal fistulas in patients who both had unwitnessed ingestions.

Most patients presented with the battery lodged in their oesophagus, which is the most serious and time-sensitive type of button battery ingestion. Tissue damage begins as soon as 15 min after oesophageal impaction, with significant burns evident as soon as 2 h post-ingestion.[14,15] The most serious complications are linked to this anatomical location, including aortoesophgeal fistula and tracheoesophageal fistula. Battery erosion through important anatomical structures was reported in 6% of patients in this current study. These types of injuries increase substantially with a longer battery in situ time. In our study, if the time of ingestion was known, less than one-third of cases were presented for assessment by a healthcare professional within the first 2 h following ingestion. One in 10 cases presented over 24 h later. Unwitnessed ingestions, which were found to be common, are also at high risk of injury given the unknown in situ time and should be assessed and treated with this in mind.

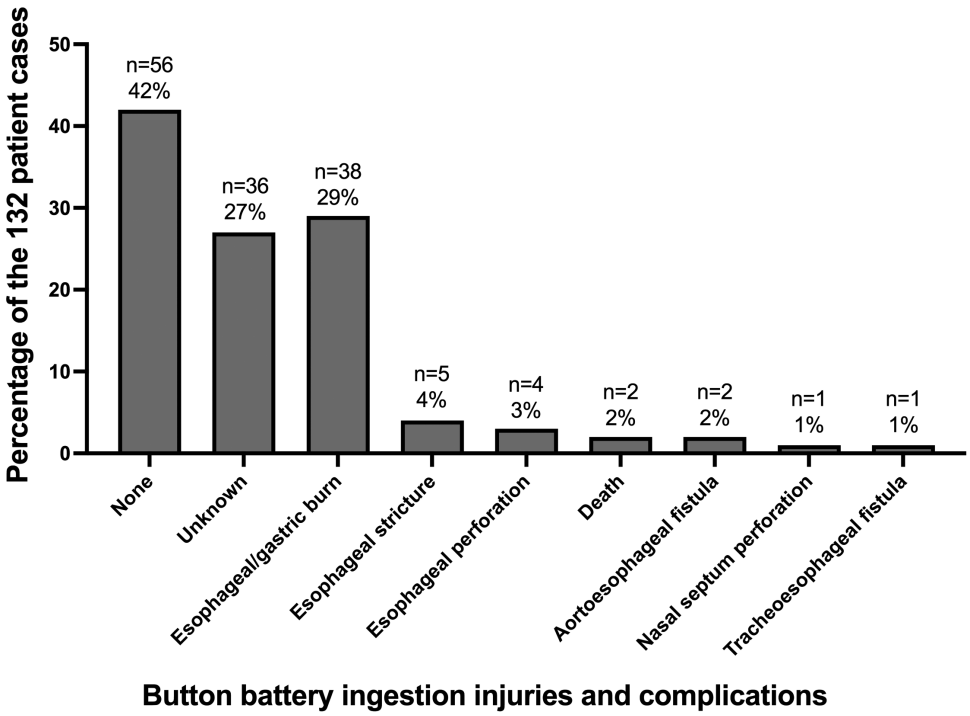

Figure 2. Percentage of injuries and complications of paediatric button battery ingestions in the 132 described patient cases. Patients could have 1 or more injury/complication. The 2 reported deaths were due to oesophageal perforation and aortoesophageal fistula.

There is an urgent need for a change in prevention efforts. A 2022 analysis of paediatric button battery ingestions presented to US Emergency Departments showed that despite public education and prevention efforts, there was a significant increase in visits from 2010 to 2017.[16] A recent review of paediatric oesophageal button battery cases also found a continued increase in cases from 2015 to 2018.[17] The Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP), which is administered by the Public Health Agency of Canada and receives emergency room reports of injuries and poisonings, has also documented a steady rise in these ingestions. However, this type of reporting also has limitations given that not all cases presenting to the Emergency Department are reported to this database. Our study also found a very low rate (3%) of physicians reporting these cases to Health Canada. Furthermore, the ICD-10 code for button battery ingestion (W4A.A1) is new and has not yet been adopted by the Canadian coding system (ICD-10-CA), which makes it very challenging to capture true incidence data. CHIRPP reported 125 cases in 2020, an average of 114 cases per year between 2016-2019, and an average of 65 cases per year between 2006 and 2014.[18,19] Our study identifies that prevention efforts could be aimed at safer battery disposal, given that finding a loose battery in the environment was the most common way in which children accessed the button battery. Safe disposal is essential even for 'dead' batteries, which can still contain enough voltage to generate a mucosal burn injury quickly.[20] Wrapping batteries in tape while awaiting definitive safe disposal has been 1 proposed strategy that demonstrated a lack of mucosal injury when exposed to cadaveric piglet oesophageal tissue.[21] Devices and toys were also identified as sources of ingested batteries in our study, despite the development of more difficult-to-open battery compartments. Currently, in Canada, there are no regulations mandating a lock feature or warning label on toys and devices that house button batteries, which would also be an important and effective prevention effort. There has been limited progress on this particularly as changing the industry manufacturing standard takes time. The majority of industry changes have been focussed on the packaging of button batteries (ie, double plastic packaging to require the use of scissors to open, individual battery packaging so unable to open multiple batteries at once, label warnings for harmful ingestion) and the batteries themselves (ie, using a bitter taste coating on the battery, having a warning label directly on the battery).[22] Overall, there is significant work left to continue to improve public safety.

Lastly, our study identified a large educational gap in patient care. Modifiable patient factors, while waiting for more definitive treatment and disposition planning include honey (10 mL every 10 min, maximum 6 doses) and/or sucralfate (10 mL every 10 min, maximum 3 doses) administration, preferably within 12 h of battery ingestion.[2,4] These easy to administer oral agents have been shown to decrease the rate of burn injury by neutralizing the tissue pH rise and therefore reducing the penetrating alkaline liquefactive necrosis injury in animal models.[14] Unfortunately the knowledge uptake on these available treatment options was found to be poor, which was reflected in only a minority of eligible patients receiving honey or sucralfate. Physician knowledge surrounding the general timing of endoscopic removal (ie, urgent (within 2 h) endoscopy for oesophageal button batteries) was improved compared to honey and sucralfate, but still only known by approximately 1 in 2 physicians. These are important areas for future educational efforts. High-impact groups to target can include those that were most commonly involved in button battery cases—general paediatricians, paediatric emergency medicine physicians, paediatric gastroenterologists, and paediatric intensivists. Other

specialities frequently involved in managing these presentations in some hospitals, including paediatric general surgery and otolaryngology, also need to be targeted.

Limitations of this study include recall bias, nonrandomized or adaptive questions, lack of IP address or cookie use to identify duplicate responders and its retrospective nature. The questionnaire did not ask about any type of imaging that was done (eg, magnetic resonance imaging of the vascular structures), which may miss vascular or other injuries. This study was not able to capture the experience of paediatric surgeons who are often involved in these cases (eg, otolaryngologists and general surgeons), as they are not members of the CPSP. Lastly, it was not possible to identify all duplicate reported cases, particularly if minimal case detail was provided but also due to the limited case detail from the nature of the short questionnaire that needed to be completed in a short amount of time. Strengths of this study include a high response rate and being the first to report Canadian paediatricians and paediatric subspecialists' experiences with these important ingestion cases. The results of this study can help inform future prospective research and quality improvement projects to enhance treatment knowledge uptake, as well as the development of safer button battery packaging and disposal.

Conclusions

A high degree of suspicion for a button battery ingestion is needed in young children presenting with dysphagia or coughing, even in the absence of a witnessed ingestion. Although rare, serious complications such as aortoesophageal fistulas, tracheoesophageal fistulas, and death, do occur and highlight the critical need for maximal effective initial management observing the most up-to-date clinical care recommendations. Future prevention efforts need to be aimed at safer and easier button battery disposal, such as including battery disposal bins at all workplaces. Educational campaigns are needed on how to use honey and sucralfate while awaiting more definitive patient management, as they have been shown to reduce the resulting injury from the battery. High-yield physician groups for educational dissemination include general paediatricians, emergency medicine physicians, paediatric and adult gastroenterologists, surgeons (general, ENT, and cardiac), and paediatric intensivists. It would also be valuable to continue to target parent education on the use of honey and the need for emergent assessment in the Emergency Department.

Supplementary material

Supplementary material is available at *Journal of the Canadian Association of Gastroenterology* online.

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Author contributions

A. S. H. (contributed to the conception and design of the work, the analysis and interpretation of the data, drafted the work, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work), M. W. C. (contributed to the design of the work, the interpretation of the data, reviewed the work critically for important intellectual content, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work)

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Conflicts of interest

In addition to this COI statement, ICMJE disclosure forms have been collected for all co-authors and can be accessed as supplementary material.

Both authors have no conflicts of interest to disclose.

Data availability

All data is available upon request.

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