

# Management of Ingested Foreign Bodies in Children: A Clinical Report of the NASPGHAN Endoscopy Committee

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## ABSTRACT

Foreign body ingestions in children are some of the most challenging clinical scenarios facing pediatric gastroenterologists. Determining the indications and timing for intervention requires assessment of patient size, type of object ingested, location, clinical symptoms, time since ingestion, and myriad other factors. Often the easiest and least anxiety-producing decision is the one to proceed to endoscopic removal, instead of observation alone. Because of variability in pediatric patient size, there are less firm guidelines available to determine which type of object will safely pass, as opposed to the clearer guidelines in the adult population. In addition, the imprecise nature of the histories often leaves the clinician to question the timing and nature of the

ingestion. Furthermore, changes in the types of ingestions encountered, specifically button batteries and high-powered magnet ingestions, create an even greater potential for severe morbidity and mortality among children. As a result, clinical guidelines regarding management of these ingestions in children remain varied and sporadic, with little in the way of prospective data to guide their development. An expert panel of pediatric endoscopists was convened and produced the present article that outlines practical clinical approaches to the pediatric patient with a variety of foreign body ingestions. This guideline is intended as an educational tool that may help inform pediatric endoscopists in managing foreign body ingestions in children. Medical decision making, however, remains a complex process requiring integration of clinical data beyond the scope of these guidelines. These guidelines should therefore not be considered to be a rule or to be establishing a legal standard of care. Caregivers may well choose a course of action outside of those represented in these guidelines because of specific patient circumstances. Furthermore, additional clinical studies may be necessary to clarify aspects based on expert opinion instead of published data. Thus, these guidelines may be revised as needed to account for new data, changes in clinical practice, or availability of new technology.

**Key Words:** aorto-esophageal fistula, button battery, esophageal food impaction, foreign body ingestion, magnet, superabsorbent

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In 2000 the American Association of Poison Control Centers documented that 75% of the >116,000 ingestions reported were in children 5 years of age or younger (1). As opposed to adults, 98% of foreign body ingestions (FBIs) in children are accidental and involve common objects found in the home environment, such as coins, toys, jewelry, magnets, and batteries (2). Children may present with overt symptoms, including, but not limited to, stridor, pain, drooling, fussiness, chest pain, abdominal pain, fever, feeding refusal, wheezing, and respiratory distress (3). Conversely, they may be completely asymptomatic but brought in after ingestion witnessed by a caretaker. For the purposes of the present article, FBIs will be categorized into the following major groups: button batteries (BBs), magnets, sharp/pointed objects, food impaction, coins/blunt objects, and superabsorbent objects. Management of caustic agents and other toxic ingestions is outside the scope of the present article.

If an object is in the esophagus, removal is considered mandatory. The airway should be protected with an endotracheal tube during removal, particularly critical if the patient has been fasting for <8 hours. Depending on the position of the object and the nil per os (NPO) status of the patient, removal by anesthesia with McGill forceps or by ENT with a rigid scope may be alternatives

to endoscopic removal. Timing of endoscopy is dependent on a number of factors, including clinical status of the patient, the time of the patient’s last oral intake, type of ingestion, and location within the gastrointestinal (GI) tract. Generally speaking, timing can be divided into categories of emergent (<2 hours from presentation, regardless of NPO status), urgent (<24 hours from presentation, following usual NPO guidelines), and elective (>24 hours from presentation, following usual NPO guidelines). A brief overview of these timing considerations is provided in Table 1.

### BUTTON BATTERY INGESTIONS

Although disk-shaped BBs have been used for almost 30 years, initial experience with GI ingestion of these batteries was fairly benign. Although there had been concern that degradation of the integrity of the battery itself may lead to caustic injury or increased levels of mercury, compiled data on battery ingestions published by the National Capital Poison Center in 1992 of >2300 BB ingestions during a 7-year period found no deaths and only a 0.1% prevalence of major effect (defined as life-threatening or disabling; in this series, there were 2 patients with esophageal stricture) (4). During the ensuing 18 years, however, that clinical experience changed dramatically with a follow-up paper from the National Capital Poison Center in 2010 (5). In this cohort of >8600 BB ingestions, there was a major effect in 73 patients (0.8%), with death in 13 patients (0.15%). There have been additional reported deaths since this publication (6,7). Although the incidence of BB ingestions had not changed significantly during the course of the 2 studies, the relative risk of major effect had increased almost 7-fold (8).

Essentially, all of these major effects involved esophageal BB injuries; thus, impaction at this site represents the highest risk for injury. As a result, esophageal BBs have emerged as the most critical indication for emergent endoscopy in children.

The cause behind this dramatic increase in morbidity and mortality seems to be linked to 2 specific changes in the BB market through that time period: increased diameter and a change to lithium cells. The larger diameter results in increased likelihood of esophageal impaction, whereas the lithium composition results in increased voltage delivery. Lithium became the preferred cell type because of longer shelf life capacity, better stability at cool temperature, lighter weight, and ability to carry twice the voltage of previously used mercuric oxide, manganese dioxide, and zinc-air cells. As a result, lithium cell ingestion rose from approximately 1% in 1990 to almost 25% of all of the BB ingestions by 2008. In addition, ingestion of BBs >20 mm in diameter increased from 1% to 18% during that same time period, comprising 94% of known fatalities. The combination of both larger size and lithium cell seems to be important, because outcomes for lithium ingestions <20 mm are comparable to other cell types (8).

The mechanism of injury in these patients is related primarily to the generation of hydroxide radicals in the mucosa, resulting in a caustic injury from high pH, instead of an electrical-thermal injury. Animal data have documented a rise in pH from 7 to 13 at the negative pole of implanted BBs within 30 minutes of ingestion. These animal models document that necrosis within the esophageal lamina propria may begin as soon as 15 minutes from the time of ingestion, with extension to the outer muscular layer within 30 minutes (9). This corresponds with anecdotal reports of significant esophageal stricture within 2 hours of ingestion. As such, continued injury may occur days to weeks even after removal of the battery, with death from aortoenteric fistulas reported up to 19 days later (6). Not surprisingly, new batteries confer a >3-fold greater risk of injury (8) compared with spent batteries. Nevertheless, extreme caution must be maintained with all of the ingestions, because lithium batteries often contain enough residual charge to cause injury even once they are no longer operational.

TABLE 1. Timing of endoscopic intervention in pediatric foreign body ingestions

Type	Location	Symptoms	Timing
Button battery	Esophagus	Yes or No	Emergent
	Gastric/SB	Yes	Emergent
		No	Urgent (if age <5 and BB ≥20 mm) Elective (if not moving on serial x-ray)
Magnets	Esophagus	Yes	Emergent (if not managing secretions, otherwise urgent)
	Gastric/SB	No	Urgent
		Yes	Emergent
Sharp	Esophagus	No	Urgent
		Yes	Emergent (if not managing secretions, otherwise urgent)
	Gastric/SB	No	Urgent
Food impaction	Esophagus	Yes	Emergent (if not managing secretions, otherwise urgent)
		No	Urgent
		Yes	Emergent (if signs of perforation, then with surgery)
Coin	Esophagus	No	Urgent
		Yes	Emergent (if not managing secretions, otherwise urgent)
		No	Urgent
Long object	Esophagus	Yes	Urgent
		No	Elective
		Yes or no	Urgent
Absorptive object	Esophagus	Yes	Urgent
		No	Emergent (if not managing secretions, otherwise urgent)
		Yes or no	Urgent

BB = button battery; SB = small bowel.

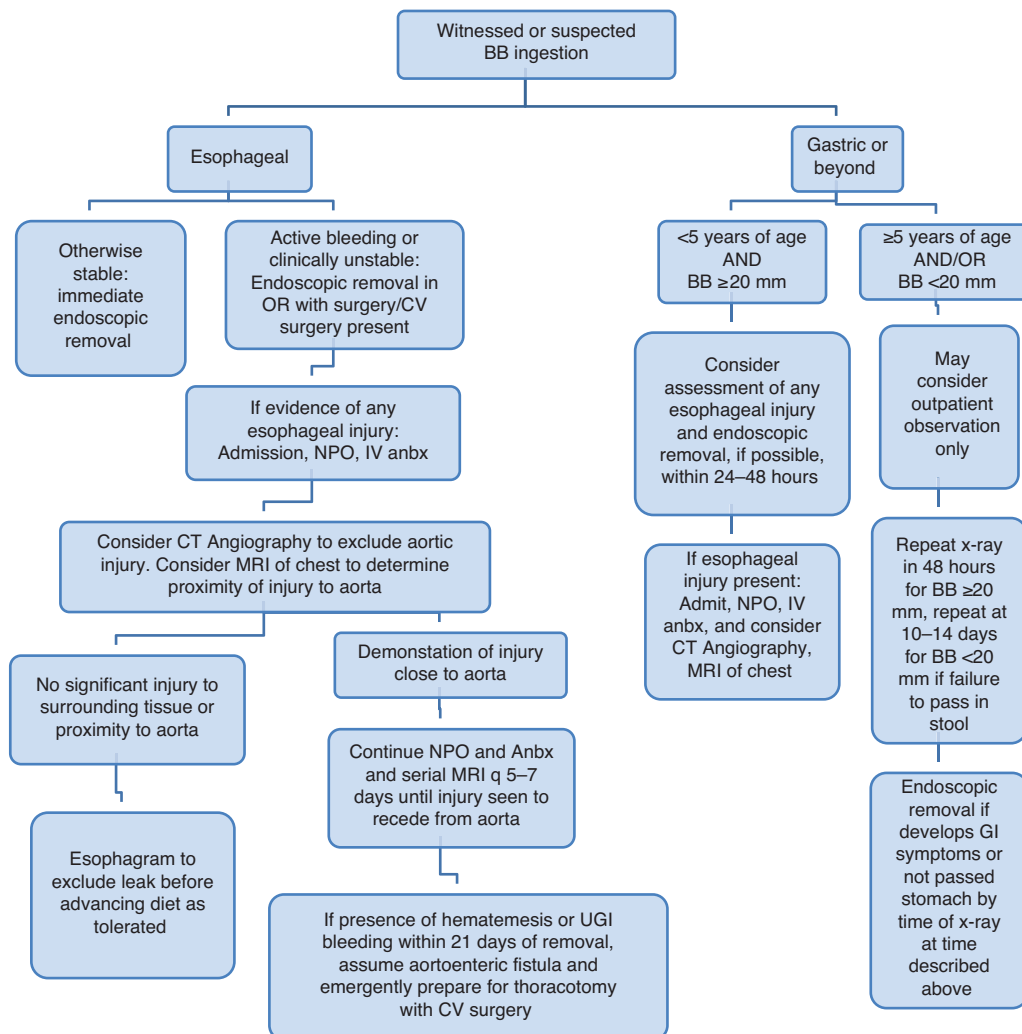
The high degree of morbidity and mortality that has been observed with BB ingestions in children has led to renewed focus to determine optimal management of these children. Types of injuries sustained have included tracheoesophageal fistula (47.9%), esophageal perforation (23.3%), esophageal strictures (38.4%), vocal cord paralysis from recurrent laryngeal nerve injury (9.6%), mediastinitis, cardiac arrest, pneumothorax, and aortoenteric fistula (7/13 fatalities) (8). Much of the attention has aimed at prevention of the catastrophic aortoenteric fistula, because only 1 case has been documented of a child being saved from this form of BB injury once it has occurred (10). Children at greatest risk are those younger than 5 years of age and those with battery ingestions  $\geq 20$  mm and multiple battery ingestions (5).

Cases of BB ingestion may be difficult to distinguish from the more common coin ingestions, discussed in a later section. Plain radiographs of the chest and abdomen should be examined carefully for the double halo sign on anteroposterior views and the “step-off” sign on lateral views, which help distinguish the offset poles of a BB from regular coins. Endoscopic removal may be difficult if there is adhesion of the battery to the mucosa because of the caustic injury. Removal forceps with a “rat tooth” design (Raptor forceps,

US Endoscopy, Mentor, OH) can often successfully grasp the step-off between the 2 poles of the battery for removal. Alternatively, a retrieval net (Roth Net, US Endoscopy) may be effective also. In patients in whom the battery’s adherence to the mucosa prohibits removal by flexible endoscopy, use of a rigid endoscope by surgery or otolaryngology may be necessary, although this may increase the risk of perforation substantially.

### Controversial Aspects

Endoscopic intervention (Fig. 1) for gastric BB remains controversial. Data from a large cohort in the national registry are reassuring, with no reported significant gastric injuries from BB ingestions (5). The potential danger, however, is evident through a report of an infant with gastric injury (11). In addition, one of the fatalities reported from aortoenteric fistula presented with a gastric BB that had apparently caused esophageal injury before reaching the stomach (6). This suggests that passage of a BB to the stomach alone cannot be used as a criterion that the child is free from potentially catastrophic underlying injury. This leaves



**FIGURE 1.** Proposed management algorithm for ingestion of BBs in children. anbx = antibiotics; BB = button battery; CT = computed tomography; CV = cardiovascular; GI = gastrointestinal; IV = intravenous; MRI = magnetic resonance imaging; NPO = nil per os; OR = operating room; q = every; UGI = upper gastrointestinal series.

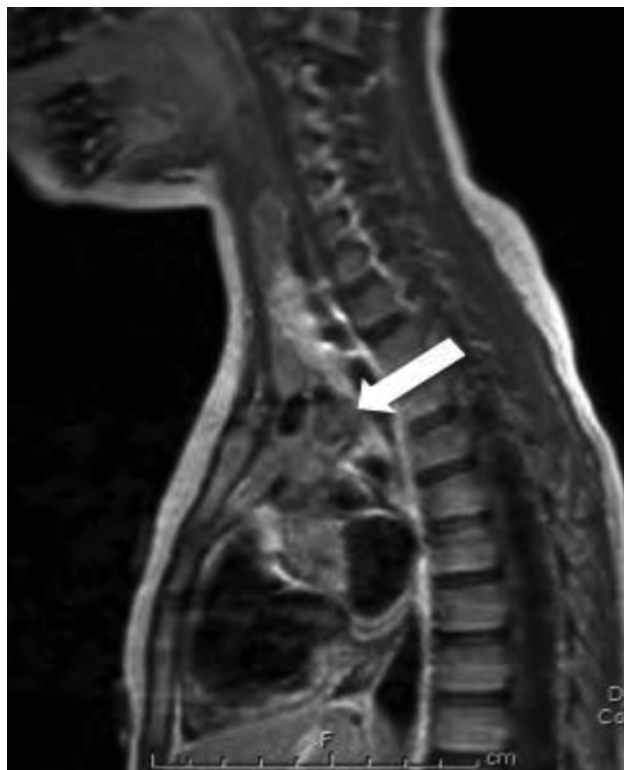
some discretion to the clinician regarding the appropriate management of gastric batteries. The newly proposed clinical recommendations in the present article represent a significant departure from previous care algorithms in considering endoscopic evaluation in cases of gastric batteries. The intent of these recommendations, however, is to evaluate whether any demonstrable esophageal injury is present instead of gastric injury. This recommendation is based on expert opinion originating from the growing experience of catastrophic injury without a defined esophageal impaction, because no prospective, randomized studies have been performed on this subject. Factors supporting observation alone, without endoscopic removal of gastric batteries, are confirmed short duration of ingestion (<2 hours), size of the battery <20 mm, absence of clinical symptoms, and a child 5 years of age or older. Consistent with American Society for Gastrointestinal Endoscopy guidelines, larger batteries ( $\geq 20$  mm) in the stomach should be checked by radiograph and removed if in place after >48 hours (12).

Another challenging aspect in caring for these patients is optimal management after endoscopic removal of the BB. Therefore, the most prudent course in those patients with a high degree of suspicion for full-thickness esophageal injury, even when asymptomatic, is to remain hospitalized. Although the economic costs of this approach may incur scrutiny from insurers, these must be weighed against the costs associated with the management of a delayed-onset aortoenteric fistula. Conservative management with inpatient observation must also take into account the distance the patient must travel to have access to care if an event occurs while in the home. Repeated endoscopic evaluation may underestimate the degree of submucosal injury present. Cross-sectional imaging with computed tomography angiography or magnetic resonance imaging (Fig. 2) has been used in this context for less invasive and more comprehensive assessment of the proximity of injury to important vascular and airway structures. Therefore, if esophageal injury is identified at the level of the aorta on endoscopy, use of these noninvasive modalities is recommended for further investigation and follow-up. Endoscopic ultrasound may offer another alternative for surveillance of submucosal injury and proximity to vascular structures in centers that have this capability, but further study is needed.

For inflammation extending through to the intima of the aorta, preemptive surgical management with thoracotomy and aortic grafting should be considered, despite the associated morbidity and mortality. Again, given the extremely poor history of success with repair of acute aortoenteric fistula hemorrhage, this aggressive approach may be warranted. For this reason, it is crucial to have representatives from cardiothoracic surgery and interventional cardiology involved early in the evaluation of these patients and to remain as part of the management team.

## Advocacy

Data from the report of the National Battery Ingestion Hotline reveal 8161 BB ingestions between 1990 and 2008, with an annual incidence ranging between 6.3 and 15.1 patients per million population (5). The overall incidence, however, did not seem to increase over time. In contrast, data from the National Electronic Injury Surveillance System estimate >40,000 injuries from batteries in children  $\leq 13$  years between 1997 and 2010, with a >2.5-fold increase in annual incidence in that time (7). The majority of injuries from ingestions occurred in children, 62.5% in those younger than 6 years of age. When a source for the ingested battery was known, 61.8% of these were obtained directly from the product and 29.8% were loose. The batteries were most commonly obtained from hearing aids (36.3%) and games/toys (22.1%). This pattern



**FIGURE 2.** Sagittal MRI demonstrating inflammation extending anteriorly from the esophagus into the immediate proximity of the aortic arch (white arrow) following removal of an impacted button battery in the mid-esophagus. MRI = magnetic resonance imaging.

highlights the need to protect this vulnerable population from easily obtained and loose BBs in the household. Present regulations from the Consumer Product Safety Commission require manufacturers to ensure that battery compartments are secured for all of the products intended for use in children younger than 3 years of age. The increase in morbidity and mortality from battery injuries has resulted in legislation introduced in the Congress to expand this requirement to all of the electronic devices. Advocacy efforts have also been launched by the battery industry in the form of a public awareness campaign and Web site (*thebatterycontrolled.com*). This Web site contains a public service video and informational handouts that can be supplied to parents of young children. Actual battery ingestions should be reported to the National Battery Ingestion Hotline, to be included in their database (202-625-3333).

## MAGNET INGESTIONS

### Background

Ingestion of magnets is by no means a new occurrence in children (13), and cautions about the increased risk of injury with ingestion of multiple magnets have been in existence for many years. The primary risk is the potential for enteroenteric fistula formation between magnets in adjacent loops of bowel with associated perforation, peritonitis, and bowel ischemia/necrosis; however, increased morbidity and mortality from these ingestions has been recognized among gastroenterologists and emergency personnel. This is largely attributed to the common use of neodymium, or rare earth, magnets in toys and other small objects. These magnets have

>5 times the attractive force of conventional magnets and have demonstrated the tendency to cause GI injury much more readily than their conventional counterparts. Although the same potential for injury and principles for management apply to non-neodymium magnets, the relative risk is significantly less because of their decreased magnetic pull.

The first report of injury from neodymium magnet ingestion was from a series of 24 patients in 2002 (14), with additional subsequent series published in the following years (15). The injurious potential has been augmented by their popular use as desk toys, under the name Buckyballs, NeoCube, and others, in which they are packaged together in large numbers (200–1000) that are harder for parents to keep track of. The small size and shiny nature of these magnets make them an attractive target for ingestion by infants and toddlers. Ingestions by older children and adolescents, however, are also common, because they use the magnets to simulate a variety of face and body piercings. In the mid 2000s, with increasing reports of ingestions, the Consumer Product Safety Commission worked with manufacturers on changes to the package labeling, to indicate that they were intended for adults and posed a specific risk to children. After continued reports of serious injury and 1 death in 2012, the Consumer Product Safety Commission issued a mandatory recall (16) of these products. This recall remains contested by some manufacturers (17), but most have complied and are no longer selling these products (see Appendix 1, <http://links.lww.com/MPG/A426>).

## Morbidity and Mortality

The reported death of a 20-month-old child following a magnet ingestion in 2006 (18) led to numerous subsequent publications documenting severe injuries in children. Data collected from the National Electronic Injury Surveillance System database showed an alarming 8.5-fold increase in the incidence of magnetic ingestions in children between 2002 and 2011, with >16,000 estimated ingestions presenting to the emergency department in that time period (19). A survey conducted by the North American Society of Pediatric Gastroenterology, Hepatology, and Nutrition of its membership revealed 424 patients in the past 10 years, with increasing incidence of 199 patients in the prior year (results presented at the 2012 AAP National Conference and Exhibition). Further analysis of these survey data is forthcoming, but preliminary results show that 52% of these patients resulted in endoscopic intervention alone, 20% with endoscopy and surgery, and 8% resulted in surgery alone. Only 15% were managed with observation alone. Of those who underwent surgery, 41% had repair of a perforation or fistula and 22% required some degree of bowel resection. In light of the increased morbidity and mortality associated with these ingestions, a proposed algorithm for their management was proposed in a 2012 article (Fig. 3) and is also endorsed by this expert committee (20).

## Controversial Aspects

There is a clear consensus that urgent removal of multiple magnet ingestions is indicated, even in the asymptomatic patient, when the location is amenable to endoscopic retrieval, by either esophagogastroduodenoscopy or colonoscopy. The type of retrieval device used may vary depending on the size and shape of the magnet ingested, although retrieval nets (Roth Net, US Endoscopy) are often the best choice for small, round magnets. The management of the asymptomatic patient with multiple magnets beyond the ligament of Treitz but proximal to the terminal ileum is more controversial. In centers with small bowel enteroscopy (single or

double balloon) available, these patients would be candidates for endoscopic removal. In most centers without this option, however, intervention would require laparotomy or laparoscopy, with concurrent increased morbidity, mortality, and costs. Conservative management with observation and perhaps laxative therapy may therefore be a reasonable alternative in this scenario. The concern, however, is that these patients may not become overtly symptomatic until a significant degree of bowel injury or even perforation has occurred. The general consensus among North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition experts has been that if conservative management for these small bowel magnet cases is chosen, direct patient observation in a controlled setting should be maintained. In addition, serial abdominal films and clear “ownership” of the patient until such time as passage of the magnets can be confirmed are vital. A more aggressive treatment plan should be strongly considered in cases in which the patient lives remotely from the treatment center or significant concerns for psychosocial factors exist that would impede access to prompt care if the child’s condition worsened. Endoscopic removal of single magnets is generally not considered necessary unless radiologic images cannot clearly determine whether a single magnet is truly present. Numerous reports document instances of multiple magnets adhered tightly together, thus appearing as a single object on x-ray. Therefore, it is imperative that at least 2 views of the chest or abdomen are obtained to discriminate the number of magnets present. If imaging shows that  $\geq 2$  magnets are adherent, then the multiple magnet protocol would apply. With other characteristics such as large magnet size or unusual shape, age of the child, location, or failure to pass as expected, endoscopic removal may be warranted.

## POINTED OBJECTS (NAILS, PINS, TACKS, TOOTHPICKS)

### Background

In the beginning of the 20th century, sharp objects were reported as one of the most commonly ingested foreign bodies. Safety pin and nail ingestions, 15% and 13%, respectively, accounted for the bulk of the sharp object ingestions in the United States. Partially because of the popularity of disposable diapers, ingestion of safety pins has significantly declined (21). During a 12-month prospective study, Paul et al reported that of 244 ingestions assessed by pediatric emergency room and pediatricians, 10% were defined as sharps and included straight pins, open safety pins, hairbrush bristles, and pine needles (22). Incidence rates between 11% and 13% were reported from European and Asian centers (23–25). The frequency and the type of ingested sharps are greatly dependent on cultural factors. Esophageal fish bones are most frequently encountered in patients of Asian and Mediterranean descent, where it is customary to introduce fish into the diet at a young age (26), whereas pin ingestions are higher in ethnic groups that use pins to fasten clothing or for religious or cultural beliefs (27,28). Toothpick ingestions tend to be more prevalent among older age groups.

### Morbidity and Mortality

Many sharp objects follow Jackson’s axiom: “advancing points puncture, trailing do not” (29), and often pass the GI tract uneventfully (25). Before the development of modern surgical and endoscopic techniques, however, morbidity and mortality for ingestion of sharp objects were reported as high as 35% and 26%, respectively (30). Delayed presentation and management increases the risk of serious complications, whereas prompt diagnosis and

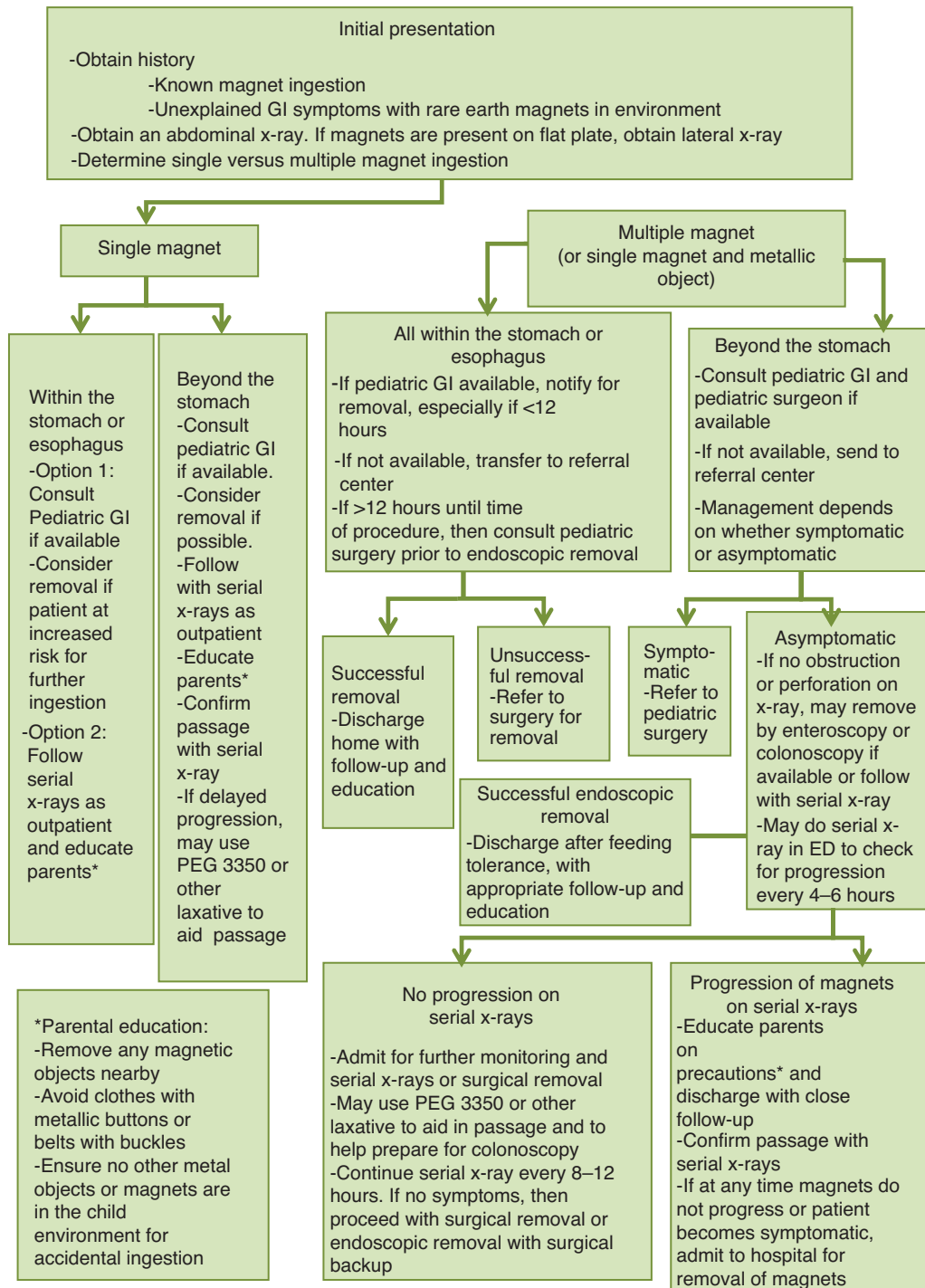


FIGURE 3. Proposed management algorithm for magnet ingestion in children. Adapted from Hussain et al (20). ED = emergency department; GI = gastrointestinal; PEG = polyethylene glycol.

availability of endoscopic therapy are likely responsible for decreased incidence of adverse events (31). Symptomatic ingestions are more common if the foreign body is lodged in the upper-mid esophagus, with the most common symptoms of pain and dysphagia (25). Up to 50%, however, can remain asymptomatic for weeks even in the case of proximal intestinal perforation (30).

Reported complications include perforation and extraluminal migration, abscess, peritonitis, fistula formation (32–38), appendicitis (39,40), liver, bladder, heart, and lung penetration (39,41–43), incarcerated umbilical hernia (44), rupture of common carotid artery (45), aorto-esophageal fistula, and death (46). The ileocecal region is the most common site for intestinal perforation, but perforations have been reported in the esophagus, pylorus, angle

of the duodenum, and colon (30,47). Rates of complications are higher in patients who are symptomatic, have a delay in diagnosis beyond 48 hours (31), or have swallowed a radiolucent foreign body (29,48,49). Toothpick and bone ingestions have a high risk for perforation (40,47) and are the most common foreign bodies that require surgical removal (48).

### Management

A clear history or a suspicion of an ingested sharp foreign body necessitates urgent radiographic evaluation (Fig. 4). The positive predictive value of radiographs is 100% for metallic objects, but is much lower for objects made of glass (43%), fish bones (26%), and wood, which is completely radiolucent (25,50). If the x-ray is negative but suspicion for a foreign body remains high, it may be prudent to proceed to endoscopic evaluation. Alternatively, computed tomography scan, ultrasounds, magnetic resonance imaging, and upper GI barium swallow have been used to identify radiolucent foreign bodies but may delay definitive treatment, especially if contrast is used (47,51,52). A sharp object in the esophagus is a medical emergency because of the high risk of perforation and migration. It should be removed even if the patient has not been appropriately fasted. If the patient exhibits signs of respiratory compromise, neck swelling, crepitus, or peritonitis, a surgical consultation is mandatory and the patient should be transferred to a facility with appropriate expertise.

Once identified, optimal management depends on the location and type of the foreign body (29). Success rates then depend on the experience level of the endoscopist and device choice (53). Magill forceps are most useful for removal of sharp foreign bodies in the oropharynx and upper esophagus such as fish bones. Direct laryngoscopy can be used for objects lodged at or above the cricopharyngeus (12). For sharp foreign bodies below the cricopharyngeus, a flexible endoscope has the lowest complication rates (12). It may be helpful to replicate the foreign body before the

procedure, and some endoscopists use a practice run to identify the best tools for removal (29). The best grasping tools for sharp objects include retrieval forceps, retrieval net, and polypectomy snare (54). Size of the child, however, will limit access to some devices, especially if the patient weighs <5 kg. A 6-mm gastroscope has a 2-mm channel and will accommodate only small polypectomy retrieval nets (diameter of 20 mm), polypectomy snares, or Dormia basket devices, as well as several commercially available forceps (54). Success rates of 96% have been reported for removal of sharp objects from the upper GI tract using rat tooth forceps (55). Polypectomy snare is a good option for longer sharp objects such as toothpicks and can be used to close open safety pins in the stomach before withdrawal (15). If the sharp end of the object is facing cephalad, it may be safest to push the object into the stomach with rat tooth forceps and rotate the sharp end caudally before removal.

### Controversial Aspects

A number of protective devices are available to limit esophageal trauma during retrieval. Although the diameter of an overtube (US Endoscopy and CONMED, Utica, NY) (56) generally precludes its use in pediatric patients, in one report a 13.2-mm overtube was successfully used in a 3-year-old boy weighing 13.2 kg (57). A foreign body protector hood (Kimberly-Clark, Irving, TX) is useful if the object is in the stomach or can be safely pushed into the stomach. Transparent distal caps have been used as protective devices and are widely available from band ligation or endoscopic mucosectomy kits (54) but can only be used with standard-sized endoscopes. When a sharp foreign body has passed the ligament of Treitz, enteroscopy and surgery can be considered for removal, although clinical, social, and economic risks and benefits must be assessed. If observation instead of removal is chosen in the asymptomatic patient, patients would benefit from monitoring in a hospital setting (23) with a daily abdominal x-ray.

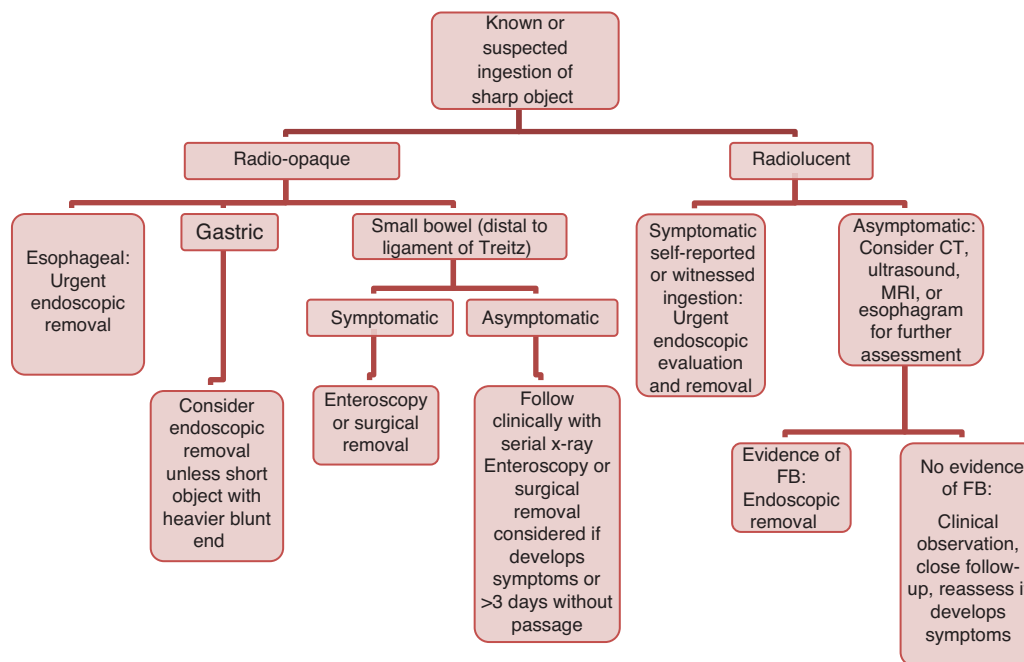


FIGURE 4. Proposed management algorithm for ingestion of sharp or pointed objects in children. CT = computed tomography; FB = foreign body; MRI = magnetic resonance imaging.

Average transit time for foreign object in children has been described at 3.6 days (22), and the mean time from ingestion of a sharp object to perforation has been reported at 10.4 days (58). So, if the foreign body has not progressed on imaging in 3 days or the patient becomes symptomatic, surgical removal may be reconsidered.

Also controversial is endoscopic removal from the stomach and small bowel of straight pins and other sharp objects weighted at 1 end. Management recommendations vary from observation with serial x-rays to laparotomy (39). A number of case reports and small case series describe successful conservative management for the majority of ingested sharp objects (39). At present, however, no known patient or object criteria can be used to predict outcome. Additionally, straight pin perforations in the proximal GI tract are commonly asymptomatic, further complicating management. Despite Jackson's axiom, given the low risk of endoscopy and albeit rare but significant risk of severe morbidity and mortality from swallowed sharp objects, removal of all of the sharp objects within the reach of the endoscope is recommended if possible. The patients and families can elect the conservative approach after a detailed informed consent discussion, given the rare nature of the adverse events.

## ESOPHAGEAL FOOD IMPACTION

### Background

Food bolus impactions are the most common type of FBI in adults with an estimated prevalence of 13 per 100,000 (59). Data in children are more limited, but several studies have shown that impaction is often secondary to underlying esophageal pathology, such as eosinophilic esophagitis (EoE), reflux esophagitis, post-anastomotic stricture following tracheoesophageal fistula repair, achalasia, and other motility disorders (59–62). Although the diagnosis of EoE is based on several criteria, several published pediatric series of esophageal food impaction (EFI) showed a range of eosinophilic inflammation on biopsy from 43 to 100 eosinophils per high-power field (61,63–65). This supports the clinical impression that acute or recurrent food impaction is a common presentation of EoE. Additional descriptive data from these pediatric series demonstrate that patients are predominantly boys with a mean age between 9 and 10 years. In the largest published series of 49 pediatric patients with EFI, 86% were white, non-Hispanic and 49% had a history of atopy (65).

### Management

EFIs should be managed endoscopically when spontaneous clearance has not occurred (Fig. 5). If the patient is acutely symptomatic or showing signs of near-complete obstruction of the esophagus (eg, drooling, neck pain), endoscopy should be performed emergently to relieve the obstruction. If patients are able to tolerate their secretions, endoscopic removal may be delayed up to 24 hours. This will allow time to coordinate and perform the procedure in a controlled environment, as well as provide additional time for spontaneous clearance. Removal may require a piecemeal approach because of the incohesive nature of the impaction, resulting in a long, arduous procedure. For larger pediatric patients, an overtube may be considered to facilitate repeated esophageal intubations with minimal trauma, although the risk–benefit ratio should be carefully assessed. Transparent caps on the tip of the endoscope have been used successfully in these patients to aid in suctioning out large pieces of meat impactions (66,67). These caps may be either taken from band ligation devices or purchased separately in a variety of shapes and sizes (Olympus America, Melville, NY). At the time of endoscopic removal, biopsies should

be obtained from the proximal and distal esophagus to assess for underlying pathology that would benefit from additional treatment and predispose to recurrence. In patients with initial endoscopic disimpaction, if EoE is suspected, dilation of any underlying stricture is best deferred for another date, after the biopsies have been able to be reviewed and appropriate treatment instituted as needed. Dilation at the initial presentation is also best avoided if the impaction has been in place for a prolonged period. Because of the high likelihood of underlying pathology, it is vital that these patients are referred for appropriate GI follow-up to ensure that appropriate treatment is initiated. Otherwise, they are likely to return with recurrent impaction.

### Controversial Aspects

Although concern was raised by the expert panel of increased perforation risk with biopsies obtained at the time of endoscopic removal of the food impaction, no evidence exists to support this contention. Use of an overtube in the pediatric population carries some increased risk for perforation, although newer tubes made of softer materials may expand the range of patients who are eligible candidates (57). Use of glucagon to relax the lower esophageal sphincter to hasten spontaneous clearance has been studied with equivocal results and has not generally been recommended for EFI (68). Data suggest that it may be particularly ineffective in patients with underlying EoE (69). It may be considered in patients with distal esophageal impactions or in facilities where endoscopic care is not readily available. It should not be allowed to limit or delay appropriate endoscopic management. Similarly, advancement of a food bolus into the stomach by bougie dilator has been advocated as a method to avoid the need for endoscopic removal; however, there are no published reports in the literature. Although found to be safe and cost-effective for uncomplicated esophageal coins in some series (70,71), this practice should generally be discouraged in patients with food bolus impactions, because it may increase the risk of perforation when there is an undiagnosed stricture present and offers no option to obtain biopsies to identify underlying pathology. Conversely, gentle pressure under direct visualization with the tip of the endoscope into the center of the bolus to advance it into the stomach may be considered, although its use in pediatrics has not been studied. A series of 189 adult patients with EFI using the “push technique” resulted in no perforations (72) but has not been validated in younger patients. Use of papain or other proteolytic enzymes to soften or loosen bolus impactions is contraindicated, having been associated with esophageal injury (73), aspiration pneumonitis (74), perforation (75), and hypernatremia (76).

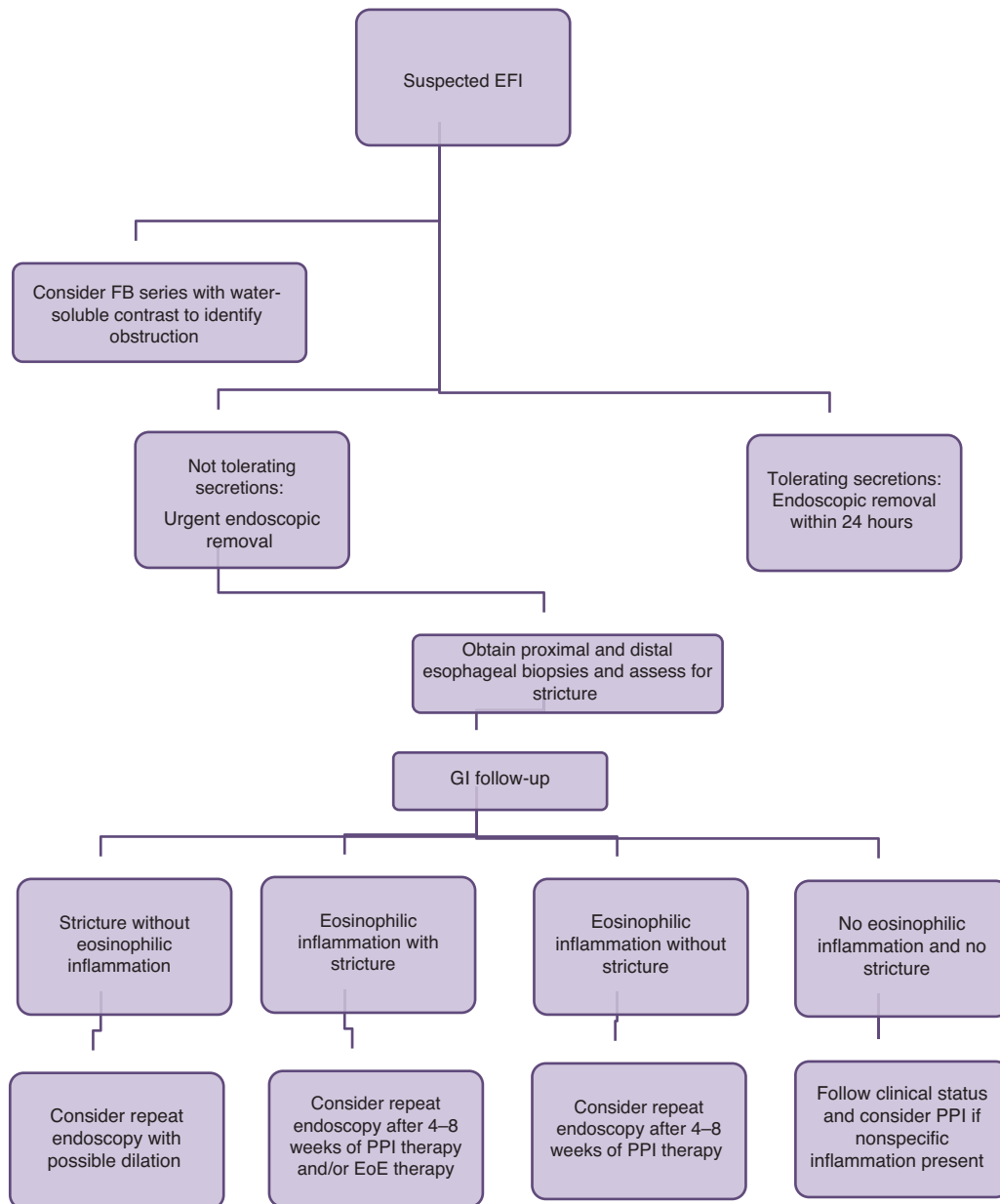
## COINS AND OTHER BLUNT OBJECTS

### Background

Coins are the most common ingested objects among children in the United States, with >250,000 ingestions and 20 deaths reported in the United States during a 10-year period (77). Factors that influence the likelihood of spontaneous passage include position in the esophagus, age of the child, and coin size. Generally, spontaneous clearance of coins occurs in approximately 30% of patients (78), whereas coins in the distal esophagus may clear before endoscopic removal in as many as 60% of patients, depending on the size of the coin and the age of the patient (79,80). Coins >23.5 mm, such as the American and Canadian quarters (24 mm), are more likely to become impacted, especially in children younger than 5 years of age.

Ingestion of large or long objects is also an issue of special concern. As with any esophageal foreign body, these ingestions





**FIGURE 5.** Proposed algorithm for management of EFIs in children. EFI = esophageal food impaction; EoE = eosinophilic esophagitis; FB = foreign body; GI = gastrointestinal; PPI = proton pump inhibitor.

require prompt removal within 24 hours. If the diameter of the object is >25 mm, however, it is unlikely to pass through the pylorus (12), especially in the younger child. Additionally, long objects, >6 cm in length, are unlikely to clear the duodenal sweep and, if they do, are equally unlikely to pass through the ileocecal valve (81). In an adult study, 80% of objects longer than 6 cm were unable to pass the pylorus by 48 hours after presentation (31). For those reasons, large or long objects, even though they are blunt, should be removed from the stomach.

**Management**

Initial management of witnessed or suspected coin ingestions should begin with a foreign body series of radiographs to identify

the presence and location of any coins (Fig. 6). Careful attention should be placed on the edges of the coin to exclude the double halo sign of a BB, which may easily be mistaken for a coin. In addition, lateral films are extremely helpful in differentiating the “step-off” between the positive and negative poles of a BB that will discriminate it from a coin. Esophageal coins should be removed within 24 hours on ingestion to reduce the risk of significant esophageal injury or erosion into neighboring structures. As with other esophageal impactions, if the patient is acutely symptomatic, unable to manage secretions, or with respiratory or other concerning symptoms, emergent removal is indicated. Otherwise, removal can be delayed up to 12 to 24 hours. A repeat radiograph, however, should be obtained immediately before the endoscopy, because up to one-fourth of esophageal coins pass spontaneously within 8 to 16 hours. After removal, the underlying esophageal mucosa should be

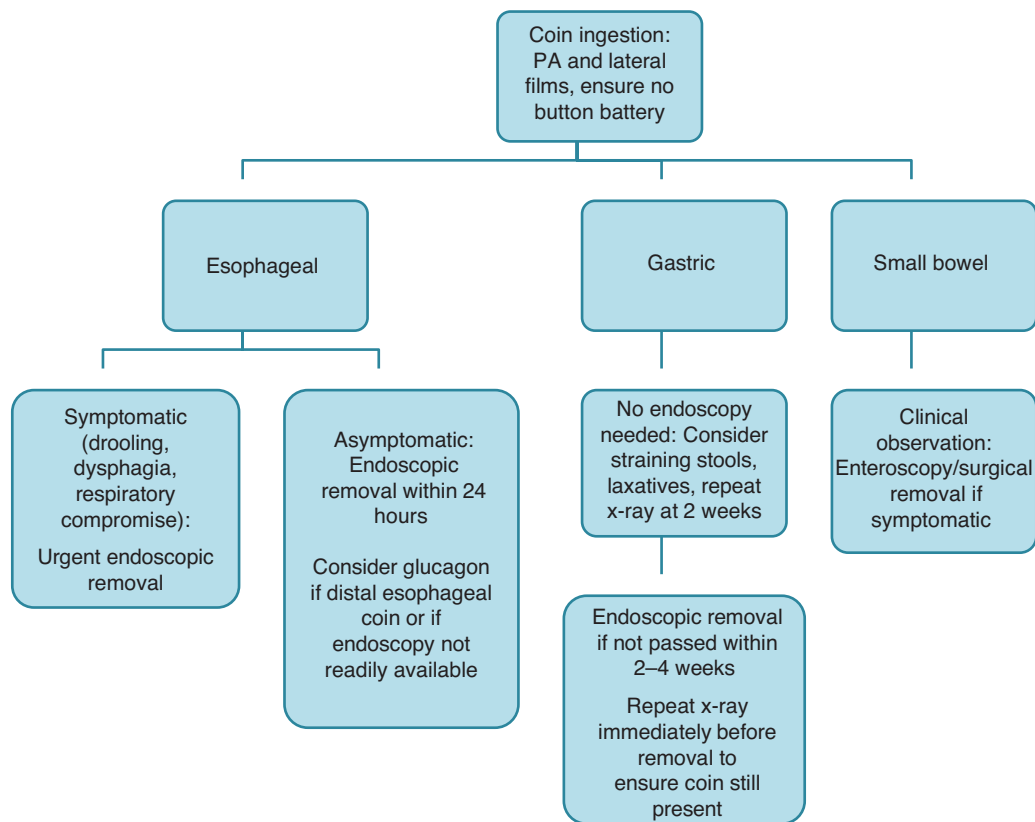


FIGURE 6. Proposed algorithm for management of coin ingestions in children. PA = posterior–anterior.

examined closely for evidence of significant injury. If the timing of coin ingestion is unknown or otherwise suspected to have been prolonged (>24 hours), urgent endoscopic removal in the operating room with involvement of the local surgery team should be considered. Gastric coins can generally be managed expectantly, unless overt GI symptoms are noted. In asymptomatic patients, parents should be instructed to monitor the stools for passage of the coin and serial x-rays obtained every 1 to 2 weeks until clearance can be documented. If the coin is retained after 2 to 4 weeks of observation, elective endoscopic removal may be considered. Although no studies specify a specific time limit by which most spontaneously passed coins will exit the stomach, children with underlying anatomic or surgical changes, such as pyloromyotomy, may have increased risk for retained coins (82,83).

If at all possible, using a standard endoscope with a 9.0-mm diameter and a 2.8-mm working channel will allow the endoscopist to pass an alligator jaw forceps. Using a small endotracheal tube or deflating the cuff may allow passage of this endoscope. Other endoscopic options include small rubber-tipped or W-shaped forceps, small alligator forceps, and tripod or pentapod forceps that may have to be only partially opened (84).

### Controversial Aspects

Alternative, nonendoscopic methods of coin removal have been successfully used at some centers, in an effort to decrease unnecessary use of resources and because of nonavailability of appropriate providers or referrals. As noted above in the discussion of EFI, data on the use of glucagon are equivocal at best and use of glucagon is not generally recommended (85), but may be

considered in cases of distal esophageal coins when endoscopy is not readily available. Use of a Foley catheter under fluoroscopic guidance to “sweep” out coins lodged in the upper esophagus while the patient is maintained in the Trendelenburg position has been reported (86). This practice, however, is greatly operator dependent and has led to concerns about perforation, aspiration, and acute airway obstruction if performed incorrectly. Conversely, “pushing” coins into the stomach has been shown to be safe and cost-effective compared with endoscopic removal in uncomplicated cases of coin ingestions (70,71), but offers the disadvantages of not allowing direct inspection of the esophagus for underlying pathology, as well as inability to retrieve the coin.

## SUPERABSORBENT OBJECTS

### Background

The use of superabsorbent polymers in a variety of personal hygiene, agricultural, and entertainment products has become increasingly common. These polymers have a number of useful applications because of their ability to retain up to 100 times their weight in water. The most common use in the market is in disposable diapers and other feminine hygiene products. Their use in tampons, however, was restricted in the 1980s because of concerns about toxic shock syndrome; however, they have been marketed in a variety of children’s toys under the trade names Water Balz, Growing Skulls, H2O Orbs, and Fabulous Flowers toys, as well as by generic manufacturers. With increased exposure to children came the inevitable ingestion cases, complicated by the potential for bowel obstruction because the objects rapidly expand in the GI tract. The amount of expansion is variable, largely

dependent on the density of the cross-linked polymers and the purity of the surrounding water, but can reach up to 30 to 60 times their original volume. Thus, the marble-sized dry beads can easily expand to a size that would obstruct the bowel or gastric outlet. To date, only 4 publications are found (2 in the US literature (87,88) and 2 international) that have documented ingestion resulting in significant morbidity and mortality, including 1 death (89). These events led to a voluntary recall by the Consumer Product Safety Commission in December 2012. Nevertheless, a large number of these products can be found in the marketplace, in addition to their use for products other than toys. Management of these ingestions is made more challenging by the fact that they are radiolucent and will generally pass easily through the proximal GI tract until they enlarge enough to cause obstruction.

In adolescents, intentional ingestion of superabsorbent products (feminine pads and tampons) has been anecdotally observed by members of the Endoscopy Committee, but at this time no reports of human ingestion have been published. Anecdotal cases of canine ingestion of (used) tampons resulting in bowel obstruction, however, have been reported. Because of their increased capacity to expand in the unused state, intentional ingestion by humans would also seem to incur a real risk of obstruction.

## Management

In the case of ingestion of beads or balls of superabsorbent polymers, such as the Water Balz or similar product, emergent endoscopic removal would be recommended. Once again, the device used will depend on the size and shape of the object. For round objects, a retrieval net or wire basket may be most effective. For larger, irregularly shaped objects, a polyp snare may be a better option. Increased time of ingestion increases both the depth of passage and the amount of absorbed water. Radiographic studies before removal are unlikely to be helpful, because of the radiolucent nature of these objects. Contrast studies could potentially identify areas of obstruction, but are likely to delay or complicate plans for endoscopic removal. As with other types of FBIs, examination of other objects from the same product can aid in the planning for removal and help assess the degree of risk. In patients in whom ingestion is suspected but not witnessed, the decision to proceed with endoscopy may be made even before the advent of clinical symptoms, depending on the level of suspicion. If upper endoscopic examination fails to identify the object, a high degree of vigilance must be reserved for the development of more distal bowel obstruction. Surgical consultation and clinical observation may therefore be advised, again depending on the level of suspicion that a true ingestion has occurred.

## Controversial Aspects

Once again, the decision on endoscopic intervention remains largely at the discretion of the endoscopist. At present, few reports, and that also only anecdotal, are available on which to base clinical recommendations. Use of more invasive intervention, such as small bowel enteroscopy or laparoscopy for removal in an otherwise asymptomatic patient, represents an even more controversial area. With increased experience, a greater consensus on the significant danger these types of ingestions represent and degree of aggressive management may develop. Until then, it seems prudent to err on the side of prompt removal whenever possible.

## SUMMARY

Management of pediatric foreign bodies remains one of the most challenging endoscopic dilemmas faced by pediatric

gastroenterologists. This is made more difficult by the lack of prospective, multicenter trials to provide a strong evidence base to develop guidelines. The present article is an attempt to provide some consensus among a panel of "expert" endoscopists to help guide clinical decision making in this population. This panel acknowledges, however, that the experiential basis used as a foundation for many of the recommendations made in the present article may contain a significant academic bias. This bias may limit applicability of these guidelines across many types of practices, and there can be no substitute for clinical judgment. It is therefore the intention of this panel that these guidelines be used as a starting point for clinical care, instead of an absolute management rubric.

## REFERENCES

- Litovitz TL, Klein-Schwartz W, White S, et al. 2000 annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. *Am J Emerg Med* 2001;19:337–95.
- Arana A, Hauser B, Hachimi-Idrissi S, et al. Management of ingested foreign bodies in childhood and review of the literature. *Eur J Pediatr* 2001;160:468–72.
- Chen MK, Beierle EA. Gastrointestinal foreign bodies. *Pediatr Ann* 2001;30:736–42.
- Litovitz T, Schmitz BF. Ingestion of cylindrical and button batteries: an analysis of 2382 cases. *Pediatrics* 1992;89 (4 pt 2):747–57.
- Litovitz T, Whitaker N, Clark L. Preventing battery ingestions: an analysis of 8648 cases. *Pediatrics* 2010;125:1178–83.
- Brumbaugh DE, Colson SB, Sandoval JA, et al. Management of button battery-induced hemorrhage in children. *J Pediatr Gastroenterol Nutr* 2011;52:585–9.
- Ferrante J, O'Brien C, Osterhout C, et al. Injuries from batteries among children aged < 13 years—United States, 1995–2010. *MMWR Morb Mortal Wkly Rep* 2012;61:661–6.
- Litovitz T, Whitaker N, Clark L, et al. Emerging battery-ingestion hazard: clinical implications. *Pediatrics* 2010;125:1168–77.
- Tanaka J, Yamashita M, Kajigaya H. Esophageal electrochemical burns due to button type lithium batteries in dogs. *Vet Hum Toxicol* 1998; 40:193–6.
- Spier A, Jamil S, Whan E, et al. Survival of patient after aorto-oesophageal fistula following button battery ingestion. *ANZ J Surg* 2012;82:186–7.
- Honda S, Shinkai M, Usui Y, et al. Severe gastric damage caused by button battery ingestion in a 3-month-old infant. *J Pediatr Surg* 2010;45:e23–6.
- Ikenberry SO, Jue TL, Anderson MA, et al. Management of ingested foreign bodies and food impactions. *Gastrointest Endosc* 2011;73: 1085–91.
- Honzumi M, Shigemori C, Ito H, et al. An intestinal fistula in a 3-year-old child caused by the ingestion of magnets: report of a case. *Surg Today* 1995;25:552–3.
- McCormick S, Brennan P, Yassa J, et al. Children and mini-magnets: an almost fatal attraction. *Emerg Med J* 2002;19:71–3.
- Kay M, Wyllie R. Pediatric foreign bodies and their management. *Curr Gastroenterol Rep* 2005;7:212–8.
- CPSC starts rulemaking to develop new federal standard for hazardous, high-powered magnet sets. 2012 [release number: 12-256]. <http://www.cpsc.gov/en/Newsroom/News-Releases/2012/CPSC-Starts-Rule-making-to-Develop-New-Federal-Standard-for-Hazardous-High-Powered-Magnet-Sets/>.
- Raabe S. Man's steely resolve. *The Denver Post*. 2013; Business section.
- Child's death prompts replacement program of magnetic building sets. 2006. <http://www.cpsc.gov/cpscpub/prerel/prhtml06/06127.html>.
- Abbas MI, Oliva-Hemker M, Choi J, et al. Magnet ingestions in children presenting to US emergency departments, 2002–2011. *J Pediatr Gastroenterol Nutr* 2013;57:18–22.
- Hussain SZ, Bousvaros A, Gilger M, et al. Management of ingested magnets in children. *J Pediatr Gastroenterol Nutr* 2012;55:239–42.
- Reilly BK, Stool D, Chen X, et al. Foreign body injury in children in the twentieth century: a modern comparison to the Jackson collection. *Int J Pediatr Otorhinolaryngol* 2003;67 (suppl 1):S171–4.

22. Paul RI, Christoffel KK, Binns HJ, et al. Foreign body ingestions in children: risk of complication varies with site of initial health care contact. Pediatric Practice Research Group. *Pediatrics* 1993;91:121–7.
23. Gregori D, Scarinzi C, Morra B, et al. Ingested foreign bodies causing complications and requiring hospitalization in European children: results from the ESFBI study. *Pediatr Int* 2010;52:26–32.
24. Chen KT, Malo MS, Beasley-Topliffe LK, et al. A role for intestinal alkaline phosphatase in the maintenance of local gut immunity. *Dig Dis Sci* 2011;56:1020–7.
25. Cheng W, Tam PK. Foreign-body ingestion in children: experience with 1265 cases. *J Pediatr Surg* 1999;34:1472–6.
26. Farmakakis T, Dessypris N, Alexe DM, et al. Magnitude and object-specific hazards of aspiration and ingestion injuries among children in Greece. *Int J Pediatr Otorhinolaryngol* 2007;71:317–24.
27. Aydođdu S, Arikan C, Cakir M, et al. Foreign body ingestion in Turkish children. *Turk J Pediatr* 2009;51:127–32.
28. Türkyilmaz Z, Karabulut R, Sönmez K, et al. A new method for the removal of safety pins ingested by children. *Ann Acad Med Singapore* 2007;36:206–7.
29. Webb WA. Management of foreign bodies of the upper gastrointestinal tract: update. *Gastrointest Endosc* 1995;41:39–51.
30. MacManus J. Perforation of the intestine by ingested foreign bodies: report of two cases and review of the literature. *Am J Surg* 1941;53:393–402.
31. Palta R, Sahota A, Bemarki A, et al. Foreign-body ingestion: characteristics and outcomes in a lower socioeconomic population with predominantly intentional ingestion. *Gastrointest Endosc* 2009;69 (3 pt 1):426–33.
32. Selivanov V, Sheldon GF, Cello JP, et al. Management of foreign body ingestion. *Ann Surg* 1984;199:187–91.
33. Braumann C, Goette O, Menenakos C, et al. Laparoscopic removal of ingested pin penetrating the gastric wall in an immunosuppressed patient. *Surg Endosc* 2004;18:870.
34. Carp L. Foreign bodies in the intestine. *Ann Surg* 1927;85:575–91.
35. Stricker T, Kellenberger CJ, Neuhaus TJ, et al. Ingested pins causing perforation. *Arch Dis Child* 2001;84:165–6.
36. Aktay AN, Werlin SL. Penetration of the stomach by an accidentally ingested straight pin. *J Pediatr Gastroenterol Nutr* 2002;34:81–2.
37. Mehran A, Podkameni D, Rosenthal R, et al. Gastric perforation secondary to ingestion of a sharp foreign body. *JSLs* 2005;9:91–3.
38. Goh BK, Chow PK, Quah HM, et al. Perforation of the gastrointestinal tract secondary to ingestion of foreign bodies. *World J Surg* 2006;30:372–7.
39. Paul RI, Jaffe DM. Sharp object ingestions in children: illustrative cases and literature review. *Pediatr Emerg Care* 1988;4:245–8.
40. Klingler PJ, Seelig MH, DeVault KR, et al. Ingested foreign bodies within the appendix: a 100-year review of the literature. *Dig Dis* 1998;16:308–14.
41. Akçam M, Koçkar C, Tola HT, et al. Endoscopic removal of an ingested pin migrated into the liver and affixed by its head to the duodenum. *Gastrointest Endosc* 2009;69:382–4.
42. Garcia-Segui A, Bercowsky E, Gómez-Fernández I, et al. Late migration of a toothpick into the bladder: initial presentation with urosepsis and hydronephrosis. *Arch Esp Urol* 2012;65:626–9.
43. Karadayi S, Sahin E, Nadir A, et al. Wandering pins: case report. *Cumhuriyet Med J* 2009;31:300–2.
44. Mirza B, Sheikh A. Open safety pin ingestion presenting as incarcerated umbilical hernia. *APSP J Case Rep* 2011;2:25.
45. Sai Prasad TR, Low Y, Tan CE, et al. Swallowed foreign bodies in children: report of four unusual cases. *Ann Acad Med Singapore* 2006;35:49–53.
46. McComas BC, van Miles P, Katz BE. Successful salvage of an 8-month-old child with an aortoesophageal fistula. *J Pediatr Surg* 1991;26:1394–5.
47. Pinero Madrona A, Fernández Hernández JA, Carrasco Prats M, et al. Intestinal perforation by foreign bodies. *Eur J Surg* 2000;166:307–9.
48. Hameed K, Hassan M, Rehman S. Management of foreign bodies in the upper gastrointestinal tract with flexible endoscope. *J Postgrad Med Inst (Peshawar-Pakistan)* 2011;25:433–5.
49. Tokar B, Cevik AA, Ilhan H. Ingested gastrointestinal foreign bodies: predisposing factors for complications in children having surgical or endoscopic removal. *Pediatr Surg Int* 2007;23:135–9.
50. Horton LK, Jacobson JA, Powell A, et al. Sonography and radiography of soft-tissue foreign bodies. *AJR Am J Roentgenol* 2001;176:1155–9.
51. Binder L, Anderson WA. Pediatric gastrointestinal foreign body ingestions. *Ann Emerg Med* 1984;13:112–7.
52. Uyemura MC. Foreign body ingestion in children. *Am Fam Physician* 2005;72:287–91.
53. Faigel DO, Stotland BR, Kochman ML, et al. Device choice and experience level in endoscopic foreign object retrieval: an in vivo study. *Gastrointest Endosc* 1997;45:490–2.
54. Chauvin A, Viala J, Marteau P, et al. Management and endoscopic techniques for digestive foreign body and food bolus impaction. *Dig Liver Dis* 2013;45:529–42.
55. Zhang S, Cui Y, Gong X, et al. Endoscopic management of foreign bodies in the upper gastrointestinal tract in South China: a retrospective study of 561 cases. *Dig Dis Sci* 2010;55:1305–12.
56. Tierney WM, Adler DG, Conway JD, et al. Overtube use in gastrointestinal endoscopy. *Gastrointest Endosc* 2009;70:828–34.
57. Barth BA, Banerjee S, Bhat YM, et al. Equipment for pediatric endoscopy. *Gastrointest Endosc* 2012;76:8–17.
58. Rodríguez-Hermosa JI, Codina-Cazador A, Sirvent JM, et al. Surgically treated perforations of the gastrointestinal tract caused by ingested foreign bodies. *Colorectal Dis* 2008;10:701–7.
59. Longstreth GF, Longstreth KJ, Yao JF. Esophageal food impaction: epidemiology and therapy. A retrospective, observational study. *Gastrointest Endosc* 2001;53:193–8.
60. Byrne KR, Panagiotakis PH, Hilden K, et al. Retrospective analysis of esophageal food impaction: differences in etiology by age and gender. *Dig Dis Sci* 2007;52:717–21.
61. Cheung KM, Oliver MR, Cameron DJ, et al. Esophageal eosinophilia in children with dysphagia. *J Pediatr Gastroenterol Nutr* 2003;37:498–503.
62. Lao J, Bostwick HE, Berezin S, et al. Esophageal food impaction in children. *Pediatr Emerg Care* 2003;19:402–7.
63. Vicente Y, Hernandez-Peredo G, Molina M, et al. Acute food bolus impaction without stricture in children with gastroesophageal reflux. *J Pediatr Surg* 2001;36:1397–400.
64. Diniz LO, Towbin AJ. Causes of esophageal food bolus impaction in the pediatric population. *Dig Dis Sci* 2012;57:690–3.
65. Hurtado CW, Furuta GT, Kramer RE. Etiology of esophageal food impactions in children. *J Pediatr Gastroenterol Nutr* 2011;52:43–6.
66. Patel NC, Fry LC, Mönkemüller KE. Modified suction cap technique for endoscopic management of esophageal food impaction. *Endoscopy* 2003;35:548.
67. Sumiyama KRE. Endoscopic caps. *Tech Gastrointest Endosc* 2006;8:28–32.
68. Weant KA, Weant MP. Safety and efficacy of glucagon for the relief of acute esophageal food impaction. *Am J Health Syst Pharm* 2012;69:573–7.
69. Thimmapuram J, Oosterveen S, Grim R. Use of glucagon in relieving esophageal food bolus impaction in the era of eosinophilic esophageal infiltration. *Dysphagia* 2013;28:212–6.
70. Arms JL, Mackenberg-Mohn MD, Bowen MV, et al. Safety and efficacy of a protocol using bougienage or endoscopy for the management of coins acutely lodged in the esophagus: a large case series. *Ann Emerg Med* 2008;51:367–72.
71. Dahshan AH, Kevin Donovan G. Bougienage versus endoscopy for esophageal coin removal in children. *J Clin Gastroenterol* 2007;41:454–6.
72. Vicari JJ, Johanson JF, Frakes JT. Outcomes of acute esophageal food impaction: success of the push technique. *Gastrointest Endosc* 2001;53:178–81.
73. Goldner F, Danley D. Enzymatic digestion of esophageal meat impaction. A study of Adolph's Meat Tenderizer. *Dig Dis Sci* 1985;30:456–9.
74. Maini S, Rudralingam M, Zeitoun H, et al. Aspiration pneumonitis following papain enzyme treatment for oesophageal meat impaction. *J Laryngol Otol* 2001;115:585–6.
75. Andersen HA, Bernatz PE, Grindlay JH. Perforation of the esophagus after use of a digestant agent: report of case and experimental study. *Ann Otol Rhinol Laryngol* 1959;68:890–6.
76. Zarlring EJ, Moeller DD. Bezoar therapy. Complication using Adolph's Meat Tenderizer and alternatives from literature review. *Arch Intern Med* 1981;141:1669–70.

77. Chen X, Milkovich S, Stool D, et al. Pediatric coin ingestion and aspiration. *Int J Pediatr Otorhinolaryngol* 2006;70:325–9.
78. Waltzman ML, Baskin M, Wypij D, et al. A randomized clinical trial of the management of esophageal coins in children. *Pediatrics* 2005; 116:614–9.
79. Tander B, Yazici M, Rizalar R, et al. Coin ingestion in children: which size is more risky? *J Laparoendosc Adv Surg Tech A* 2009;19:241–3.
80. Conners GP, Chamberlain JM, Ochsenschlager DW. Symptoms and spontaneous passage of esophageal coins. *Arch Pediatr Adolesc Med* 1995;149:36–9.
81. Velitchkov NG, Grigorov GI, Losanoff JE, et al. Ingested foreign bodies of the gastrointestinal tract: retrospective analysis of 542 cases. *World J Surg* 1996;20:1001–5.
82. Stringer MD, Kiely EM, Drake DP. Gastric retention of swallowed coins after pyloromyotomy. *Br J Clin Pract* 1991;45:66–7.
83. Fleisher AG, Holgersen LO, Stanley-Brown EG, et al. Prolonged gastric retention of a swallowed coin following pyloromyotomy. *J Pediatr Gastroenterol Nutr* 1986;5:811–3.
84. Kay MWR. Techniques of foreign body removal in infants and children. *Tech Gastrointest Endosc* 2002;4:188–95.
85. Mehta D, Attia M, Quintana E, et al. Glucagon use for esophageal coin dislodgment in children: a prospective, double-blind, placebo-controlled trial. *Acad Emerg Med* 2001;8:200–3.
86. Harned RK, Strain JD, Hay TC, et al. Esophageal foreign bodies: safety and efficacy of Foley catheter extraction of coins. *AJR Am J Roentgenol* 1997;168:443–6.
87. Moon JS, Bliss D, Hunter CJ. An unusual case of small bowel obstruction in a child caused by ingestion of water-storing gel beads. *J Pediatr Surg* 2012;47:E19–22.
88. Zamora IJ, Vu LT, Larimer EL, et al. Water-absorbing balls: a “growing” problem. *Pediatrics* 2012;130:e1011–4.
89. Mirza B, Sheikh A. Mortality in a case of crystal gel ball ingestion: an alert for parents. *APSP J Case Rep* 2012;3:6.