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REVIEW

Foreign object ingestion and esophageal food impaction: An update and review on endoscopic management

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Abstract

Foreign body ingestion encompasses both foreign object ingestion (FOI) and esophageal food impaction (EFI) and represents a common and clinically significant scenario among patients of all ages. The immediate risk to the patient ranges from negligible to life-threatening, depending on the ingested substance, its location, patient fitness, and time to appropriate therapy. This article reviews the FOI and EFI literature and highlights important considerations and implications for pediatric and adult patients as well as their providers. Where published literature is insufficient to provide evidence-based guidance, expert opinion is included to supplement the content of this comprehensive review.

Key words: Foreign bodies; Endoscopy; Gastrointestinal emergency; Medical management; Dysphagia

Core tip: Foreign body ingestion encompasses both foreign object ingestion (FOI) and esophageal food impaction (EFI) and represents a common and clinically significant scenario among patients of all ages. This article reviews the FOI and EFI literature and highlights important considerations and implications for pediatric and adult patients as well as their providers.

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INTRODUCTION

Foreign body ingestion is a common and potentially life-threatening clinical problem with an estimated annual incidence of 120000 cases in the United States alone[1]. The majority of these cases occur in children as a result of curiosity and accidental ingestion, with peak incidence occurring between the ages of 6 mo and 3 years[2]. In adults, groups at higher risk include those with severe psychiatric disorders, mental retardation, acute intoxication, or seeking secondary gain (*e.g.*, incarcerated individuals seeking transfer out of prison to a medical facility)[3-5]. Although the majority of ingested foreign bodies will traverse the gastrointestinal (GI) tract uneventfully, 10-20% will require intervention, most often endoscopic, to mitigate complications such as impaction, ulceration, perforation, and potentially death[6-9]. These complications preferentially occur at areas of physiologic or pathologic sharp angulation or narrowing (Figure 1) and appear to be more common and associated with relatively higher morbidity in intentional as compared to accidental ingestion[3,10-12].

Foreign body ingestion can be classified into two main groups: true foreign object ingestion (FOI) and esophageal food impaction (EFI). These groups encompass a wide variety of potentially ingested substrates, making every case a new potential challenge for even highly experienced gastroenterologists. Furthermore, there is considerable geographic variation in the epidemiology of FOI, both in terms of the ingested substrate as well as the patient demographic. For example, in the United States, food (meat) impaction is the most common FOI in adults[13,14], and eosinophilic esophagitis has become recognized as an increasingly common underlying diagnosis (Table 1)[14-16]. In contrast, bones (primarily fish) represent the most common foreign body ingestions in Spain[17], Iran[18], Nigeria[19], Ethiopia[20], India[21], and China[22,23]. These patterns are different, however, among pediatric patients (where FOI, *e.g.*, coin ingestion, is more common)[2,24-27] and elderly patients (where dental prosthesis ingestion is more common) both in the United States as well as globally[22]. Given the heterogeneity in types of foreign bodies (Table 2) and in demographic characteristics, clinical presentation can vary between cases, as can the array and likelihood of complications. Accordingly, management requires careful diagnosis, recognition of the potential risks, and planning for appropriate intervention.

As GI endoscopy has become the method of choice for the management of most FOIs and EFIs, it is critically important for gastroenterologists to understand the role and timing of endoscopic intervention as well as the tools for proper therapy in order to avoid complications and mitigate potential morbidity. Therefore, this review will summarize available evidence that should be considered when managing FOI and EFI and provide diagnostic and therapeutic algorithms for clinicians involved in the care of these patients. Where evidence is limited, we suggest pragmatic approaches based on current data, clinical experience, and expert opinion.

GENERAL PRINCIPLES OF MANAGEMENT

Diagnosis

History and physical examination: In most adults and older children, FOI and EFI are often recognized at the time of the incident, and the history, including the material swallowed and location of discomfort, can be obtained from the patient. In younger children and the psychiatrically (or otherwise mentally) impaired, diagnosis often becomes more challenging, especially when an episode is unwitnessed. Importantly, the site of discomfort or other symptomatology (if present) often does not reliably predict the location of pathology, especially when occurring below the cricopharyngeus[28]; for example, distal esophageal impaction related to an underlying peptic stricture may be referred to the throat region.

The presentation of FOI depends greatly on the nature of the ingested material, anatomical factors (*e.g.*, prior surgery), and the time that has elapsed from initial

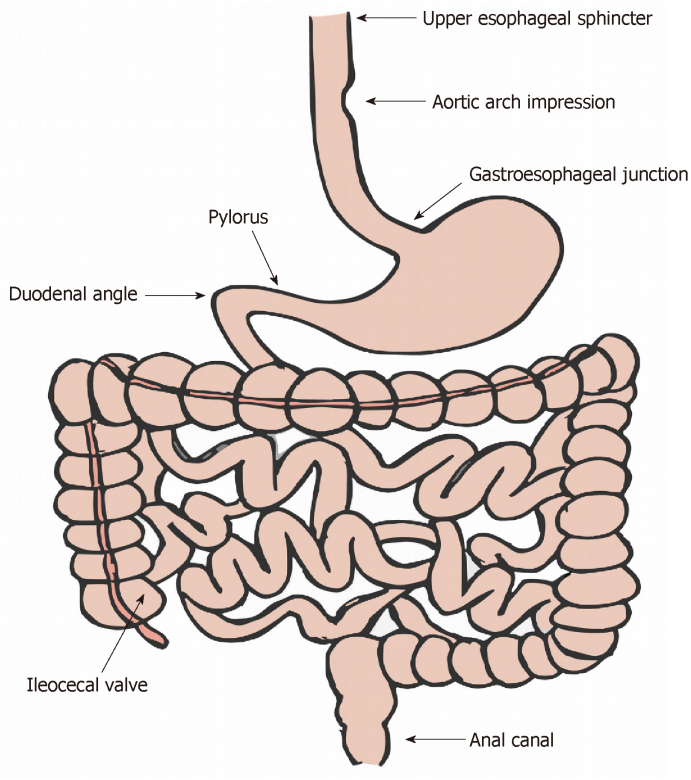

Figure 1 Areas of acute angulation and narrowing (physiologic or pathologic) in the gastrointestinal tract. The areas depicted represent sites of potential food or foreign object impaction.

ingestion. Presenting symptoms may include choking, refusing to eat, vomiting, abdominal pain, respiratory distress (particularly in pediatric patients with proximal esophageal FOI or EFI), or blood-tinged saliva, among others[29-32]. Thus, a careful history (*e.g.*, regarding the ingested material, prior history of dysphagia/similar episodes, the use of removable dental hardware, and prior GI surgeries) obtained from the patient and/or witnesses is essential and may provide critical diagnostic clues.

With regard to EFI, the classic presentation consists of acute onset substernal chest pain/discomfort and difficulty swallowing while eating boneless (typically roasted or pulled) pork, beef, or poultry due to a sensation that food is "getting stuck". In some cases, the presentation may be more insidious, and often times patients frequently will not present until several hours after symptom onset, hoping that symptoms will resolve spontaneously with time. In addition to chest pain and dysphagia, other commonly reported symptoms include foreign body sensation, odynophagia, sialorrhea, and a need to spit up secretions. When obtaining a history, it is important to inquire about the content of recent meals and assess whether the ingesta was boneless or if it may have contained bones, as this could change the management approach and the spectrum of potential sequelae.

The physical examination in patients with suspected FOI or EFI should involve evaluating for evidence of luminal obstruction and other complications, especially perforation (which may manifest, for example, with cervical swelling and/or crepitus in the case of oropharyngeal/proximal esophageal perforation, or with fever and peritonitis in the case of intestinal perforation).

Imaging and localization: Assessment of the anatomic location is of central importance in the clinical management of FOI and EFI. Imaging studies can provide valuable information on the location as well as the morphology and nature (*e.g.*, size and sharpness, composition, and number of objects) of the foreign body. Fortunately, most FOIs are composed of radiopaque material and can be identified on projectional X-rays (*e.g.*, posterior-anterior and lateral images) of the neck, chest, or abdomen. However, objects such as thin bones, plastic, glass, and wood may not be readily seen. X-rays can also provide useful information regarding possible aspiration and free mediastinal or peritoneal air[33]. Contrast administration should generally be avoided given the risk and potential complications of contrast aspiration[6]; moreover, contrast coating of the foreign body and esophageal mucosa can compromise subsequent

Table 1 Underlying disorders in esophageal food impaction

Eosinophilic esophagitis
Schatzki's ring
Peptic stricture
Radiation-induced stricture
Esophageal carcinoma
Zenker's diverticulum
Non-Zenker's esophageal diverticulum
Post-surgical (*e.g.*, fundoplication)
Achalasia
Other spastic dysmotility

Upon further evaluation, many patients with esophageal food impaction are found to have one or more of these disorders.

endoscopy[29,34]. Computed tomography (CT) scanning may be useful (Figure 2)[35-38], particularly if complications are suspected[9], and its sensitivity and accuracy can be improved with three-dimensional reconstruction[39]. Handheld metal detectors can be useful in metallic FOI, particularly in pediatric patients, as well as in the detection of certain radiolucent metallic foreign bodies like aluminum[40-44]. Additional details regarding initial noninvasive diagnostic as well as elimination follow-up imaging have been discussed in recent radiology society clinical guidelines[45].

In the setting of a negative radiographic evaluation but suspected foreign body ingestion and persistent esophageal symptoms, endoscopic intervention is warranted[29,46]. In addition, patients with suspected non-bony EFI without complications (*e.g.*, no evidence of perforation or respiratory distress) can proceed to endoscopic evaluation without obtaining radiographs[6,9].

Preparation and planning

Airway management: Initial management of patients with FOI and EFI includes assessment of ventilatory status and airway protection. Most adult cases of FOI and EFI may be managed with moderate sedation. In the presence of wheezing, stridor, or dyspnea, however, emergent endotracheal intubation may be indicated. Similarly, endotracheal intubation is appropriate for facilitating airway protection in patients who are unable to manage their secretions (*e.g.*, due to very proximal EFI) and are thus at high aspiration risk[9]. Endotracheal intubation may likewise be indicated for patients with FOI or EFI that is difficult to remove and in cases with multiple objects requiring removal. An overtube may be used to provide additional airway protection, and these are discussed in a forthcoming section[9]. Notably, pediatric GI endoscopy often requires general endotracheal anesthesia, in part due to the fact that smaller and more compliant airways have a higher risk of airway obstruction during endoscopy[46].

Timing and urgency of intervention: Once FOI or EFI is diagnosed, the provider must decide whether intervention is necessary, and if so, how urgently intervention is required. The need for and timing of an intervention for FOI and EFI are dependent on multiple factors; these include patient age and clinical condition, the location and characteristics of the ingested material (Table 2), time since ingestion, and the technical capabilities of the endoscopist and facility[47]. Based on these factors and the perceived risks of aspiration, obstruction, perforation, and other potential complications, as well as the likelihood of procedural success, the timing and nature of endoscopic intervention is determined. As stated previously, patients unable to effectively manage their secretions (*e.g.*, due to complete esophageal obstruction from EFI) or with sharp or disk battery FOI require emergent endoscopic intervention (preferably within 2 h, and at the latest within 6 h)[9]. Other scenarios (*e.g.*, asymptomatic blunt foreign object in the esophagus or incompletely obstructing EFI) need not be managed emergently but should undergo endoscopic intervention within 24 h as delay beyond this time interval decreases the likelihood of successful removal and increases the risk of complications, including but not limited to perforation[48-50]. In cases of FOI where the object has made it past the esophagus, most patients who are clinically stable, in no acute distress, and without signs of GI obstruction will not require urgent endoscopy as the ingested object will often pass spontaneously[3,6,51]. For such patients, conservative outpatient management is reasonable[9,52,53], although endoscopic removal may also be appropriate depending on the circumstance (*e.g.*, disk and cylindrical batteries in the stomach that have not progressed in 48 h),

Table 2 Classification of ingested foreign objects

Size
Length (≤ 5 *vs* > 5 cm) Width (≤ 2 *vs* > 2 cm)
Surface consistency
Sharp/pointed *vs* blunt
Smooth *vs* rough/traumatic
Material
Food (boneless *vs* with bone)
Battery
Magnet
Packaged drugs
Chemical/physical characteristics
Radiodensity
Metallic *vs* non-metallic
Chemical reactivity/inertness

A clinically practical classification system for ingested foreign objects. Variations (*e.g.*, in size categories) may exist in specific scenarios.

especially given the high success rate and low risk of adverse events in the majority of cases[6,22,54,55]. If endoscopy is foregone, patients may resume a regular diet but should monitor their stool for passage of the ingested object. In the absence of symptoms, weekly imaging (*e.g.*, X-rays, depending on the type of FOI) should be obtained to follow the progression of small blunt objects that have not yet passed in order to ensure their passage. Specific clinical circumstances are discussed in forthcoming sections.

When to avoid endoscopic intervention: As mentioned above, endoscopy can be foregone in cases where patients are asymptomatic and spontaneous passage is believed to be likely. Special note should be made of the importance of avoiding endoscopic intervention in cases of internal concealment of illicit drugs (*i.e.*, "body packers" or "drug mules"). Here, multiple packets of contraband are typically swallowed and pose a risk for obstruction or rupture. Endoscopic removal should generally not be attempted because of the high risk of rupturing a packet, which can lead to fatal drug overdose. Therefore, these patients should be managed conservatively with close monitoring, serial imaging, and assessments for potential toxicity; surgical intervention may be indicated should removal become necessary[8].

Therapeutic equipment and supplies

Endoscopes: Most FOIs and EFIs are best treated with flexible endoscopes[6,56]. This approach has a high success rate, is generally safer than rigid endoscopy[57], and can be performed with moderate sedation in a majority of cases. However, in some instances, rigid esophagoscopy may be preferable, *e.g.*, for proximal FOIs and EFIs impacted at the level of the upper esophageal sphincter or hypopharynx (*i.e.*, above the cricoid cartilage)[17,54,57-59]. Standard or therapeutic endoscopes are preferable, but small-caliber endoscopes may be used (*e.g.*, if a transnasal approach is deemed necessary or if the patient is unfit for sedation)[60]. However, based on randomized controlled trial (RCT) data, cases of small-caliber endoscope failures can frequently be successfully treated with a standard endoscope, whereas the converse does not appear to be true[61]. Recently, single- and double-balloon enteroscopes are being used in the management of FOIs which are beyond the reach of conventional endoscopes; this is discussed further below[62-65].

Retrieval devices and accessories: A variety of devices and accessories have been described in the published literature for management of FOI and EFI, including but not limited to rat-tooth and alligator forceps, polypectomy snares, multi-prong graspers, Dormia baskets, Roth retrieval nets, Foley catheters, and variceal ligator caps[66-68]. More recently, the use of balloon dilators[69] and sutures[70] has also been described, as has the use of other accessories[71]. The choice of retrieval device depends largely on the type of FOI or EFI and endoscopist experience and preference[72-74]. Foley catheter techniques have also been described and may be more cost-effective in certain pediatric care scenarios (*e.g.*, coin ingestion)[75,76] but are not often used in the adult population. A recent RCT showed that use of a soft, clear cap at the end of the

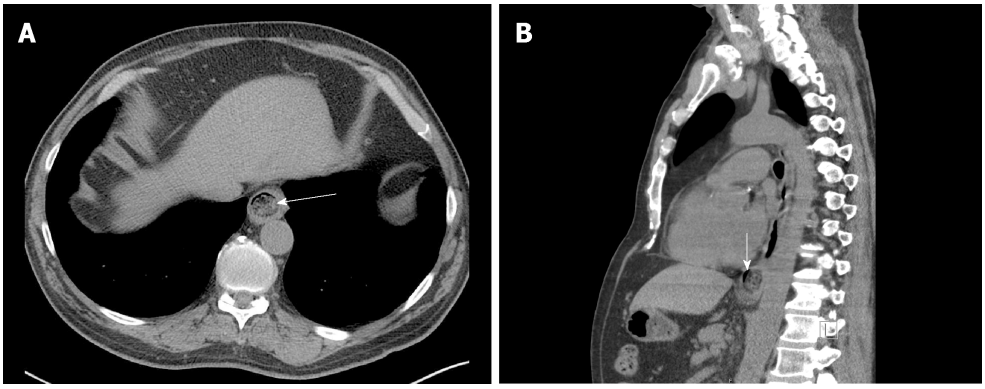

Figure 2 Computed tomography revealing an esophageal food impaction. A: Axial tomogram revealing a food bolus (arrow) in the distal esophagus; B: Sagittal tomogram reveals a sliver of space around the bolus (vertical arrow) suggestive of an opportunity to wedge in the endoscope and employ the push technique or to pass a guidewire (*e.g.*, for the balloon dilation technique).

endoscope may provide an advantage by improving visibility and shortening the procedure time[77]. Regardless of the technique and devices/accessories used, *ex-vivo* practice using the planned retrieval equipment and an object similar to the ingested foreign object can help determine the suitability of the proposed therapeutic approach.

Overtubes: Use of an overtube during the management of FOI and EFI: (1) provides airway protection during retrieval and (2) allows for multiple passes of the endoscope during retrieval, and iii) shields the esophageal mucosa from injury when removing sharp or pointed objects[78,79]. When the object is distal to the esophagus, a longer overtube that extends across the esophagogastric junction can provide additional protection and is often recommended[9]. Overtubes are less commonly used in pediatric patients, as there may be increased risk of esophageal injury and retching associated with overtube insertion. However, newer, softer overtubes may be considered in larger children and adolescents[80].

An alternative to an overtube in cases of sharp or pointed object retrieval is the use of a latex protector hood, which is placed over and affixed to the tip of the endoscope. The bell portion of the protector hood remains inverted during insertion of the endoscope and then flips back to its original shape during withdrawal as it crosses a region of narrowing (*e.g.*, the lower esophageal sphincter)[8,81,82].

Pharmacologic agents: Glucagon has long been employed in the management of EFI and is in fact one of the only interventions to have been studied in the setting of an RCT[83]. The proposed mechanism of action of glucagon in facilitating resolution of EFI involves its spasmolytic activity. Although the aforementioned RCT failed to show therapeutic effects, the study had several notable limitations. For example, it did not specifically investigate whether glucagon could facilitate endoscopic therapy (by facilitating engagement of the impacted bolus via decreasing esophageal spasms), but rather assessed whether it would increase the rate of spontaneous passage. Based on one prospective (non-randomized) study[84], anecdotal experience, and various retrospective series[71,85,86], treatment with glucagon is generally reasonable in the management of patients with EFI[6,29], realizing though that it will be effective in only some patients[9,87]. With respect to dose, esophageal tone appears to reach a nadir at 0.5 mg (based on the results of the only published study of its kind)[88]; however, these data were obtained in normal healthy controls and based on pressure measurements at the lower esophageal sphincter and therefore cannot necessarily be extrapolated to individuals with EFI in a more proximal portion of the esophagus. As a result, and based on its safety and potential usefulness as demonstrated in a prospective (nonrandomized) trial[89], most practitioners advocate for the administration of glucagon 1.0 mg intravenously in cases of EFI prior to endoscopic intervention[6]. If there is no apparent improvement in symptoms and no adverse effects, a repeat dose (within 15-30 min) in an attempt to further relax the esophagus is reasonable, particularly for non-meat EFI, although high quality evidence to support this practice is currently lacking[86].

Effervescent agents such as cola or other carbonated drinks have long been used alone or in combination with other pharmacologic agents (*e.g.*, glucagon)[90-93]. The evidence supporting their use includes a single prospective study[84] and several case series and reports; the collective results suggest that effervescent agents may help to achieve spontaneous resolution of EFI and are associated with little risk in patients

capable of protecting their airway. Therefore, the administration of an effervescent is reasonable in select patients (*e.g.*, who do not appear to have severe impaction), but as with other pharmacologic therapies, should not delay endoscopic intervention[93].

The use of various other agents has been described in the management of EFI but is not routinely recommended for this indication[6,94]. Hyoscine butylbromide (*i.e.*, butylscopolamine), a peripherally acting antimuscarinic, anticholinergic agent, is believed to exert potentially therapeutic effects through its spasmolytic activity (similar to glucagon); its use is supported by very limited published data, none of which are prospective[95-97]. Benzodiazepines have also been employed in patients with EFI[83,98,99]. However, the evidence for their use is sparse, and the literature suggests that they are no more effective than placebo[83]; moreover, there is concern that benzodiazepines may impair a patients alertness and thus airway protection. Lastly, use of proteolytic enzymes (*e.g.*, papain) has been described, but this should be avoided due to numerous associated risks, including esophageal erosion and perforation[8,29,100].

MANAGEMENT OF EFI

The most common EFI in adults in the Western world is impacted meat[8]. Endoscopic treatment options for disimpaction include extraction of the impacted food bolus or advancement of the bolus into the stomach, as discussed below and summarized schematically in Figure 3. Extraction may involve either en bloc or piecemeal removal, depending on the clinical circumstance, using the various accessories and devices as listed above. Radiographic assessment prior to endoscopy is not necessary unless bone fragments are suspected based on the clinical history; if present, these should serve as an alert to the endoscopist, as they may increase complexity of endoscopic treatment. As mentioned earlier, pharmacologic agents are reasonable in an attempt to promote non-invasive passage of the bolus and avoid urgent endoscopy.

Advancement (*i.e.*, pushing) of the bolus into the stomach is the primary means of treating EFI. Prior to doing so, however, the esophagus distal to the obstruction should be examined (by passing the endoscope around the bolus)[9,29,47,71]. The rationale for this lies in the relatively high incidence of underlying esophageal pathology associated with food impactions, thus raising concern for and risk of esophageal perforation[14,15]. Nevertheless, large published series have suggested that the push technique for soft food impaction, when performed by an experienced endoscopist, is both safe and frequently effective[101,102]. In these series, gentle pressure is applied to the middle of the food bolus in an attempt to push the object into the stomach. If this fails, pieces of the bolus are broken off, typically with forceps, followed by a repeat attempt to push the object forward. A balloon dilation technique has been described wherein a guidewire is passed through the food bolus, over which a dilating balloon is passed, inflated in the stomach, and then pulled back through the stricture; once the stricture is dilated, the food bolus is advanced into the stomach[69]. An alternative technique which the authors have recently described involves burning through a food bolus with a bipolar coagulation probe followed by securing the food bolus with opening of an Ovesco triprong anchor in the burn defect (Figures 4A-D)[103]. Regardless of the technique(s) chosen for an individual case, disimpaction attempts should not be delayed beyond 12-24 h from symptom onset given the increasing risk of complications with time[29,47,49,104,105]. In addition, and as described earlier, an overtube should be used in situations where a food bolus has become soft and fragmented, thus requiring repeated esophageal intubations, or if there is an increased risk of aspiration without an option for timely general endotracheal anesthesia.

Once food bolus advancement or extraction has been performed, in most circumstances, it is considered beneficial and safe to perform esophageal dilation (if an underlying stricture is found) in order to reduce the risk of recurrent EFI[6,29,71,101,102]. In cases of prolonged EFI, if eosinophilic esophagitis is suspected, or if underlying mucosal trauma is noted, dilation should be deferred to a later date (and often following a course of acid suppression therapy) to minimize the risk of iatrogenic perforation[71,106]. If a stricture or other luminal narrowing is not found, esophageal biopsies should be considered after the EFI has been cleared (*e.g.*, to rule out eosinophilic esophagitis).

MANAGEMENT OF FOI

In the forthcoming subsections, we provide an overview of FOI management based on the type/characteristics of the object, as summarized schematically in Figure 5.

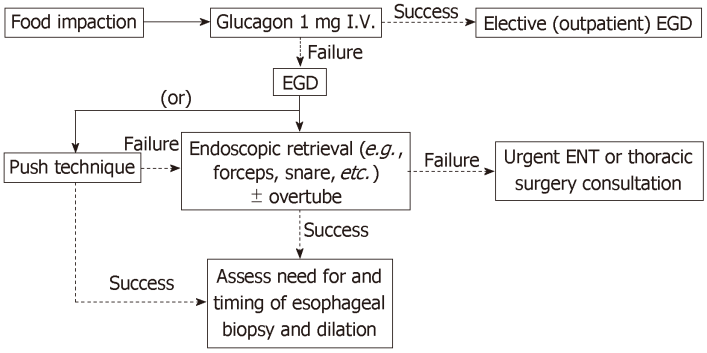

Figure 3 Proposed management algorithm for esophageal food impaction. In the management of esophageal food impaction, the use of glucagon can be first attempted to relax the esophagus and promote spontaneous passage. If unsuccessful, endoscopic retrieval or advancement of the bolus into the stomach can be attempted. EGD: Esophagogastroduodenoscopy; ENT: Ear, nose, and throat (otolaryngology).

Short, blunt objects

FOI involving short, blunt objects such as coins and buttons occurs most often in the pediatric population. When there is suspicion of such FOI in a pediatric patient, X-ray radiographs should be ordered, as impaction in the esophagus may be asymptomatic in a substantial proportion of cases[107]. Coins lodged in the esophagus should be treated with endoscopic retrieval within 12 to 24 h to allow an appropriate pre-anesthetic fast in patients who are asymptomatic[6,80]. In contrast, endoscopic retrieval of coins in the esophagus should be performed emergently in symptomatic patients who are unable to swallow secretions or have acute respiratory symptoms. If more than an hour has elapsed since the last imaging study, imaging should be repeated to confirm that the object is still in the esophagus prior to proceeding with endoscopy. Objects lodged at or above the level of the cricopharyngeus are generally best removed laryngoscopically, while impactions below this level can be removed via flexible upper endoscopy[58,107,108]. If a coin or similar object is found in a patient with several days of symptoms, the possibility of esophageal erosion by the object should be considered, and additional diagnostic evaluation, such as CT imaging, should be performed[37,80].

In adults, endoscopic removal can usually be achieved under moderate sedation, whereas in pediatric patients, general endotracheal anesthesia is typically required, as mentioned earlier[57]. Coins can be easily retrieved with a forceps device (*e.g.*, rat-tooth, alligator) or a snare; smooth, spherical objects are best retrieved with a Roth retrieval net[29,109], as demonstrated in a prospective study[72]. Objects that cannot be readily grasped in the esophagus may be advanced into the stomach to facilitate grasping and retrieval[47]. The use of an overtube with an inner diameter greater than that of the ingested object provides an additional degree of safety, particularly if multiple objects are suspected or present[29]. Alternative techniques, including use of Foley balloon catheters and nasogastric tubes outfitted with magnets, have also been reported (*e.g.*, in cases where endoscopy is not readily available)[110,111], but these approaches generally offer no advantage over or are inferior to endoscopic removal[29,68,112]. The major disadvantage to such techniques is that they provide: (1) minimal control of the object as it is being removed; (2) no airway protection; and (3) no visualization of the esophagus to assess for underlying pathology or complications (*e.g.*, mucosal injury)[47]. Once the ingested (blunt, short) object enters the stomach, conservative outpatient management is usually appropriate[6,9,29], and the majority of objects will pass spontaneously within 4 to 6 d. However, spherical objects > 2.5 centimeters in diameter (or smaller in pediatric patients) are less likely to pass the pylorus, and if retained for > 3-4 wk (or less, depending on composition) or remaining in the same location for > 1 wk, should generally be removed endoscopically[8,29,47,54]. A regular diet can usually be continued while patients monitor their stools for passage of the foreign body. As long as a patient remains asymptomatic, radiographs evaluating the progression of small blunt objects can be performed weekly[8,13]. If symptoms of fever, vomiting, or abdominal pain arise, immediate CT imaging is warranted followed by prompt endoscopic and/or surgical evaluation[3,6,8,29].

Sharp and pointed objects

A myriad of sharp and/or pointed FOIs have been described, and these may be accidental or intentional. In children, most such ingestions are accidental; in adults, sharp bones (*e.g.*, fish, chicken) and toothpicks (Figure 6A-C) are usually ingested

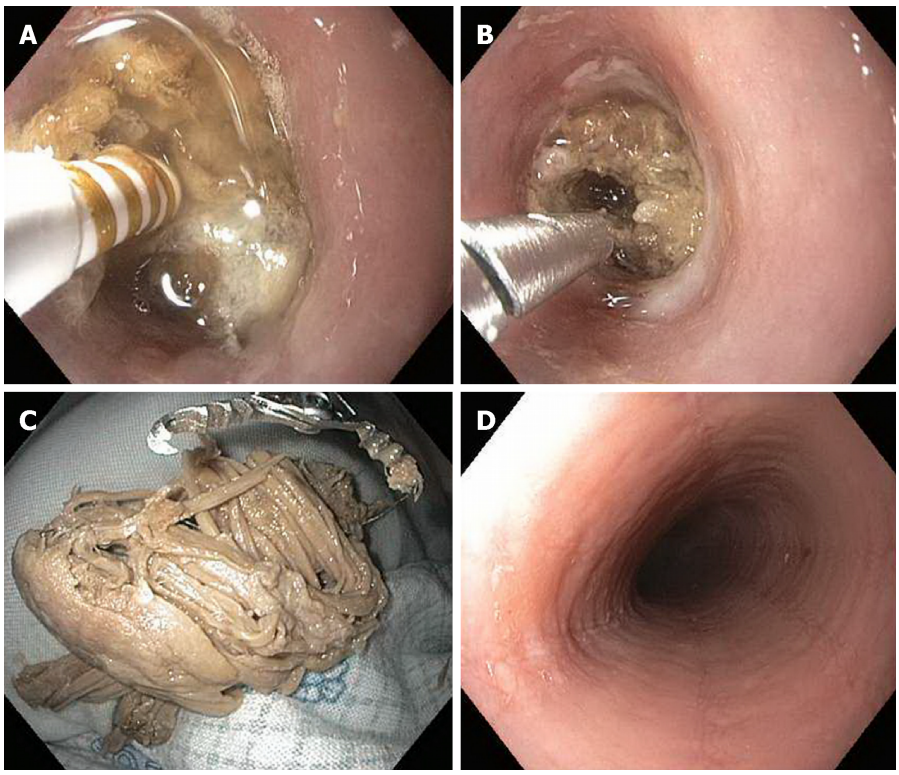

Figure 4 Esophageal food impaction removal. A 48-year-old man in whom attempted extraction of an esophageal food impaction had failed at an outside emergency department was emergently referred to our institution for further management. Endoscopic examination revealed a boneless meat bolus lodged in the mid-esophagus. A: A tract in the center of the bolus was made using a bipolar coagulation probe; B, C: Next, an Ovesco triprong anchor was deployed in the tract (B), and the meat bolus was extracted in one piece (C). D: Mucosal changes including a ringed esophagus, longitudinal furrows, and small-caliber esophagus were found (D), and mucosal biopsies demonstrated evidence of underlying eosinophilic esophagitis[103].

accidentally, whereas most other sharp and/or pointed FOIs (*e.g.*, pins, needles, razorblades, nails, straightened paper clips) are intentional[29,80]. Patients suspected of sharp and/or pointed FOI must be thoroughly evaluated to define the nature, location, and potential complications related to the object. Since many such objects are not readily visible by plain films, CT imaging may be considered in lieu of (and may be more cost-effective than) simple radiographs[35-38,113], and endoscopy should follow a negative radiologic examination to ensure absence or passage of the FOI, or to provide therapy[56].

Sharp and/or pointed FOIs represent a potential medical emergency given their potential for serious complications, with earlier intervention associated with a lower risk of complications[29,105,114,115]. As with other FOIs, sharp objects lodged at or above the cricopharyngeus should be retrieved via direct laryngoscopy, while objects below this area should be retrieved via flexible endoscopy[116]. Objects will generally pass through the GI tract uneventfully once entering the stomach, though the risk of potential complication is not insignificant[13,80]. Therefore, retrieval should be pursued if within safe endoscopic reach (*e.g.*, in the stomach or proximal small bowel)[29,82,117]. Otherwise, these pointed objects, as with others, may be followed with noninvasive imaging studies to document their passage or failure to progress, in which case surgical consultation should be obtained[8,29]. In the interim, patients should be advised to immediately report abdominal pain, persistent fever, vomiting, hematemesis, or melena.

In the management of sharp and/or pointed FOI, Chevalier Jackson's axiom: "Advancing points puncture, trailing do not"[8] can be helpful to remember. In this, the father of modern endoscopy of the upper airway and esophagus referred to the ability to minimize risk of mucosal injury during retrieval of sharp objects by orienting the object with its sharp point trailing during extraction. Endoscopic retrieval of such objects can be accomplished with a variety of accessories and devices, including a forceps or snare, depending on the particular object and endoscopist experience[6,47,72]. To further provide mucosal as well as airway protection, overtube use is advisable, or alternatively, the endoscope tip can be fitted with a protector hood, as mentioned previously[23,77,81]. Some endoscopists prefer endotracheal

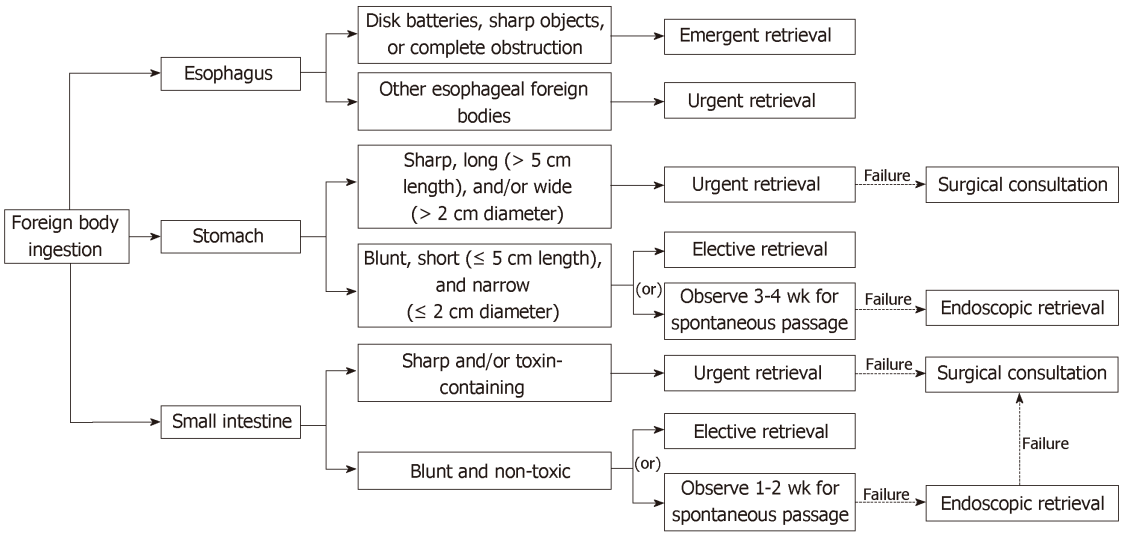

Figure 5 Proposed management algorithm for true foreign body ingestion. Timing (emergent, 2-6 h; urgent, < 24 h) and management of true foreign body ingestions depend on the nature as well as the location of the object. In some instances, imaging and/or surgical consultation may be indicated prior to deciding upon endoscopic intervention; indeed, individualized decisions often need to be made weighing the risks and benefits of endoscopic intervention in a particular case, recognizing that in some scenarios, observation may overall be a safer and more preferable management strategy than endoscopic or other intervention.

intubation for removal of sharp-pointed objects, but this is seldom required from a procedural perspective if an overtube or protector hood is used[47,82].

Long objects

Although typically not sharp, long and/or large (> 5 cm) objects (*e.g.*, toothbrushes, pens, eating utensils, dental appliances) may carry considerable risk of complications when ingested (Figure 7). The majority of such objects are unlikely to spontaneously traverse the duodenal sweep and should thus be removed[3,6,118]. Width/thickness of the object should also be considered in addition to length. The GI tract of younger (pediatric) patients is smaller, thus modified dimension criteria should be applied in these patients.

In general, endoscopic retrieval of long or large objects can be performed after an interval of pre-procedural fasting as long as the patient is asymptomatic. A variety of devices and accessories can be used for endoscopic retrieval; commonly, the object is best grasped with a snare or Roth retrieval net and then maneuvered into an overtube[80] (Figure 8). Once this is achieved, the entire apparatus (*i.e.*, foreign object, overtube, and endoscope) can then be removed from the patient in one motion so as to avoid losing grasp of the object within the overtube[29,119].

Batteries

Due to their small size, slippery texture, as well as increasing prevalence in many everyday electronics (*e.g.*, hearing aids, watches, toys, calculators, *etc.*), disk and button battery ingestion is on the rise, with children under the age of 5 responsible for most cases[6,120,121]. Direct pressure applied to the mucosa by the battery (leading to pressure necrosis), leakage of strongly alkaline contents (causing chemical damage), and generation of an electrical current (due to the production of hydroxide at the negative pole of the battery, resulting in a high pH), contribute to the high risk of liquefactive necrosis and mural perforation that can rapidly occur when a disk battery is lodged in the esophagus[29,122,123]. Lithium battery ingestions are particularly dangerous given their generally larger size and ability to generate more electrical current in a short period of time[124]. Thus, the use of honey (dosed at 10 mL every 10 min) in the prehospital setting, or sucralfate (dosed at 10 mL every 10 min) in the emergency department setting, has been suggested to coat the battery and delay hydroxide generation and exposure[125,126]. In fact, the National Capital Poison Center has recently updated their Battery Ingestion Triage and Treatment Guideline to incorporate the aforementioned suggestions (for up to 12 h after ingestion of a lithium coin battery)[127]. Of note, however, honey should not be given to children under the age of 1 year due to the risk of infantile botulism[128].

Once discovered on imaging, batteries lodged in the esophagus should be emergently removed, as damage to the esophageal mucosa and deeper tissues can occur within hours[129,130]. Endoscopic retrieval using a retrieval net is often successful for this indication[72]. An alternative method is to use a through-the-scope balloon,

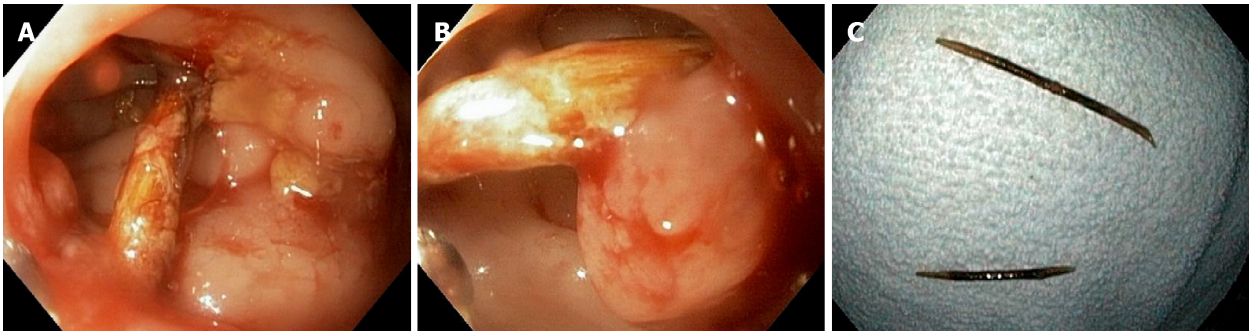

Figure 6 Endoscopic extraction of embedded toothpick. An 82-year-old woman with remote history of accidental toothpick ingestion and presumed spontaneous passage underwent colonoscopy for fecal incontinence. A, B: Upon reaching the rectosigmoid junction, polypoid inflammatory changes were visualized at the base of both ends of what appeared to be an embedded toothpick; C: Colorectal surgery was called to the procedure room, and a multidisciplinary decision was made to attempt endoscopic removal. Using standard biopsy forceps, the toothpick was grasped and, using gentle traction, successfully removed in two pieces.

whereby a balloon is passed through the working channel beyond the foreign body. The balloon is then inflated, and the entire endoscope and balloon are withdrawn, thus pulling the battery up and out of the body[8]. To protect the airway, an overtube or endotracheal tube is necessary with the aforementioned method. In cases where retrieval of the battery from the esophagus is not possible, the foreign body should be advanced into the stomach, grasped or otherwise captured therein, and then removed. The National Capital Poison Center now also recommends endoscopic irrigation of the injured esophagus with 150 mL of 0.25% acetic acid immediately after battery removal (in an attempt to neutralize injury from alkaline batteries)[127,130], but no studies have been performed to evaluate whether this intervention improves outcomes, and the risks may outweigh the benefits in cases where there is no endoscopically visible chemical injury.

Batteries that have spontaneously progressed beyond the esophagus do not necessarily need to be retrieved unless the patient has signs or symptoms of GI tract injury[129]. A large-diameter (> 20 mm) battery remaining in the stomach longer than 48 h, as documented by repeat imaging, however, should be removed (even in the absence of signs or symptoms of injury)[6,131]. Use of emetics and cathartics has been reported, but this practice is not recommended and may be harmful[6,29,131]. Once beyond the duodenum, the majority of batteries, even those that are large and/or long, will be passed out of the body within 72 h[120] unless a pathologic narrowing (*e.g.*, from adhesions) is present. Radiographs can be obtained every 3 to 4 d to ensure progress and ultimate passage[6].

Magnets

Ingestion of magnets can cause severe GI injury and even death. The number of magnets is important, as ingestion of a single magnet is unlikely to result in GI complications, whereas ingestion of more than one magnet may be exceedingly hazardous because of the attractive force generated between magnets, which can lead to fistulization, obstruction, mural necrosis, and perforation[6,80].

Imaging should be considered following magnet ingestion to localize the magnet(s), determine their size, and evaluate for the development of complications. It has been suggested that, when possible, any and all magnets be removed, even if only one magnet is reported or visualized on imaging, as undetected magnets or other ingested metal objects together with a magnet can lead to significant injury[132]. In many instances, however, if a magnet is not large and is already beyond the reach of an upper endoscope or enteroscope, careful monitoring for continued passage through the GI tract is preferable[80,133].

Drug packets

Internal concealment of narcotics or other illicit drugs wrapped in plastic or contained in latex condoms, referred to as "body packing," is a form of drug trafficking[134,135]. Although historically a phenomenon seen only in adults, cases of pediatric body packers (*i.e.*, smuggling "mules") have been reported[80,136,137]. Drug packets can usually be seen by non-invasive imaging modalities (particularly CT)[138,139]. Use of activated charcoal to bind drug and decrease drug absorption or bowel irrigation with polyethylene glycol solution to promote evacuation may be attempted, but data to support these practices are limited. Paraffin or mineral-oil-based laxatives should be avoided due to their ability to degrade latex and thus increase risk of drug exposure[140]. When imaging is equivocal and/or patient history is unreliable,

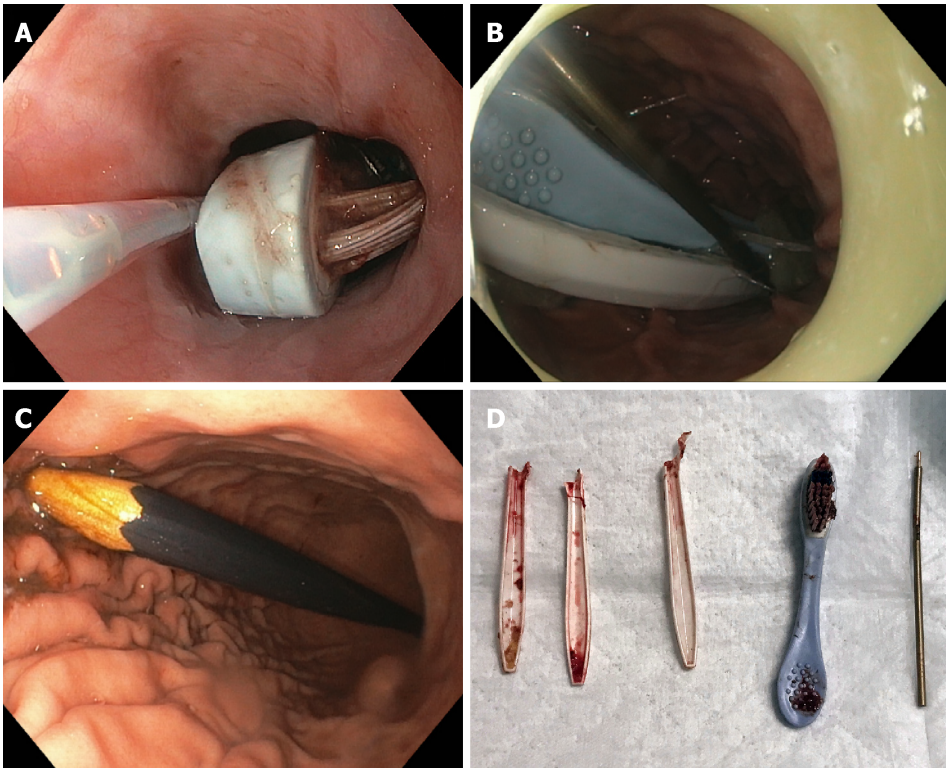

Figure 7 Endoscopic extraction of multiple long objects. A, B: A 36-year-old male was found to have multiple foreign ingested objects in the stomach, including a toothbrush (A), pen cartridge, and several forks (B); C: On subsequent encounters, the same patient was found to have other ingested objects, including pencils; D: Items recovered during endoscopy are shown in.

diagnostic endoscopy can be considered to confirm the presence, location, and number of drug packets. Endoscopic removal, however, should typically not be attempted given the risk of packet rupture, drug leakage, and potentially fatal ensuing events. A Swiss study of 132 patients found the risk of drug packet rupture when left to pass the GI tract on its own to be nil (though the authors acknowledged that variations in risk may exist between different countries based on the quality of the packaging)[141]. Surgical intervention is generally indicated in cases with failure of the packet(s) to progress spontaneously, signs or symptoms of GI obstruction, or suspected packet rupture[47]. On a similar note, endoscopic removal of detergent packets (also known as "laundry pods") is not recommended, as these packets dissolve quickly, and attempted removal can lead to aspiration and other complications[142].

Small intestinal foreign objects

If an object has already passed through the upper GI tract, it will typically continue to pass through the small intestine, into the colon, and out of the body. In some instances, however (*e.g.*, in the setting of jejunal or ileal strictures related to Crohn's disease or radiation), retention may occur in the midgut, *i.e.*, in the small intestine beyond the reach of a standard upper endoscope. In such instances, enteroscopy (*e.g.*, push, balloon-assisted, and laparoscopically assisted) can facilitate access to and removal of retained objects as well as identification of a cause for retention. For example, case reports and series have described the successful use of anterograde and retrograde balloon enteroscopy to retrieve retained video endoscopy capsules (Figure 9)[143-146] as well as other FOIs[147]. Although data on enteroscopy for retrieval of ingested foreign bodies from the midgut are currently limited, accessories such as hoods, baskets, and forceps, do exist for balloon enteroscopes, and thus it represents an option in select cases. In the interim, clinical decision making regarding enteroscopy in the management of FOIs should consider variables such as the nature of the FOI, patient stability, underlying disease and anatomical factors, anterograde vs. retrograde approach, availability of appropriate endoscopic accessories, need for fluoroscopy, and endoscopist expertise[6].

Colorectal foreign objects

Colorectal foreign objects can result from anterograde passage of ingested objects down to the colorectum (Figure 8) or from direct retrograde insertion. Retrograde

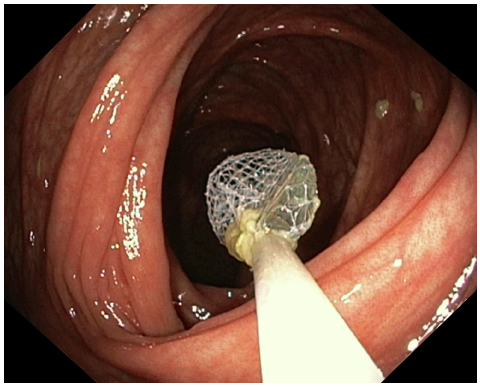

Figure 8 Retrieval of foreign object with Roth retrieval net. A 27-year-old man who reportedly swallowed glass while working under a skylight that shattered. A glass shard was removed from the cecum via colonoscopy with a retrieval net[148].

insertion is usually a result of sexual practices, psychiatric illness, or illicit drug smuggling. Patients with colorectal foreign objects may be asymptomatic or may present with a variety of symptoms, including GI bleeding, tenesmus, large bowel obstruction, peritonitis, or perforation. Blunt objects lying low (distally) in the rectum may be amenable to digital removal under moderate sedation; objects in a more proximal location may require sigmoidoscopic or colonoscopic removal. For sharp and/or pointed objects, a digital rectal exam should be deferred; such objects should be removed under direct visualization, generally with a protector hood or similar apparatus. Large objects (*e.g.*, vibrator or bottle) usually require general anesthesia and anal sphincter dilation or retraction, and some may even necessitate the use of a large-caliber rigid proctoscope (usually performed by a colorectal surgeon). In rare instances, laparotomy may be required.

CONCLUSION

FOI and EFI are common clinical problems which generally require multidisciplinary care coordination. This review has provided evidence- and experience- based guidance and updates regarding the diagnosis and management of FOI and EFI in their various forms and presentations. In many instances, endoscopy is safe and effective and generally the treatment of choice for both FOI and EFI. To further improve patient outcomes associated with these clinical scenarios, well-designed RCTs evaluating pharmacologic, imaging, and endoscopic aspects of the care of patients presenting with FOI and/or EFI may be considered to better formulate evidence-based, cost-effective management strategies.

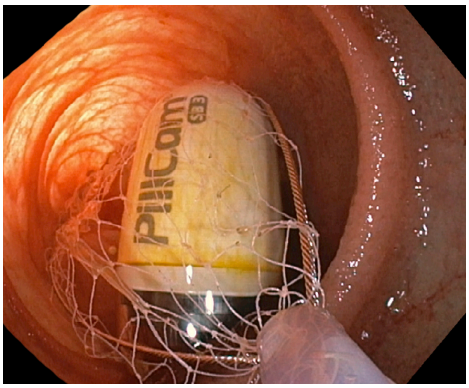

Figure 9 Laparoscopically-assisted enteroscopic foreign object retrieval from the deep small bowel. Retrieval of a retained video capsule in the distal ileum via laparoscopically-assisted anterograde enteroscopy in a patient with Crohn's disease.

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