Diagnostic imaging for foreign bodies

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Learning objectives

In this article, we describe foreign bodies entering the respiratory or gastrointestinal tract via swallowing, inserted foreign bodies, penetrating foreign bodies, and iatrogenic (retained) foreign bodies. We also describe interventional radiology techniques for identifying and managing such foreign bodies.
Background

Incidents involving the retention of foreign bodies within a patient's body are relatively rare. Most notably, in both children and adults with psychiatric disorders, accurate information is often not available, and many of the symptoms of foreign body retention are nonspecific.

Because treatment varies depending on the type, nature, and location of foreign bodies, as well as secondary changes, diagnostic imaging plays a major role in treatment.
Findings and procedure details

Swallowed foreign bodies

Foreign body aspiration is asymptomatic in half of cases. Most such foreign bodies pass through the gastrointestinal tract without problems and are spontaneously excreted. It is believed that, before endoscopy was widely adopted, 93-99% of blunt foreign bodies were excreted spontaneously.

Accidental ingestion of foreign bodies commonly occurs in children and the elderly. The rather commonly swallowed foreign bodies are coins, toys, and buttonbatteries in children; and dentures, press-through package (PTP) sheets, food boluses (e.g., fish bones and pieces of meat), and toothpicks in the elderly. (Accidental ingestion of PTP sheets will be described in more detail in a separate section).

When foreign bodies remain in pharyngeal soft tissue, the common sites among those targeted for diagnostic imaging include the tonsils, epiglottic vallecula, pyriform sinus, and esophageal entrance. The detection rates employing cervical plain radiography are low. Assessment with computed tomography (CT) is useful for determining the presence or absence/locations of foreign bodies, the depth and direction of wall penetration, and the presence or absence/severity of accompanying complications.

**Fig. 1 on page 13** shows a case of accidental denture ingestion resulting in abscess formation.

In the area from the oropharynx to the hypopharynx, there is a foreign body depicted as a high-density area that appears to be a metal object in form of the letter C. CT reveals a tubular shadow, with a density which is not as high as that of metal but is nonetheless relatively high. The upper end of the foreign body is embedded in the soft tissue of the left pharyngeal wall, where a localized abscess formation has occurred.

In apparent cases of accidental foreign body ingestion, radiography is performed. It is important to determine the locations of foreign bodies, especially whether or not they remain in the esophagus. In the event of accidental ingestion of a round object, a circular shadow depicted on frontal radiographs, as shown in **Fig. 2 on page 13**, indicates that the foreign body is located in the esophagus. (An elongated shadow on frontal radiographs suggests that the foreign body might be located in the trachea).
A 4-year-old girl was brought to our hospital after accidentally ingesting a slot machine coin. Because it appeared as a circle on a frontal radiograph and was located on the posterior wall of the respiratory tract on a lateral radiograph, the coin was visualized as remaining in the esophagus. It was removed employing an endoscope.

The presence of a gastrointestinal foreign body indicates a state in which an object that does not exist in the gastrointestinal tract under normal circumstances is retained therein. Gastrointestinal foreign bodies, which include objects such as a bezoar formed within the body and parasites, can be classified as oral and transanal foreign bodies (the latter is described below in the section on inserted foreign bodies). The causes include accidental and intentional ingestion. In this category, there are considered to be far more cases with upper gastrointestinal foreign bodies.

We herein describe the therapeutic management of foreign bodies according to the treatment algorithm used for foreign body aspiration shown in Fig. 3 on page 14. In the case of an asymptomatic, blunt foreign body found to have passed through the esophagus based on radiography, only follow-up radiography is acceptable (however, in the case of a large foreign body having become lodged in the esophagus, endoscopic removal should be considered). When an esophageal foreign body is a circular coin, a button, or a piece of plastic, there is no urgency. When a coin is ingested, it passes into the stomach within 24 hours without complications in the majority of cases (if the coin is found in the stomach on follow-up examination conducted the next day, there is no need for concern). However, when a button battery is ingested, it should be removed within 2 hours because the electric current produces hydroxide, which may cause necrosis of the esophageal mucosa.

A button battery is depicted as a double rim sign because the negative terminal is slightly smaller than the positive terminal. Although accidental ingestion of a button battery is considered to be asymptomatic in at least 80% of cases, there are also reports of serious complications, such as aorto-esophageal and trachea-esophageal fistulae. Fig. 4 on page 15 and Fig. 5 on page 16 show accidental coin and button battery ingestions; these are not cases in which esophageal foreign bodies must be removed.

Compared to that in Fig. 4 on page 15 (accidental ingestion of a coin), the shadow in Fig. 5 on page 16 can be identified as a button battery because of the double contour.

Sharp esophageal foreign bodies are endoscopically removed. During removal, attention should be given to concomitant mediastinitis.
**Fig. 6 on page 17** shows a case with an esophageal foreign body (sea bream bone). In this case, sudden thoracodorsal pain occurred during a meal. Under suspicion of aortic dissection, the patient was transported by ambulance and a CT scan was performed. The scan revealed a linear high-density object in the upper thoracic esophagus at the level immediately above the carina as well as edematous change in the esophagus around the object.

Gastric foreign bodies should be removed if they cause pain and/or other symptoms. Sharp foreign bodies especially should be removed early, employing endoscopy, while they remain in the stomach. In the event of a small blunt foreign body being asymptomatic, follow-up radiography can only be performed weekly. If a button battery remains in the stomach, follow-up radiography alone should be performed every 3 or 4 days. Relatively large blunt foreign bodies are an indication for endoscopic removal. An object measuring 2 cm or more in diameter and 3 cm or more in length is considered to be large in pediatric cases such as children 1 year of age or younger, while an object measuring 3-5 cm or more in length would be deemed large in children 1 year of age or older. If a foreign body remains in the stomach during follow-up, it should be endoscopically removed.

**Fig. 7 on page 18** shows a case in which a fish bone penetrated the gastric wall and thereby caused a pancreatic abscess.

A man in his 50s remembered eating fish at a banquet approximately 2 weeks earlier. Abdominal pain subsequently occurred. There was a marked inflammatory response. An extensive, irregular soft tissue shadow containing a poorly enhanced area that appeared to be liquid was observed in a primary area ranging from the lower duodenal bulb to the ventral descending duodenum. Plain CT revealed a linear high-density area at the center of the shadow. A large area with adipose tissue elevation was observed around the shadow, and there was also severe edematous hypertrophy of the wall ranging from the hepatic flexure of the colon to the oral side of the transverse colon. Spread of inflammation was suggested. Endoscopy revealed a submucosal tumor-like protrusion at the posterior wall of the gastric angle and discharge of pus from the top. According to the surgical findings, a relatively hard mass was confirmed in the pancreatic head, and there was adherence of the stomach to the pancreas. When the pancreatic head was compressed after detachment of the adhesion, a fish bone measuring 5 cm in length was extruded together with pus from the pancreatic head.

Although the majority of blunt foreign bodies that pass through the pyloric ring are excreted within 4 to 6 days, elongated foreign bodies or those with a sharp point may cause obstruction at sites of postoperative stricture or flexure (e.g., duodenal loop and ileum terminal). Removal of foreign bodies should be considered when subjective symptoms (e.g., fever, abdominal pain, and vomiting) occur, when foreign bodies obstruct openings and outlets, and when the passage of foreign bodies is slow despite the lack...
of subjective symptoms (when foreign bodies remain in the same area for 1 week). In cases with ingestion of old button batteries, their removal should be considered because mercury might be leaking from such batteries.

**Accidental ingestion of PTP sheets**

In order to prevent accidental ingestion of PTP sheets, measures, such as only laterally-perforated packages, have been implemented since 1996. However, these incidents are still being reported, and CT is frequently performed to locate ingested PTP sheets. Many accidentally ingested PTP sheets remain in the esophagus. The common sites, in order of frequency, are considered to be the esophageal entrance, middle thoracic esophagus, and esophageal hiatus of the diaphragm, which are physiologically stenotic sites. Because of the sharp edges of PTP sheets, endoscopic removal is indicated. Although PTP sheets that have passed into the stomach are often excreted with the feces, these sheets can cause perforation in patients with a history of surgery or radiotherapy.

PTP is comprised of a plastic sheet with depressions designed to contain tablets and an aluminum sheet that covers the depressions. The plastic sheet is made from polyvinyl chloride or polypropylene. The polyvinyl chloride sheet, which is depicted as a high-density area, can be detected by CT, whereas the polypropylene sheet cannot be seen on CT images.

**Fig. 8 on page 19** shows simulated images. A PTP sheet made from polyvinyl chloride can be identified by increasing the CT window width, whereas the polypropylene sheet is not recognizable (recently, in consideration of the environmental burden, many manufacturers have changed the raw materials for PTP sheets from conventionally used polyvinyl chloride to polypropylene, which does not contain chlorine). Moreover, X-ray absorption by drugs themselves also varies depending on their components. As shown in **Fig. 9 on page 20** and **Fig. 10 on page 21**, a PTP sheet can often be identified due to air contained in the depression; however, a PTP sheet with a torn aluminum sheet may not be identifiable. Caution is thus necessary when interpreting images.

**Inserted foreign bodies** (e.g., otolaryngological region, urogenital organs, and rectum)

Foreign bodies may accidentally be inserted into the external auditory canal during cleaning of the ears even in adults. However, the majority of cases with nasal foreign bodies result from self-insertion due to simple curiosity. There are many cases involving preschool infants with a peak incidence in the age range of 2-3 years. While commonly inserted objects are toys such as beads, there are also reports of nasal septum perforation caused by button batteries as with esophageal foreign bodies. Thus, caution is necessary. Foreign bodies in the external auditory canal include small objects such as toys and small animals such as flies and mosquitoes. In terms of types of foreign bodies,
the incidence of living foreign bodies is reported to be significantly lower in children than in other age groups. Although only a few cases with either foreign body type are indicated for diagnostic imaging, caution is necessary because detection may be delayed in cases with mild symptoms that are treated as having chronic inflammation.

Insertion of foreign bodies in the urogenital organs (the bladder and vagina) is also common in children. While masturbation is considered to be a common reason for such insertion, other sexual issues might be relevant to the insertion of foreign bodies into the bladder and urethra (the possibility of molestation should also be kept in mind). Children tend to hide such insertions because of embarrassment and fear of subsequent treatment. In many cases, children are taken to a hospital due to abnormal results of urine tests conducted during school physical examinations. Imaging studies play an important role in assessing these children.

Insertion of foreign bodies into the rectum is common in male adults and is often performed to attain physiological pleasure. Patients visit a hospital due to inability to retrieve foreign bodies, anal pain, difficulty defecating, and, occasionally, intestinal perforation. Types of foreign bodies have tended to increase in variety. According to previous reports, the most common foreign body would be a bottle, and others include sex toys, plastic containers, and cans.

**Fig. 11 on page 22** shows a case of colorectal perforation caused by insertion of a foreign body.

The patient visited our hospital with a chief complaint of abdominal pain and underwent CT for detailed examination. A metal shadow was observed on the scout view, and, as the figure shows, a soft tissue-like shadow in the form of a shoehorn and a linear metal shadow (with a hooked tip) were observed on the CT images in the oblique sagittal plane.

The intraoperative findings revealed sigmoid colon perforation caused by a wire. The removed foreign body is shown.

**Penetrating foreign bodies**

The common causes of penetration by a foreign body are falling with a rod-like object, such as a chopstick, toothbrush, or pencil, held in the mouth by a child, while in adults such incidents generally involve self-injury behaviors and accidents. For diagnostic imaging, it is important to be familiar with pathological conditions directly caused by injury immediately after the incident, pathological conditions manifesting a few hours to days after injury such as infection and ischemia, and delayed conditions caused by retained foreign bodies. Foreign bodies are often difficult to identify on plain radiography. It is important to perform CT and magnetic resonance imaging (MRI) for assessments including the identification of any secondary changes.
Fig. 12 on page 23 shows a case with an intraorbital foreign body.

A 40-year-old woman underwent orbital MRI for suspected scleritis. The MRI revealed abnormalities, and CT was thus also performed. A rod-like structure with a major axis of 25 mm located parallel to the right side of the left medial rectus muscle, which was slightly displaced, was seen on the MRI. No abnormally enhanced area was apparent in the orbit, nor was there any difference in eyeball shape between the right and left eyes. Likewise, there was no abnormal signal intensity suggesting scleritis, and no apparently abnormal signal intensity in the optic nerves. CT revealed a less clearly demarcated high-density area accompanied by calcification and surrounded by faint fluffy opacities indicating either fibrillization or granulation. When the patient was interviewed after MRI, she described an episode in which, while playing with chopsticks as a child, one of them accidentally pierced her orbit, and its tip portion was never found.

Iatrogenic (retained) foreign bodies

Commonly reported iatrogenic foreign bodies are pieces of gauze left in the body during surgery.

Foreign bodies remaining after an operation carry a risk not only of reoperation to search for such foreign bodies, and are thus systemically invasive, but also create a sense of distrust of medical practitioners in patients and their families. This is mentally and financially detrimental to healthcare providers. Recently, radiography has often been performed to prevent foreign bodies from being left in the body intraoperatively.

The "Practical Guidelines of Perioperative Care," established by the Japanese Association for Operative Medicine, indicate that the times for counting gauze should be 1) before the start of surgery, 2) before closure of the body cavity, 3) before closure of the muscle layer, and 4) after the completion of surgery.

Generally, gauze used for surgery is laced with a steel wire (polypropylene fibers containing barium sulfate) to make the gauze detectable in the body by radiography. The radio-opaque marker in the gauze has a characteristic pattern on radiographs.

Long-term retention of gauze causes fibrillization (e.g., encapsulation, calcification, and granulation) or exudative changes (e.g., cyst and abscess formation), and the radio-opaque marker may be masked by calcification. Figures 13 and 14 show images obtained in 2 cases in which long-term retention of gauze caused calcified granulomas.

Fig. 13 on page 24

A 50-year-old man had a history of partial gastrectomy performed for gastric ulcer at another hospital. A cystic lesion was detected in the pancreatic tail by ultrasonography conducted as part of a physical examination. There was a soft mass containing calcified
matter between the pancreas and the spleen, but there were no areas of enhancement. Laparotomy was performed, and the mass was found to be a gauzoma.

**Fig. 14 on page 25**

A 50-year-old woman with a history of total hysterectomy visited our hospital with chief complaints of nausea, vomiting, and abdominal pain. Plain radiography revealed a mass shadow accompanied by calcification in the right lower abdomen, and there were several niveau signs suggestive of ileus on an upright radiograph. Contrast-enhanced CT revealed an approximately 5-cm mass lesion with calcified margins in the right lower abdomen and continuous small-bowel dilatation, with the presenting portion located at the same site.

T1- and T2-weighted MRI revealed wavelike low signal intensity in a peripheral area corresponding to the calcification seen on CT images and a central area with relatively homogeneous signal intensity. No enhanced area was observed on contrast-enhanced CT images, and the lesion was not depicted as having apparently abnormal signal intensity on diffusion-weighted images. Gauzoma was diagnosed and then resected.

At our hospital, the presence or absence of retained foreign bodies is checked at the completion of surgery and confirmed by radiologists on duty according to the medical safety protocol. However, medical materials other than gauze can also be left in the body. (It can readily be imagined that vessel loops and injection needles especially, as well as fragments of broken energy devices, might be left in the body. In addition, there are many medical materials in an operating room that radiologists are not familiar with) As shown in **Fig. 15 on page 26**, images of major medical materials used for surgery were taken during simulations and compiled into a Microsoft Power Point file, which radiologists on duty share. This file contains plain images of each medical material placed on each acrylic phantom part, followed by Photoshop processing.

**Fig. 15 on page 26** . Images of major medical materials used for surgery

A: BK Gauze

Corded gauze used for protection of organs and absorption of blood/body fluid during surgery.

B: Gauze ball

Spherical gauze mainly used for detaching tissue during surgery.

C: Navigation ball

A ball used as a probe for navigation in the field of orthopedic surgery.
D: Anastafow

A shunt used for bypass grafting of coronary arteries, etc.

E: Fogarty soft jaw spring clip

When the tip of a vascular graft is connected to a coronary artery during coronary artery bypass grafting, the clip is used to temporarily obstruct the vascular graft. The image shows the clip applied to a vascular graft. Because the polymer contains barium sulfate powders, the clip is detectable by radiography.

F: Rubber for forceps

Covers used when a blood vessel is held with forceps.

G: La Base

This material is used for absorption of fluid, protection of organs, a filter for suction, etc., in endoscopic surgery. At our hospital, the use of this material has been decreasing since the introduction of Trox.

H: Vessel loop

A surgical tape used for identification of blood vessels, etc., and temporary fixation of tissue in cardiovascular or thoracic surgery.

I: Trox (sterile gauze for scope-guided surgery)

In scope-guided surgery, the gauze is inserted from a trocar and used during detachment of tissue around blood vessels and nerve fibers.

J: Packing gauze

Gauze used for suppression of bleeding, absorption of fluid, and protection of organs from abrasion, desiccation, or contamination.

K: M.Q.A. #Medical.Quick.Absorber.#

Super-quick absorbing paper that can quickly absorb a large amount of fluid generated during surgery (often used for microsurgery)

Moreover, retention, loss, and breakage of suture needles are complex problems encountered by surgeons. While a wide variety of suture needles exists, extremely fine needles are used for vascular anastomosis. At our hospital, images of each of the suture needle types, as shown in Fig. 16 on page 27, have also been taken in simulations and are shared by radiologists on duty. Fine needles (3-6.5) absorb very little X-ray energy and are thus difficult to identify visually.
When the presence or absence of foreign bodies is checked, it is important to use a high-definition monitor that enhances visibility.

In parts that can be imaged in different positions, such as the head and limbs, it is also effective to obtain images in several positions.

**Interventional Radiology for foreign bodies**

An event that is very frequently encountered and is a good indication for Interventional Radiology is intravascular rupture of a central venous catheter, while other indications include angiographic catheter rupture and embolic coil migration. Interventional Radiology is unlikely to be indicated in a case with a foreign body located in the peripheral pulmonary artery or one with an organized thrombus around a foreign body.

Catheters used for removal of extravascular foreign bodies are categorized into two main types: basket and loop snare. These devices are both available on the market as kits for removal of intravascular foreign bodies. In preparation for emergency removal of foreign bodies, the minimum required devices should always be kept available in hospitals. However, it was formerly common to use a handmade snare loop that was formed by bending a 0.016- or 0.025-inch guidewire into two parts and inserting it into a 7-Fr. or larger catheter. This technique is worth remembering when the recommended devices are not available at the time of an emergency.

For removal of intravascular foreign bodies, knowing the location and shape of their stumps is extremely important. When the stump of a retained catheter is attached to the artery wall, the stump is freed by rotating a basket catheter to move the retained catheter or by using a pigtail catheter or a catheter with a curved tip. In addition, when foreign bodies are located in the right atrium, the right ventricle, and/or the pulmonary artery, the use of an endomyocardial biopsy sheath facilitates appropriately setting the direction of any device necessary for the removal procedure.

**Fig. 17 on page 28** shows retrieval of a retained catheter in the central vein.

As shown on thoracic and abdominal plain radiographs, a catheter was located from the superior vena cava through the right atrium and up to the inferior vena cava. The femoral vein was punctured, and an 8-Fr sheath was placed. After the retained catheter had been confirmed to be in the snare loop of a snare catheter for foreign body removal, the snare wire was pulled, and a guiding catheter was advanced to capture the retained catheter.
Fig. 1: Fig. 1 shows a case of accidental denture ingestion resulting in abscess formation. In the area from the oropharynx to the hypopharynx, there is a foreign body depicted as a high-density area that appears to be a metal object in form of the letter C. CT reveals a tubular shadow, with a density which is not as high as that of metal but is nonetheless relatively high. The upper end of the foreign body is embedded in the soft tissue of the left pharyngeal wall, where a localized abscess formation has occurred.

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Fig. 2: A 4-year-old girl was brought to our hospital after accidentally ingesting a slot machine coin. Because it appeared as a circle on a frontal radiograph and was located on the posterior wall of the respiratory tract on a lateral radiograph, the coin was visualized as remaining in the esophagus. It was removed employing an endoscope.

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Figure 3. Treatment Algorithm for Accidental Foreign Body Ingestion

Accidental foreign body ingestion

Radiography

Foreign body in the stomach or below

- Remove if symptomatic
- Asymptomatic

Esophageal foreign bodies
- Button battery → Remove within 2 hours
- Others
  - Sharp foreign body → Endoscopic removal
  - Blunt foreign body → Wait-and-see approach for 24 hours can be considered.

Small blunt foreign body

Follow-up examination
- Perform radiography each week.
- Perform radiography every 3-4 days in case of a button battery.
- Gastric foreign body
  - Remove if foreign body is not excreted in 3-4 weeks.
  - If a button battery is not excreted in 48 hours, consider removal.
- Foreign body in the duodenum or below
  - If foreign body remains in the same site for 1 week, consider removal.

Large blunt foreign body

Age ≤1 year: Size ≥2-3 cm
Age ≥1 year: Size ≥3-5 cm

Gastric foreign body
→ Endoscopic removal
- Foreign body in the duodenum or below
  - Perform radiography each week.
  - Perform radiography every 3-4 days in case of a button battery.
  - If a foreign body remains in the same site for 1 week, consider removal.

Sharp foreign body

Gastric foreign body
→ Endoscopic removal
- Foreign body in the duodenum or below
  - Perform radiography each day.
  - If a foreign body is not excreted in 3 days, consider removal.

Fig. 3

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Fig. 4: Compared to that in Fig. 4 (accidental ingestion of a coin), the shadow in Fig. 5 can be identified as a button battery because of the double contour.

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**Fig. 5:** Compared to that in Fig. 4 (accidental ingestion of a coin), the shadow in Fig. 5 can be identified as a button battery because of the double contour.

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Fig. 6: Fig. 6 shows a case with an esophageal foreign body (sea bream bone). In this case, sudden thoracodorsal pain occurred during a meal. Under suspicion of aortic dissection, the patient was transported by ambulance and a CT scan was performed. The scan revealed a linear high-density object in the upper thoracic esophagus at the level immediately above the carina as well as edematous change in the esophagus around the object.

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Fig. 10

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Conclusion

Diagnostic imaging of foreign bodies, retained in the body for various reasons, likely to be encountered in daily clinical practice is described with simulated images. As noted above, while occasions to perform diagnostic imaging of foreign bodies are rare, accurate information may not be available, and many symptoms are nonspecific. Thus, it is important to understand typical imaging findings of various foreign bodies. Moreover, we should be aware that images of foreign bodies often show only very minor changes, depending on their types.
References


13. "Practical Guidelines of Perioperative Care," established by the Japanese Association for Operative Medicine


