Foreign Objects Encountered in the Abdominal Cavity at CT

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Foreign objects are not infrequently seen at computed tomography (CT) of the abdomen and pelvis and may pose a diagnostic challenge to the radiologist, who must recognize the object, characterize its nature and location, and determine its clinical significance. Most foreign objects are incidentally detected at CT, but they may mimic a wide range of pathologic conditions. Some foreign objects (eg, an object that has been swallowed either intentionally or unintentionally) are the cause of the patient’s signs and symptoms and require prompt medical attention. Other objects, such as a sponge or surgical instrument that has been retained postoperatively, may have medicolegal consequences. Furthermore, certain objects, such as intentionally concealed drug packets, may go undetected unless a high degree of suspicion exists and appropriate window settings are used to review the study. The radiologist should be familiar with the wide range of foreign objects that may be encountered at abdominopelvic CT, be able to recognize them promptly, and understand their implications for patient treatment.

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Introduction

Foreign objects are not infrequently encountered at computed tomography (CT) of the abdomen and pelvis. Most of these objects are related to prior surgery or some other interventional medical procedure. However, a pertinent history is often lacking, since both the patient and the referring physician may be unaware of its relevance for the interpreting radiologist. The radiologist needs to accurately characterize the exact nature and location of any foreign body that is detected.

Imaging of various retained surgical sponges in the abdomen and pelvis has previously been reported (1). To our knowledge, however, there has been no systematic review of the CT findings of the entire spectrum of foreign bodies seen in the abdomen and pelvis. In this article, we review the CT appearances and clinical significance of both common and uncommon foreign objects seen in the abdomen and pelvis. We have categorized foreign bodies seen in the gastrointestinal tract as either intraluminal or extraluminal. Intraluminal objects are those found within the lumen of the gastrointestinal tract, whereas extraluminal objects are those found in the peritoneal cavity.

Intraluminal Objects

A variety of objects may be found within the lumen of the gastrointestinal tract. We have categorized these objects according to whether they are the result of (a) a pathologic condition (e.g., bezoars), (b) a prior medical procedure (e.g., dislodged tubes), (c) swallowing of a diagnostic device (e.g., endoscopic capsules), or (d) accidental or nonaccidental ingestion of some other object (e.g., fish bones, batteries).

Foreign Bodies from Pathologic Conditions

Bezoars.—Bezoars are concretions of ingested material in the stomach or small intestine. The two most common bezoars are trichobezoars (composed of hair) and phytobezoars (composed of nondigestible plant products and typically containing cellulose). Bezoars are usually formed in the stomach. The mass, in part or in whole, may pass into the small intestine and become impacted, causing small bowel obstruction (2). Complete small bowel obstruction is the most common clinical manifestation of a bezoar (3), a finding similar to that seen in patients who present with small bowel obstruction from other causes. However, there are distinct CT findings that allow accurate preoperative diagnosis of a bezoar as the underlying cause of small bowel obstruction. These findings include a mottled intraluminal mass with soft-tissue attenuation that contains air bubbles and is located immediately proximal to the site of the obstruction (Fig 1). The role of CT in these cases is not limited to helping detect the bezoar and its exact location, but includes helping identify additional bezoars in the gastrointestinal tract.

Figure 1. Bezoar causing small bowel obstruction in a patient with no prior history of abdominal surgery. Contrast material–enhanced CT scan through the abdomen shows a bezoar with a mottled appearance (arrow) at the transition zone (arrowhead) of a small bowel obstruction. Subsequent laparotomy and enterotomy revealed a partially digested vegetable (possibly a cucumber or a date) lodged in the bowel.

Figure 2. Small bowel feces in a patient with adhesive small bowel obstruction. Coronal contrast-enhanced CT scan shows a distended small bowel loop (arrow) containing particulate material mixed with gas bubbles. A transition zone (arrowhead) is noted distal to the small bowel feces. Small bowel feces appear more amorphous and affect longer segments compared with a small bowel bezoar, which appears as a well-defined, focal, ovoid mass with a mottled gas pattern.
Impacted bezoars in the small bowel need to be differentiated from the “small bowel feces” sign, a finding that corresponds to the presence of well-formed solid feces in the small bowel, which are sometimes seen in patients with small bowel obstruction. Distinguishing between a bezoar and small bowel feces is clinically important because of the different therapeutic approaches to these two conditions. Small bowel feces are often present in obstructions related to adhesions, the treatment for which may be conservative, whereas an impacted small bowel bezoar requires surgical treatment. However, distinguishing between these conditions at CT is often not straightforward. Generally, small bowel feces appear more amorphous and affect longer segments (Fig 2), whereas a small bowel bezoar is a well-defined, focal, ovoid mass with a mottled gas pattern at the site of the obstruction (Fig 1) (4). Detection of a gastric lesion with characteristics similar to these is considered to be strongly indicative of a bezoar (2–4).

**Gallstones.**—Gallstones may be found in the bowel after having eroded into the gastrointestinal tract as a result of chronic cholecystitis. The gallstone (or, occasionally, gallstones) usually erodes into the bowel at the level of the duodenum. Fewer than one-half of these stones will cause obstruction because most are excreted uneventfully in the stool (5). Obstruction (when present) occurs most frequently at the ileocecal valve and less frequently at the duodenal-jejunal junction, the sigmoid colon, or a site of stricture (6). Most reports indicate that stones smaller than 2.5 cm pass spontaneously, although stones of this size have produced ileus and stones as large as 5 cm have passed spontaneously (5). Gallstone ileus is a complication in 0.3%–0.5% of all cases of cholelithiasis (5).

Generally, ileus-causing stones are single, large, faceted, and 2–5 cm in their greatest dimension. When stones are impacted in the ileum, it is important to be aware that additional stones may be present in the proximal bowel (5).

The morbidity and mortality of gallstone ileus may be substantial, especially in elderly patients. Treatment is usually surgical and includes removal of the impacted stone, cholecystectomy, and fistula repair (7).

The CT findings of gallstone ileus are characteristic and are the equivalent of the Rigler triad—bowel obstruction, pneumobilia, and a radiopaque stone at the transition zone between dilated and collapsed bowel (Fig 3)—although this triad is not present in all patients: The pneumobilia is variable, and the gallstone is difficult to visualize if it is not well calcified (6). Nevertheless, as with other types of bowel obstruction, the site of obstruction can be precisely defined for preoperative planning.

**Figure 3.** Gallstone ileus manifesting with the Rigler triad. (a) Coronal reformatted noncontrast CT image reveals two gallstones (arrow) impacted at the ileocecal valve. (b) Coronal reformatted noncontrast CT image shows small bowel obstruction (arrowheads) and pneumobilia (arrow), both of which were caused by the gallstones.
**Foreign Bodies from Prior Procedures**

Various dislodged tubes may be detected in the gastrointestinal tract, including dislodged feeding tubes and biliary endoprostheses that have migrated from the biliary tract. A tube should be recognized to establish that it no longer serves its intended purpose, and because it may mimic other swallowed foreign objects.

**Biliary Stents.**—Endoscopic biliary stent placement is a well-established treatment for hepatic, biliary, and pancreatic disorders. Stents may be made of either plastic or metal. Plastic endoprostheses are less expensive but are at higher risk for clogging and dislocation. However, they are frequently used because they are easier to remove or change than are metal stents. Distal stent migration is an uncommon late complication that occurs in up to 6% of cases (Fig 4) (8,9). Most biliary endoprostheses pass through the intestine without any problems. Rarely, however, stents get stuck in the bowel, leading to severe complications such as intestinal perforation. In such cases, surgical stent removal is necessary (8,9).

**Feeding Tubes.**—Feeding tubes are used to provide enteral nutrition and to prevent aspiration pneumonia in chronically demented and bedridden patients who have difficulty eating. The most common complication associated with these tubes is unintentional dislodgement (10,11), which may remain asymptomatic but may also result in small bowel obstruction (Fig 5). This dislodgement may occur when the inflated bulb of a catheter obstructs a small bowel loop. It is important for radiologists to be aware that feeding tubes may potentially migrate and cause gastric or small bowel obstruction.

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**Figure 4.** Dislodged biliary stent. (a) Noncontrast CT scan demonstrates a plastic biliary stent with high attenuation (arrow) that has become dislodged and has migrated into the small bowel. (b) Topogram shows a correctly placed new biliary stent (arrowheads) that has been inserted to replace the dislodged stent (arrow). Topograms are often useful in identifying dislodged stents.

**Figure 5.** Small bowel obstruction caused by a dislodged feeding tube. Coronal reformatted contrast-enhanced CT image demonstrates the distal inflated balloon of a dislodged feeding tube (arrowhead) and the coiled proximal portion of the tube in the terminal ileum (arrow).
Ingestion of Diagnostic Devices

Technologic innovations have resulted in the development of various sophisticated devices for evaluating different parts of the alimentary tract. These devices are swallowed by the patient and usually pass uneventfully in the stool. However, they may occasionally be encountered radiologically before they pass out of the body, thereby posing a diagnostic challenge, particularly if the relevant patient history is lacking.

**pH Meter Capsule.**—Twenty-four-hour pH monitoring is currently the standard of reference for diagnosing intra- and extraesophageal manifestations of gastroesophageal reflux. The disposable Bravo pH capsule (Given Imaging, Yokneam, Israel) is a catheter-free device that measures pH levels in the esophagus. The capsule is a very small device (6 × 5.5 × 25 mm) that is temporarily attached to the wall of the esophagus during endoscopy and left there. It takes continuous pH measurements for up to 48 hours and transmits this information wirelessly to a small receiver. After the study, information from the receiver is uploaded to a computer for analysis. The capsule will spontaneously detach and pass through the digestive system after several days (12). It might be incidentally detected along the gastrointestinal tract at CT within days after being placed. The capsule has a characteristic appearance at CT that might be better evaluated on multiplanar reformatted images than on axial scans (Fig 6). Prompt recognition of this foreign body as a detached pH capsule will eliminate unnecessary concern.

**Endoscopic Capsule.**—Capsule endoscopy is a novel diagnostic tool for the detection of small bowel disease. The video capsule measures 11 × 26 mm and weighs less than 4 g. The main clinical indication for capsule endoscopy is obscure gastrointestinal bleeding, but this technique is also indicated for evaluation of early Crohn disease (13). Capsule endoscopy is generally a safe procedure with few complications. Clinically significant complications including symptomatic capsule retention and aspiration occur in less than 1% of examinations (14). Retained capsules requiring surgical removal are most commonly seen in patients with strictures due to Crohn disease or induced by nonsteroidal anti-inflammatory drug use (diaphragm disease) (13,15). Other potential causes of capsule retention include postoperative changes with a blind-ending loop, diverticula, and tumor obstruction. Conventional radiography of the abdomen can help verify the intraabdominal location of the capsule if retention is clinically suspected, but CT may better delineate the anatomy and site of obstruction for planning of retrieval (Fig 7) (16). The radiologist should be able to recognize the retained device and should be aware that retention is likely caused by stricture or some other bowel abnormality.
Accidental or Nonaccidental Ingestion

A wide variety of foreign bodies find their way into the gastrointestinal tract, including coins, toys, keys, batteries, jewelry, pins, needles, razor blades, nails, clips, and bones. Ingested foreign bodies are not infrequently found incidentally at CT of the abdomen. Most ingested foreign bodies pass uneventfully in the stool; however, long, hard, or sharp objects such as fish bones, chicken bones, and toothpicks may cause perforation. Accidental ingestion accounts for most cases and is commonly seen in children and elderly people, patients with dentures, mentally handicapped individuals, and alcohol abusers. Intentional foreign body ingestion occurs in prisoners, patients with underlying psychosis, and persons who attempt suicide. Common sites of gastrointestinal tract perforation include less fixed segments or those with acute angulations (eg, ileum, ileocecal, and rectosigmoid segments).

A clinical history of foreign body ingestion is rarely available, the degree of clinical suspicion low, and the manifestation often nonspecific. Therefore, analyzing CT findings with a high degree of suspicion is important for establishing the diagnosis. The definitive CT diagnosis is made by identifying an ingested foreign body in the gastrointestinal tract. Extraluminal findings such as localized pneumoperitoneum and infiltrated fat adjacent to a thickened bowel segment should suggest the possibility of a foreign body causing focal perforation and prompt dedicated analysis and a search for the foreign body. Bone window settings allow better detection of calcified foreign bodies (eg, fish bones, chicken bones) (Fig 8) or metallic foreign bodies (eg, needles, batteries, dentures) (Figs 9–12) (17).

The ingestion of “button” batteries requires special attention on the part of the radiologist due to its potential to cause harm to the patient. Button batteries are small, coin-shaped batteries that are used in watches, calculators, hearing aids, and other similar devices. Button batteries vary from 7.9 to 23 mm in diameter and from 1 to 10 g in weight (18). The ingestion of button batteries has become more prevalent during the past several years and occurs mainly in children (18–20). Button batteries contain mercury, silver, zinc, manganese, cadmium, lithium, sulfur oxide, cop-
per, brass, or steel. The toxic effect from the battery contents depends on whether the battery becomes lodged in the esophagus or moves quickly through the gastrointestinal tract (19). The most commonly ingested batteries contain an alkaline solution that is strong enough to cause rapid liquefaction necrosis of tissue. This might represent a severe problem if the battery becomes lodged in a single area rather than floating freely in the gut, in which case the potassium hydroxide becomes diluted, producing a more diffuse but less intense effect. Impaction also allows a slow leak to have a cumulative effect on localized tissue. Liquefaction necrosis and perforation can occur as soon as 4–6 hours after a button battery becomes lodged in the esophagus (18,21). Therefore, batteries found in the esophagus should be removed promptly with endoscopy to prevent fatal or life-threatening events (18,19,21). If the battery is initially identified in the stomach, it will usually move on through the gastrointestinal tract without long-term complications, and the patient can be treated conservatively.

At CT, button batteries appear as small, round, high-attenuation foreign bodies, often causing beam-hardening artifacts. As with any metallic object, a scout image may be helpful in identifying the object (Fig 11b).

Ingestion of items of odontogenic origin by patients under general anesthesia, including dislodged teeth, crowns, fixed partial dentures (bridges), and removable partial and complete dentures, as well as various other dental and orthodontic appliances, is rare but often goes unnoticed initially, leading to potentially dangerous late complications that require surgical intervention. Certain patient populations are at increased risk for unnoticed ingestion, and some patients are at increased risk for developing perforations from ingested objects. The shape
and dimension of the ingested odontogenic item can affect whether it will pass through the gut without incident. Perforations occur more often in certain portions of the gastrointestinal tract, namely, the ileocecal junction and the sigmoid colon (Fig 12) (22).

The gastrointestinal tract is sometimes used to smuggle illicit narcotics. This smuggling inside the human body is called “body packing.” Handmade or commercially produced packets are swallowed, or perhaps inserted into the rectum (or vagina), and then transported. Insertion of foreign bodies into the rectum is performed for a variety of reasons: concealment, anal autoeroticism, attention-seeking behavior, accident, assault, and alleviation of constipation. The carrier is at risk for acute drug intoxication due to rupture of the package within the gastrointestinal tract, which is often fatal. Even undamaged packages can lead to rapid fatal poisoning because the wrapping may act as a semipermeable membrane, allowing fluid to pass through the wall of the package with consequent absorption. Gastrointestinal obstruction may also occur. Therefore, it is necessary to identify and remove these packages as soon as possible.

The radiologist may be confronted with a diagnosis of body packing either when a person is suspected to be a drug courier or when complications such as intoxication and obstruction occur. Imaging has an important role in detecting body packets in potential drug carriers (23–25). Conventional abdominal radiography is an important and effective method of identifying drug packets but is sometimes suboptimal in delineating the margins of the packet and differentiating the packet from residual bowel contents. CT has been described as having greater potential than conventional radiography in the detection of drug packets. At CT, drug packets (when swallowed) may be found anywhere along the entire gastrointestinal tract, and in the rectum (or vagina) when inserted there. They appear as well-defined, round or ovoid intraluminal foreign objects of uniform shape and varied attenuation. Although the specific appearances and physical densities of various drugs have been described, the CT attenuation depends mainly on the purity of a substance or the admixture to a drug (23). The radiologic appearance depends on the way packets are formed, produced, and inserted into the body. Homogeneous isoattenuating packets in the gastrointestinal tract may go undetected at abdominal CT if standard window width and level settings are used. Therefore, when drug packet ingestion is suspected, the use of greater window width (eg, with lung windows) is recommended (Fig 13) (24,25).

Extraluminal Objects

Various foreign bodies may be found in the extraluminal cavity of the abdomen and pelvis. Like intraluminal foreign bodies, they may be related to prior surgery or some other medical procedure. Some of these objects are meant to remain within the body for therapeutic purposes, whereas others may have been left behind unintentionally, possibly leading to clinical consequences. Some foreign bodies related to prior surgery may mimic pathologic findings and, if inaccurately identified, may result in harm to the patient.

Foreign Bodies Related to Prior Surgery

Prosthetic Mesh.—The development of new biologic materials has led to a change in the approach to treatment for both ventral and inguinal hernias. Hernia repair now frequently includes implantation of a prosthetic mesh, either during open surgery or, increasingly, as part of laparoscopic repair (26).

Two different types of meshes are used for ventral hernia repair: polypropylene meshes (MarlexH [C. R. Bard, Murray Hill, NJ]; ProleneH [Ethicon, Somerville, NJ]; SurgileneH
Figure 14. Abdominal wall mesh. Contrast-enhanced CT scan demonstrates an abdominal wall mesh (arrow) that had been used to repair a ventral hernia. Note that the mesh is held in place with multiple metallic structures along the periphery.

Figure 15. Mesh plugs. Contrast-enhanced CT scan demonstrates bilateral round soft-tissue masses (arrows) at the internal ring of the inguinal canal. These findings are compatible with mesh plugs that had been used for bilateral herniorrhaphy.

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[Sherwood Medical, St Louis, Mo]) and the expanded polytetrafluorethylene mesh (Gore-Tex MicroMesh; W. L. Gore & Associates, Flagstaff, Ariz). Polypropylene meshes are monofilament polypropylene meshes that are nonabsorbable, inert, sterile, and porous, with a thickness of approximately 0.44 mm. The polytetrafluorethylene mesh is a 1-mm-thick mesh made from strong, soft, inert, and conformable material, with a structure that ensures early fixation to host tissue with minimal foreign body reaction.

At conventional radiography, neither polypropylene nor polytetrafluorethylene meshes are visible. At CT, the two types of meshes have different appearances, probably because of their different composition and thickness. The polypropylene mesh is visible in only a small percent-
age of patients and is seen as a line with an attenuation similar to that of the adjacent muscles. The polytetrafluorethylene mesh is visible in all patients and appears as a line of increased attenuation (Fig 14) (26).

Inguinal hernia repair is one of the most frequently performed surgeries in the United States, with 770,000 procedures recorded in 2003 (27). Over the last 2 decades, the treatment of inguinal hernias has evolved dramatically. Since the late 1980s, most surgeries have been performed with mesh-based techniques and prosthetic material (27,28).

At CT, these mesh plugs appear as focal inguinal lesions with a diameter of up to 3 cm; a ringlike, nodular, or feathery appearance; and a mean attenuation of 39 HU ± 28. Awareness of postsurgical CT findings of uncomplicated plug mesh hernioplasty allows expected postsurgical changes to be differentiated from pathologic findings in the pelvis (mainly, inguinal lymphadenopathy) (Fig 15) (27,28). Another potential pitfall arises from 2-[fluorine-18]fluoro-2-deoxy-D-glucose (FDG) uptake around inguinal mesh prostheses at FDG positron emission tomography (PET). This phenomenon has been described as occurring up to 10 years after the surgical repair of inguinal hernias and most likely results from persistent foreign body reaction (29).

Gallstones and Surgical Clips.—Laparoscopic cholecystectomy has become one of the most common abdominal surgical procedures and is the treatment of choice for uncomplicated gallbladder disease. Although the overall complication rate for laparoscopic cholecystectomy is less than that for open cholecystectomy, gallbladder perforation and gallstone spillage occur more often during the former procedure. Spillage of gallstones into the abdominal cavity (“dropped gallstones”) is fairly common during laparoscopic cholecystectomy, occurring in up to 30% of procedures. However, subsequent abscess formation is relatively rare (≤3% of cases) (30). If an abscess does form, the dropped gallstone usually serves as the nidus for infection, which may occur days to years after cholecystectomy (Fig 16).

Patients who develop an abscess will usually develop recurrent abscesses until the stone is removed, either percutaneously or surgically. Abscess drainage and antibiotic treatment are not effective unless and until the calculus is removed.
At CT, gallstone spillage appears as one or more calcified high-attenuation areas with or without a fluid collection, often in the vicinity of the liver (usually in the Morison pouch). However, gallstones may be found anywhere in the peritoneal cavity. It is essential that a gallstone be identified because it may become the focus of an inflammatory process (Fig 17).

Awareness of gallstone spillage is important because dropped gallstones may mimic other conditions such as peritoneal metastatic disease and metastatic ovarian cancer (Fig 17). Failure to recognize a dropped gallstone as the underlying cause for an abscess will result in delayed treatment (30,31).

Dropped surgical clips are also frequently observed after laparoscopic cholecystectomy. Unlike dropped gallstones, however, they seem to be much less clinically significant, with only rare case reports of an ensuing abscess (31–33).

**Migrated Intrauterine Device.**—An intrauterine device (IUD) is among the most effective forms of birth control available. However, uterine perfo-
Abdominal packing for control of hepatic hemorrhage in a patient with severe hepatic trauma. (a) Topogram clearly shows several radiopaque ribbons (arrows), findings that indicate the presence of non-absorbable sponges that have been used to stem hemorrhage. (b) Coronal reformatted contrast-enhanced CT image shows the radiopaque markers (arrows) and the sponge material itself (arrowheads), which has a mottled appearance and should not be confused with an abscess. The sponges were retrieved at a later date, after the patient’s condition had stabilized.

Abdominal Sponges for Hepatic Packing.—The successful management of liver trauma with sponge packs placed in the abdomen was first described in the early 1980s (40). Abdominal sponges are systematically packed around the liver and can help control bleeding even in a coagulopathic patient with advanced hepatic injuries. Packs are removed approximately 36–48 hours after resuscitation and stabilization with correction of coagulation and metabolic deficits (41). The patient might undergo CT in the interim between placement and removal of the abdominal sponges. These sponges usually contain radiopaque markers and appear similar to inadvertently retained sponges (discussed later) (Fig 19). Recognition and awareness of the purpose of perihepatic sponges are important so as not to mistake them for retained sponges.
Figure 20. Absorbable sponges used to achieve hemostasis. Contrast-enhanced CT scans obtained in two different patients who had undergone left colectomy (a) and cholecystectomy (b), respectively, show absorbable sponges (arrow) that were used to control bleeding. Without the appropriate surgical correlation, such sponges may be mistaken for postoperative abscess formation.

Bioabsorbable Sponges.—Bioabsorbable hemostatic agents are commonly used to help control intraoperative bleeding. These agents are intentionally placed in the surgical field, unlike nondegradable sponges, which are sometimes inadvertently left during surgery. The bioabsorbable sponge aids in achieving rapid hemostasis by forming an artificial clot and providing a mechanical matrix for platelet aggregation. The most commonly used hemostatic agents are collagen, gelatin (Gelfoam; Pharmacia & Upjohn, Kalamazoo, Mich), oxidized regenerated cellulose (Surgicel; Johnson & Johnson Medical, New Brunswick, NJ), and microfibrillar collagen. Types of surgery in which absorbable gelatin sponges are often used include vascular surgery, transplantation, hysterectomy, and partial nephrectomy. These packing agents are usually absorbed within 7–14 days but can mimic the appearance of an abscess at imaging performed prior to absorption (42–44). This pitfall is due to numerous gas pockets within the absorbable sponge, which in the early postoperative period may raise suspicion for an abscess. At CT, the sponge appears as an ill-defined, gas-filled heterogeneous mass at the surgical site (Fig 20). Differentiating postsurgically between a bioabsorbable sponge and an abscess is not always easy. It has been suggested that (a) the linear arrangement of tightly packed gas bubbles that maintain their position on subsequent images and (b) lack of an air-fluid level or an enhancing wall are more characteristic of hemostatic agents than of an abscess (42).

Rarely, these hemostatic agents invoke a foreign-body reaction and are replaced by soft tissue, thereby forming a foreign-body granuloma. Such soft-tissue masses can mimic local recurrence and pose a diagnostic challenge (45,46).

Both pitfalls—misinterpretation of hemostatic agents as an abscess and local recurrence—can be avoided if the radiologist is aware of prior use of these materials and is familiar with their imaging appearances.

Urethral Bulking Agents.—Various materials are used for minimally invasive therapy for stress urinary incontinence. These materials are injected into the submucosa with use of a transurethral or periurethral approach and have different imaging characteristics. The most frequently used materials are collagen, carbon-coated microbeads, and graphite-coated microbeads. A collagen deposit has an attenuation similar to that of soft tissue and is therefore difficult to discern. In contrast, carbon-coated microbeads have an attenuation of 1500–2000 HU, so that the microbead agent appears at least as dense as cortical bone (Fig 21). Consequently, the material may be mistaken for deposits of calcium or even metal. The newer graphite-coated microbeads have a lower attenuation similar to that of medullary bone. The use of bone window settings allows better delineation of the individual injection sites (47).
Figure 22. Intraperitoneal clamp in a patient who presented with vague abdominal pain 9 months after undergoing laparotomy and ileostomy. (a) Noncontrast CT scan obtained at the level of the pelvis demonstrates a high-attenuation foreign body (arrow) whose appearance is made ambiguous by beam-hardening artifact. (b) Topogram clearly reveals the object (arrow) to be a surgical clamp.

Unintentionally Retained Surgical Materials

Despite precautions, a foreign body retained in the abdominal cavity after surgery is a persistent problem that may lead to complications, including adhesions, perforation, and abscess or fistula formation (48–50). The exact prevalence of foreign body retention is estimated to be one in 1000–1500 intraabdominal surgeries (48,49). A large series by Gawande et al (48) revealed that the abdomen and pelvis are the most common locations for a retained foreign body. Sixty-nine percent of cases involved sponges, whereas 31% involved instruments, with clamps being the most frequently retained instrument (Fig 22).

Although a retained sponge will often become symptomatic in the early postoperative period, it is possible for a foreign body to go unnoticed for months or even years (48–50). Risk factors for foreign body retention after surgery include emergency surgery, unplanned change of procedure, and obesity (48). Imaging plays a very important role in the diagnosis of a retained foreign body, which is often an unexpected finding and is not necessarily related to the patient’s symptoms. Since the advent of CT, retained foreign bodies have been recognized more easily and frequently. The appearance of retained sponges at CT is highly variable. Typically, a retained sponge is seen as a soft-tissue-attenuation mass and may show a whorled texture or a spongiform pattern containing gas bubbles (1,50). Rim or internal calcification is a rare finding. A radiopaque marker (when seen) usually provides an important clue to the diagnosis (Fig 23) and is often best appreciated on the scout image. However, it is not considered to be a reliable sign because many pitfalls have been recorded. Radiopaque markers can be distorted by folding or may disintegrate over time and have been misinterpreted as calcification or oral contrast agent (50).
Figure 23. Sponge left unintentionally in the abdomen. (a) Coronal contrast-enhanced CT scan demonstrates a sponge (black arrows) with a radiopaque marker at its center (white arrow). (b) Topogram shows the classic appearance of the radiopaque marker (arrow).

Figure 24. Unintentionally retained viscera retainer. (a) Contrast-enhanced CT scan reveals a curvilinear structure (arrows) within the pelvis. (b) Coronal contrast-enhanced maximum intensity projection image helps identify the object (arrow) as a retained SurgiFish Viscera Retainer (Greer Medical).

A rare sequela of a retained surgical sponge is transmural migration of the sponge from the intraabdominal space into the intestinal lumen. Most reported cases of transmural migration involve the intestine, but cases have been described that involve migration into the stomach and bladder, as well as transdiaphragmatic migration (51).

The possibility of a retained foreign body should be considered when unfamiliar findings cannot be explained in any other way. Three-dimensional CT offers additional planes that may facilitate the identification and localization of a retained foreign body, particularly in difficult and perplexing cases in which the diagnosis may not be readily apparent on axial CT scans (52).

The SurgiFish Viscera Retainer (Greer Medical, Santa Barbara, Calif) is a device used by sur-
geons to protect the omentum and viscera during closure of the peritoneal cavity. It is inserted at the end of the surgical procedure, just before closure of the abdominal wall. The device is intended to prevent inadvertent puncture of the bowel during closure of the peritoneum and fascia and is removed just before the fascia is closed.

The device, made of latex-free thermoplastic rubber, has an oval body joined to a small “tail” portion by a relatively narrow waist. It is imprinted with a series of contour lines along which one may cut should a smaller size be needed. Its high elasticity allows it to be folded and easily removed, even through a very small aperture. The device is almost radiolucent at conventional radiography but is clearly visible at CT. On axial CT scans, it appears as a linear high-attenuation area (Fig 25) and, if not correctly identified, may be mistaken for retained postoperative material. The radiologist should also recognize that the abdominal wall defect is a normal postoperative finding and is not indicative of failed abdominal closure.

Mimics of Foreign Bodies

**Bogota Bag.**—Temporary abdominal closure is indicated in various conditions and is ideal for patients with severe secondary peritonitis when one or more surgical procedures are required (54,55).

Various methods may be used for temporary closure of the abdomen. One such method involves covering the viscera with a sheet of polyvinyl chloride cut from an empty intravenous fluid bag (54,55). This option has been termed the “Bogota bag” because it was first used in Bogota, Colombia, for temporary abdominal closure in trauma patients (55). The bag is unfolded by cutting the seam and is then sterilized. The plastic sheath is trimmed to the appropriate size and then sutured to the skin edges of the surgical incision. The advantages of its use include low price, bowel protection (unlike with much stiffer mesh materials), and transparency, which allows early diagnosis by the surgeon of any significant ongoing hemorrhage or uncontrolled leak from the gastrointestinal tract (54).

At CT, the Bogota bag appears as a linear high-attenuation area in the abdominal wall (Fig 25) and, if not correctly identified, may be mistaken for retained postoperative material. The radiologist should also recognize that the abdominal wall defect is a normal postoperative finding and is not indicative of failed abdominal closure.

**Heterotopic Mesenteric Ossification.**—Heterotopic ossification of the mesentery and peritoneum (also referred to as osseous metaplasia) is an unusual condition that can develop after trauma or repeated intraabdominal surgical procedures. The pathogenesis of heterotopic mesenteric ossification is not entirely clear, although it has been postulated that this condition represents metaplasia of the submesothelial mesenchyme (56). Heterotopic mesenteric ossification has been reported in patients who underwent one or more abdominal surgical procedures for nonneoplastic disease and presented with subsequent small bowel obstruction (57). In most cases, the mesenteric ossification was the direct cause of the obstruction.

At abdominal radiography and CT, heterotopic mesenteric ossification is characterized by multiple high-density or high-attenuation linear-branching structures within the mesentery and extending up to the peritoneal surfaces (Fig 26) (56,58). This finding can be misinterpreted as extravasation of oral contrast agent from the bowel, dystrophic calcification, or osseous neoplasia.
Certain features serve as clues to the diagnosis of heterotopic mesenteric ossification. A trabecular architecture is highly suggestive of ossification and is uncharacteristic of barium extravasation or dystrophic calcification. In addition, the presence of mature trabeculae helps distinguish heterotopic mesenteric ossification from osseous neoplasia. Furthermore, the unusual trabecular pattern remains unchanged on serial images, whereas extravasated contrast material will show a change in configuration, pool in gravity-dependent locations, and become less dense or demonstrate lower attenuation over time (56).

**Heterotopic Ossification in Surgical Incisions of the Abdomen.—**Heterotopic ossification in surgical incisions of the abdomen is thought to represent a subtype of traumatic myositis ossificans in which osseous, cartilaginous, and, occasionally, myelogenous elements form within a surgical incision (59,60). Its exact prevalence is not well established, although it has been reported to affect about 25% of patients with abdominal incisions (60). It mainly occurs after vertical midline abdominal incisions and more often with upper midline incisions.

Heterotopic ossification developing in surgical incisions of the abdomen may be mistaken for a retained foreign body. Although the identi-
Figure 28. Peritoneal loose body. (a) Fused PET-CT image reveals a centrally calcified soft-tissue mass (arrow) in the left side of the pelvis. (b) Contrast-enhanced CT scan obtained 9 days later shows the mass (arrow) in the right lower quadrant. The clear margins of the mass help distinguish it from any adjacent structures, a finding that, along with the mobile nature of the mass as indicated by the interval movement (cf a), suggests the diagnosis of a peritoneal loose body.

Peritoneal Loose Body.—Peritoneal loose bodies (also known as free peritoneal bodies or peritoneal mice) are calcified concretions that grow around a nidus of necrotic tissue, usually fat derived from appendices epiploicae. At pathologic analysis, peritoneal loose bodies appear as laminated calcification around a core of necrotic adipose tissue. Most of these loose bodies are small (0.5–2.5 cm) and asymptomatic (63). They may, however, reach a diameter of 5–10 cm, and are then termed “giant” or “huge” peritoneal bodies (64–67).

Appendices epiploicae may twist upon themselves due to their narrow pedicle. When such torsion and strangulation occur acutely, the result is acute epiploic appendagitis, which typically resolves with conservative treatment. In contrast, chronic torsion usually goes unrecognized clinically and produces saponification, calcification, fibrosis, and, ultimately, autoamputation, with the epiploicae being released free into the peritoneal cavity. The epiploicae are frequently identified in a variable location at serial imaging studies—mostly in the pelvis, because they gravitate to the most dependent part of the abdominal cavity (63,65,66). Peritoneal loose bodies have been implicated in a few case reports as a cause of urinary retention and bowel obstruction (64–67).

Failed Renal Transplant.—Transplanted kidneys are commonly left in place after graft loss (68). Such a failed graft commonly loses its original size and reniform shape (69,70). Failed allografts...
usually undergo global shrinkage and often calcify heterogeneously. Both shrinkage and graft calcification seem to be a function of the passage of time after failure. Patients with failed renal transplants in whom the graft has been left in situ may undergo CT for various unrelated indications. At CT, a failed allograft often appears as a small, rounded soft-tissue mass with coarse parenchymal calcifications that is located in the iliac fossa (Fig 29) (69,70). A failed renal allograft may be diagnostically confusing and may have been misinterpreted at previous CT as a pelvic mass or an abnormal bowel segment (70).

**Conclusions**

Awareness of and familiarity with the wide spectrum of foreign objects that may be detected at CT of the abdomen and pelvis are important for establishing the correct diagnosis. CT allows an accurate diagnosis in terms of the location (ie, intraluminal or extraluminal) and nature of a foreign body. Inspection of the scout image may often be helpful and should be an integral part of the imaging evaluation. Recognition of a foreign object may be crucial when prompt intervention is necessary. Conversely, failure to recognize a foreign body as an innocuous object may result in its being misinterpreted as a pathologic condition.

**Acknowledgment.**—The authors thank Marjorie Hertz, MD, for her editorial assistance.

**References**

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These packing agents are usually absorbed within 7–14 days but can mimic the appearance of an abscess at imaging performed prior to absorption.

A radiopaque marker (when seen) usually provides an important clue to the diagnosis (Fig 23) and is often best appreciated on the scout image. However, it is not considered to be a reliable sign because many pitfalls have been recorded. Radiopaque markers can be distorted by folding or may disintegrate over time and have been misinterpreted as calcification or oral contrast agent.

This finding can be misinterpreted as extravasation of oral contrast agent from the bowel, dystrophic calcification, or osseous neoplasia.

At CT, a peritoneal loose body typically appears as a well-circumscribed soft-tissue mass, usually with coarse central calcifications, and may be mistaken for a retained sponge with a radiopaque marker.

A failed renal allograft may be diagnostically confusing and may have been misinterpreted at previous CT as a pelvic mass or an abnormal bowel segment.