Jpn J Radiol (2015) 33:177–186
DOI 10.1007/s11604-015-0400-y

PICTORIAL ESSAY

Complications related to medical devices of the abdomen and pelvis: pictorial essay

Ji Su Kim · Hyun Cheol Kim · Sang Won Kim · Dal Mo Yang · Jung Kyu Ryu · Sun Jung Rhee · Se Hwan Kwon

Received: 9 December 2014 / Accepted: 31 January 2015 / Published online: 11 February 2015

Abstract A variety of medical devices are used to monitor or treat abdominal and pelvic diseases. They are routinely recognized on abdominal radiographs and computed tomography (CT), and complications associated with their use are not uncommon. The complications associated with the use of the medical devices are migration, malposition and fracture, which can be easily recognized on abdominal radiographs. Additional potential complications include bleeding, obstruction, infection and organ injury, which may be detected on CT. Therefore, awareness of these complications and familiarity with their imaging findings are important aspects of the management of patients with medical devices. The aim of this pictorial review is to demonstrate the abdominal radiography and CT features of potential complications associated with the use of medical devices.

Keywords Medical device · Complication · Abdominal radiographs · CT

Introduction

A wide variety of medical devices are used for patient management, and they are usually evident with distinctive features on abdominal radiographs and computed tomography (CT) [1–3]. Complications associated with their use are not uncommon [4]. In fact, the complications may be as varied as the types of medical devices, the purpose of their use and the condition of each patient who has them. Complications following placement of medical devices account for significant numbers of requests to inform the patients' physicians promptly. Radiology plays an important role in the monitoring of patients with indwelling medical devices as well as in the diagnosis of potential complications associated with these devices. To our knowledge, no previous systematic review has specifically focused on complications related to medical devices seen in the abdomen and pelvis.

The purpose of this pictorial review is to familiarize radiologists with complications associated with various tubes, stents, assorted catheters and some miscellaneous devices on abdominal radiographs and CT. To this end, we illustrate abdominal radiograph and CT findings of the complications, which are grouped into a few major categories for simplification, consisting of migration, malposition, fractures and miscellaneous (Table 1).

Migration

Migration means spontaneous displacement of a medical device from its original insertion site. Occurrence of migration can be categorized as follows: (1) an internal drainage stent at the conduit system, such as the pancreatico-biliary duct, gastrointestinal tract and urinary tract; (2) an external drainage catheter, such as percutaneous transhepatic biliary drainage, continuous ambulatory peritoneal dialysis (CAPD) and percutaneous abscess drainage; (3) any device with a special purpose, such as an intrauterine device (IUD), accompanied by solid organ perforation.

J. S. Kim · H. C. Kim (✉) · S. W. Kim · D. M. Yang · J. K. Ryu · S. J. Rhee
Department of Radiology, Kyung Hee University Hospital at Gangdong, School of Medicine, Kyung Hee University, 149 Sangil-dong, Gangdong-gu, Seoul 134-727, Republic of Korea
e-mail: khcppp@lycos.co.kr

S. H. Kwon
Department of Radiology, Kyung Hee University Hospital, School of Medicine, Kyung Hee University, 1 Hoegi-dong, Dongdaemun-gu, Seoul 130-702, Republic of Korea

Table 1 Complications related to medical devices

Complication	Relevant medical device
Migration	Pancreatic and biliary stent
	Gastrointestinal stent
	Ureteral stent
	External drainage catheter
	Continuous ambulatory peritoneal dialysis catheter
	Intrauterine device
Malposition	Nasogastric tube
	Gastrostomy tube
	Foley catheter
Fracture	Drainage catheter
	Biliary stent
	Gastrointestinal stent
	Ventriculo-peritoneal shunt catheter
	Inferior vena cava filter
Miscellaneous	
Intestinal retention	Capsule endoscopy
Infection	Any catheter and stent
Bleeding	Any catheter and stent
Retained surgical sponge	Surgical sponge

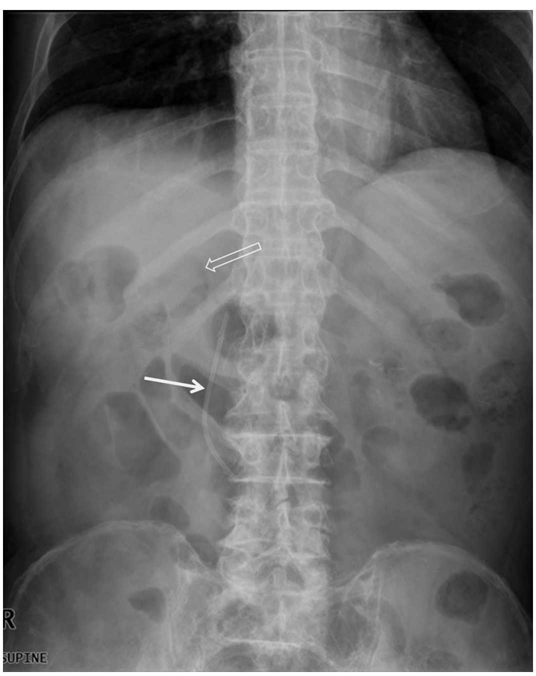

Fig. 1 Biliary stent migration in an 87-year-old male with a Klatskin tumor. Abdominal radiograph taken 50 days after plastic biliary stent placement shows distal migration of the stent (*arrow*). Note the air-filled extrahepatic bile duct (*open arrow*)

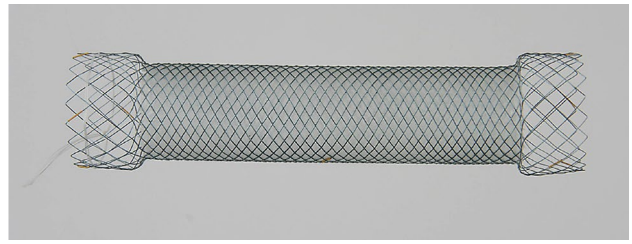

Fig. 2 Photograph of a partially covered metallic stent for dilation of the gastrointestinal tract

Pancreatic and biliary stents

Pancreatic and biliary stents are made with plastic or metal and are usually used for patients who have an obstructed pancreatic or bile duct. The major adverse events are migration and stent occlusion. Migration occurs in 5–10 % of cases with pancreatic or biliary stents (Fig. 1) [5]. Uncovered self-expandable metallic stents migrate less frequently than covered metallic stents or plastic stents.

Gastrointestinal stent

Gastrointestinal stents are mainly used to reestablish patency in various diseases causing gastrointestinal tract obstructions (Fig. 2). Although covered stents benefit from lower rates of obstruction by tumor in-growth, they have a tendency to migrate more frequently than uncovered stents [6]. The migration rate of covered stents has been reported to be 10–25 %, whereas migration of uncovered stents has been reported to be 2–6 % [6]. The migrated stent itself can cause fatal complications such as bowel obstruction, hemorrhage or perforation (Fig. 3).

Ureteral stent

Ureteral stents are generally implanted for the treatment of ureteral obstruction or fistula (Fig. 4) [7]. The proximal and distal parts of the stents are designed in a J or pigtail shape to prevent migration from the ureter. Nevertheless, the migration of a stent can occur as a result of peristalsis (Fig. 5) [7].

External drainage catheter

Percutaneous catheter drainage is generally used for management of abscess or abnormal fluid collection, to relieve the obstruction of any conduit organ or to provide an access route for stent placement (Fig. 6) [1]. Once the catheter has been successfully inserted, it is important

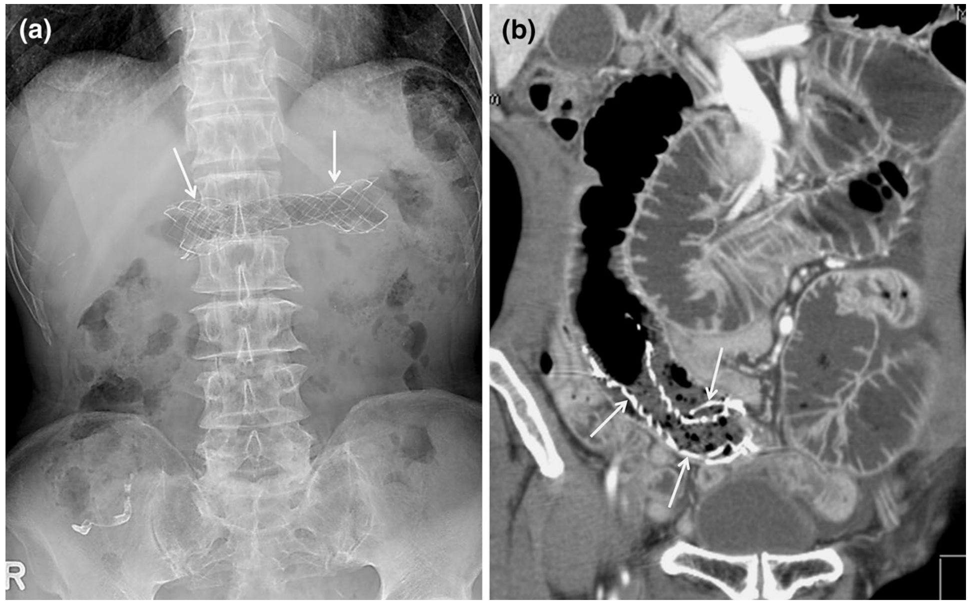

Fig. 3 Gastric pyloric stent migration causing small bowel obstruction in a 64-year-old male with advanced stomach cancer. **a** Abdominal radiograph shows a covered metallic pyloric stent (*arrows*) for the treatment of the gastric outlet obstruction. **b** Coronal reformatted CT scan taken 20 days later shows small bowel obstruction caused by the migrated stent (*arrows*)

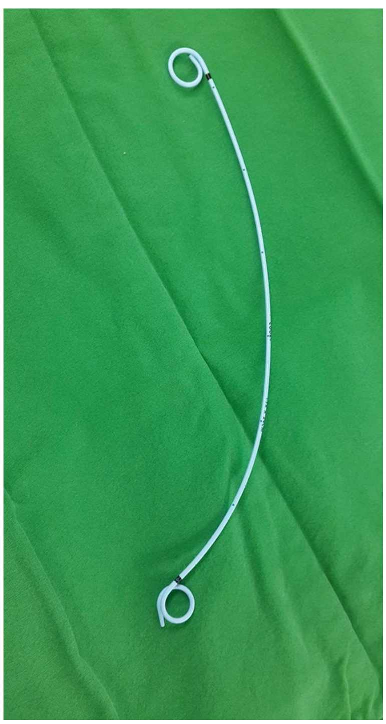

Fig. 4 Photograph of a ureteral stent. Note the proximal and distal pigtail loops, which prevent migration

to maintain the catheter in the optimal position. If the catheter tip migrates, the drainage function may be dramatically impaired (Fig. 7). To avoid catheter migration, catheter fixation to the skin is important.

Continuous ambulatory peritoneal dialysis catheter

CAPD is mainly used for the treatment of patients with end-stage renal failure (Fig. 8) [8]. In catheter placement, the distal tip of the CAPD catheter should be inserted in a dependent position into the pelvic cavity to allow adequate outflow during dialysate exchange. Migration of the catheter tip out of the pelvic cavity causes impaired dialysate outflow and inadequate fluid drainage (Fig. 9). The incidence of this event is reported as 57 % of patients within 1 year of catheter placement [8].

Intrauterine device

IUDs are commonly used and highly effective temporary contraceptive devices. They should be located centrally within the endometrial cavity. However, they can migrate within the uterine cavity, be released distally into the vagina or be expelled into the peritoneal cavity via uterine perforation (Fig. 10) [2].

Malposition

Malposition of a medical device is defined as an inappropriate position in comparison with the expected placement; it can occur during the insertion procedure [7].

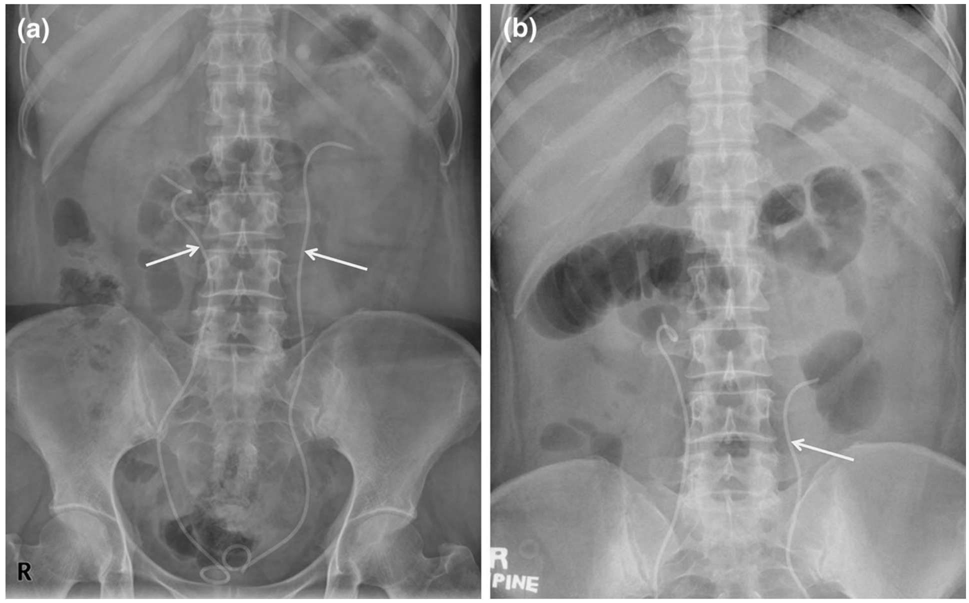

Fig. 5 Ureteral stent migration in a 54-year-old female with bilateral ovarian cancer. **a** Abdominal radiograph shows well-inserted *double-J* ureteral stents (*arrows*). **b** Abdominal radiograph taken 5 months later shows the *downward* migration of the *left* ureteral stent (*arrow*)

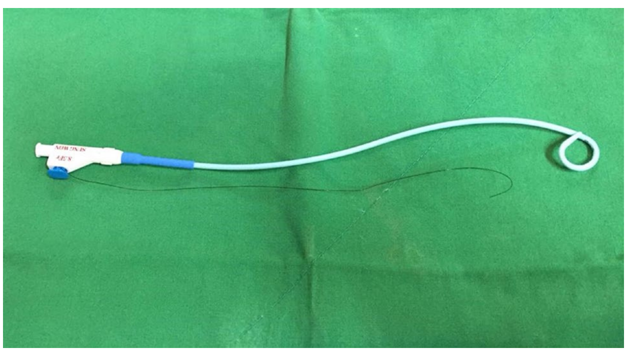

Fig. 6 Photograph of a percutaneous drainage catheter

Common medical devices of the abdomen and pelvis, such as nasogastric tubes (Fig. 11), gastrostomy tubes (Fig. 12) and Foley catheters (Fig. 13), may be inappropriately positioned [4].

Nasogastric tubes have been inserted at the bedside blindly, without fluoroscopic visualization [2]. The tube is often inserted not in the stomach, but in another site of the gastrointestinal tract such as the esophagus or duodenum, sometimes even the trachea (Fig. 14). Gastrostomy tubes are placed surgically, endoscopically or percutaneously for long-term assisted feeding. The inflated balloon component of the tube maintains the position of the tip, which should be placed in the stomach [2]. Malposition is one common complication after gastrostomy tube insertion (Fig. 15).

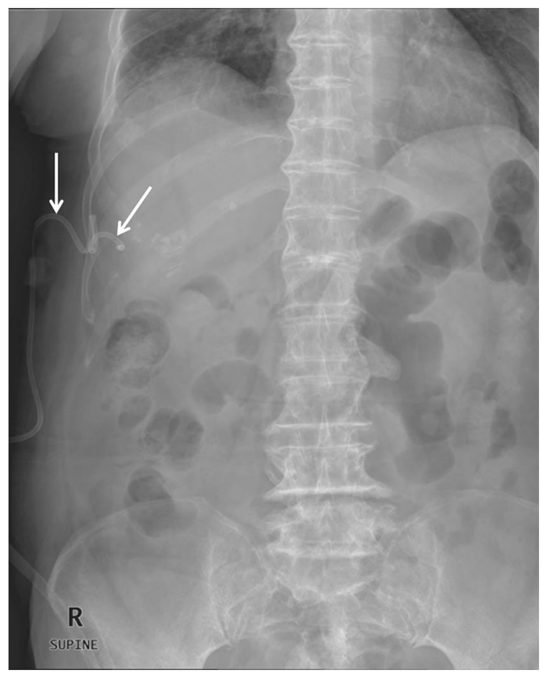

Fig. 7 Cholecystostomy catheter migration in an 87-year-old female with cholecystitis. Abdominal radiograph shows a catheter (*arrows*) that has backed out of the gallbladder. Subsequently, the catheter was removed and a new catheter was properly placed (not shown)

Malposition of the tube can cause peritonitis by leakage of gastric contents into the peritoneal cavity. Malposition of a Foley catheter can lead to injury resulting from inflation of the catheter balloon within the urethra [4].

Fracture

Fractures of some medical devices may be attributed to device materials, implantation duration, the anatomical structure in which a device is placed and any procedures after device installation [9]. The underreported incidence of stent fractures might be due to a lack of awareness and difficulty in detecting the events [10]. Fractures of a biliary or gastrointestinal stent can occur spontaneously or can be caused by balloon dilatation or argon plasma coagulation, which are used for the treatment of tumor regrowth (Fig. 16) [10]. These fractures can cause gastrointestinal bleeding, recurrent biliary obstruction, bowel obstruction or perforation.

Inferior vena cava filters have been used to prevent life-threatening pulmonary embolism in patients with refractory anticoagulation therapy (Fig. 17) [1]. The risk of filter fracture may be related to the length of time the filter remains in the body, although the reported incidence of filter fractures was approximately 5.5 %; the predicted fracture rate at 5.5 years was 40 % in one study (Fig. 18) [9]. In addition, migration of fractured fragments can cause life-threatening complications. Thus, if protection from pulmonary emboli is no longer needed, removing the filter should be considered as soon as possible.

Fig. 8 Photograph of a CAPD catheter. The subcutaneous cuff (*arrow*) and deep cuff (*open arrow*) are designed to maintain the catheter anchoring

Miscellaneous

Retention of ingested diagnostic devices

Some medical devices are designed to be swallowed and usually exit the body on their own over time [3]. Inappropriately retained medical devices can cause irritation, inflammation, bowel obstruction and even more severe complications such as abscess formation.

Capsule endoscopy has been used to evaluate small bowel disease (Fig. 19). A diagnostic endoscopy capsule

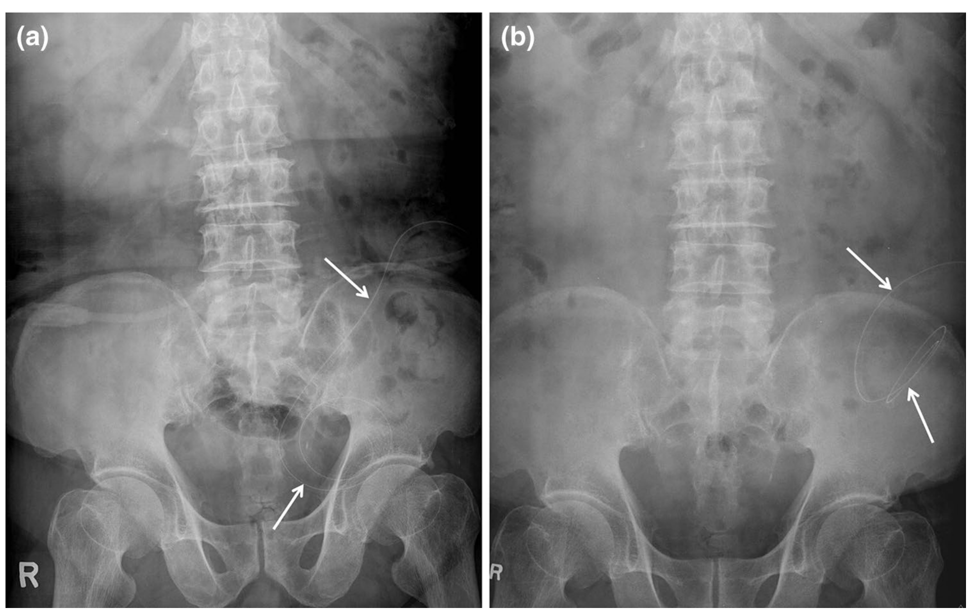

Fig. 9 Migration of CAPD catheter in a 70-year-old male with chronic renal failure. **a** Abdominal radiograph shows proper location of a CAPD catheter (*arrows*) tip in the pelvic cavity. **b** Abdominal radiograph taken 7 days later shows superior lateral migration of the catheter (*arrows*). The CAPD catheter was reinserted by an interventional procedure (not shown)

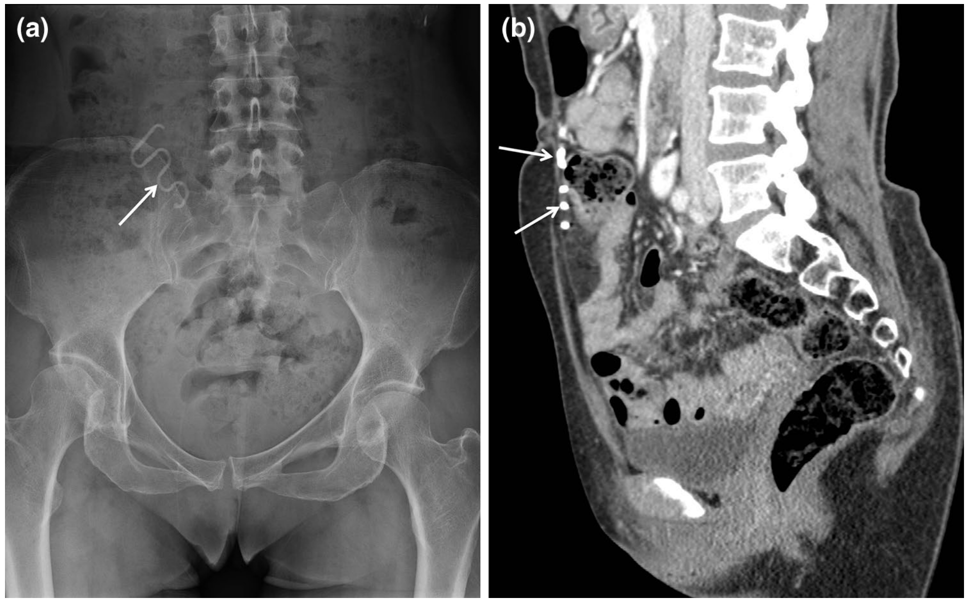

Fig. 10 Migration of an IUD in a 54-year-old female. **a** Plain radiograph shows a Lippes loop (*arrow*) in the *right* lower abdomen, not its original insertion site. **b** Sagittal reformatted CT scan clearly demonstrates the greater omental location of the migrated IUD (*arrows*). The IUD was removed by laparoscopic surgery

Fig. 11 Photograph of a nasogastric tube

Fig. 13 Photograph of a Foley catheter

Fig. 12 Photograph of a percutaneous endoscopic gastrostomy tube

should exit the body within 1–2 days [11]. Capsule retention is the most feared complication of the procedure and is defined as the capsule remaining in the gastrointestinal tract more than 2 weeks [11]. The risk of capsule retention ranges from 0 to 13 %, and it occurs more frequently in patients with bowel stricture of known Crohn's disease [11]. Serial follow-up of abdominal radiographs or CT can be helpful to verify the location of a capsule if retention is suspected (Fig. 20) [3].

Infection

The use of medical devices can increase the risk of bacterial or fungal growth. Catheters are particularly associated with increased nosocomial infection rates [12]. The main

Fig. 14 Malposition of a nasogastric tube in an 89-year-old male with chronic renal disease. Abdominal radiograph shows a tube coiled in the esophagogastric junction with the tip (*arrow*) in the distal esophagus

Fig. 15 Malposition of a percutaneous endoscopic gastrostomy tube in a 75-year-old male with a cerebrovascular accident. Sagittal reformatted CT scan shows a tube (*arrows*) within the small bowel loop, not in the stomach (Sto). The misplaced tube was subsequently removed, and another gastrostomy tube was properly placed in the stomach (not shown)

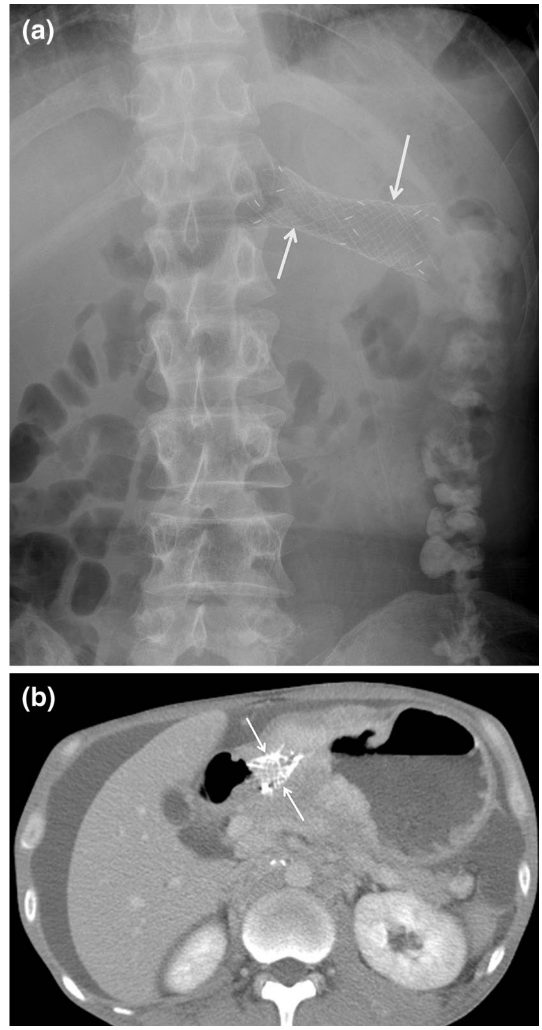

Fig. 16 Fracture of a pyloric stent in a 44-year-old male with stomach cancer who had a history of vomiting the fragmented stent. **a** Abdominal radiograph shows a pyloric stent (*arrows*) in the upper abdomen. **b** A follow-up CT image taken 70 days later shows a remaining stent fragment (*arrows*) in the gastric pylorus. Subsequently, a new pyloric stent placement was performed (not shown)

concern of infection associated with medical devices of the abdomen and pelvis may be peritonitis. Infection is the most common complication related to CAPD catheters and peritoneal segments of ventriculo-peritoneal shunts [8, 13]. Infection can also develop as a complication of stent instrumentation [7, 10]. Infection can be difficult to recognize on abdominal radiographs; therefore, CT plays an important role in detecting infection (Fig. 21).

Bleeding

Bleeding can occur during the installation of a medical device or shortly after its removal. Most minor bleeding from the abdominal wall can be managed by application

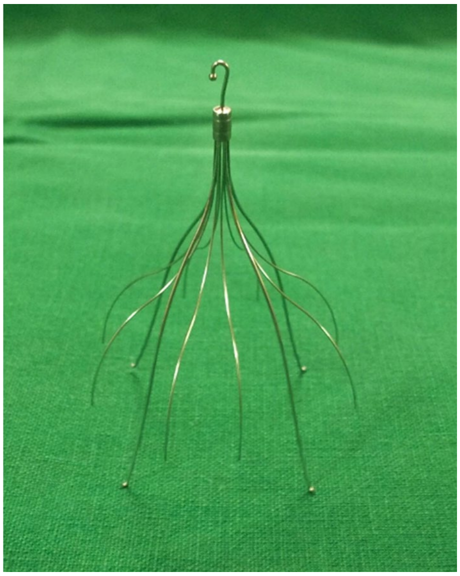

Fig. 17 Photograph of an inferior vena cava filter

Fig. 18 Fracture of inferior vena cava filter in a 40-year-old male with quadriplegia because of a traffic accident. Coronal reformatted CT scan shows multiple fractured filter fragments (*arrows*) in the inferior vena cava. Note the newly inserted filter (*open arrow*) in the inferior vena cava at the level of the *left* renal vein insertion

of compressive devices [14]. However, some cases of refractory bleeding and intraperitoneal active bleeding remain the most serious complications, requiring embolization or surgical intervention. Bleeding cannot be detected with abdominal radiographs alone. Contrast-enhanced

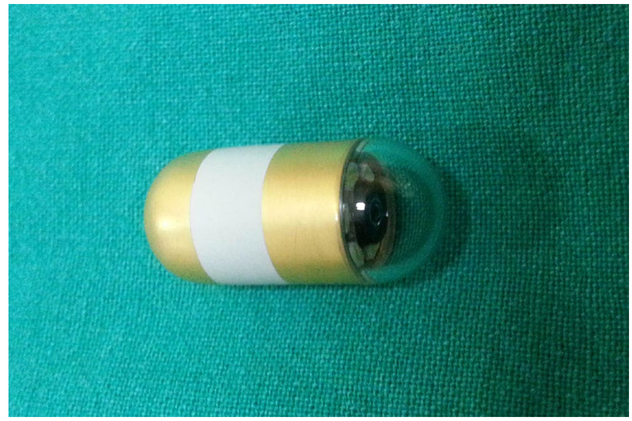

Fig. 19 Photograph of a capsule endoscope

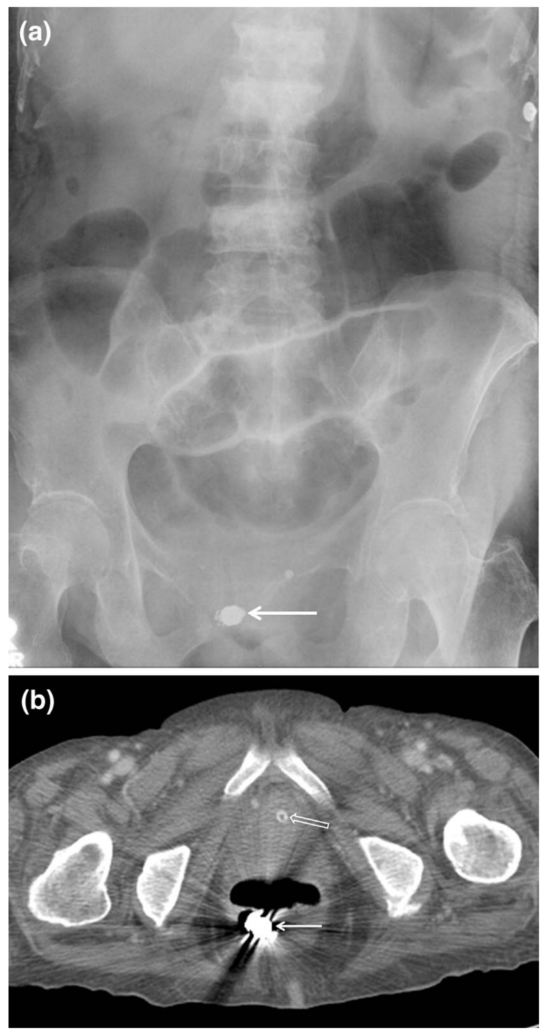

Fig. 20 Retention of an endoscopic capsule in an 81-year-old female with chronic renal disease who had recent melena. **a** Abdominal radiograph obtained 25 days after capsule ingestion shows a retained capsule (*arrow*) in the lower pelvic cavity, suggestive of the rectum. **b** Subsequent CT scan demonstrates the capsule (*arrow*) within the rectum and a surrounding beam-hardening artifact. Note the inserted Foley catheter (*open arrow*)

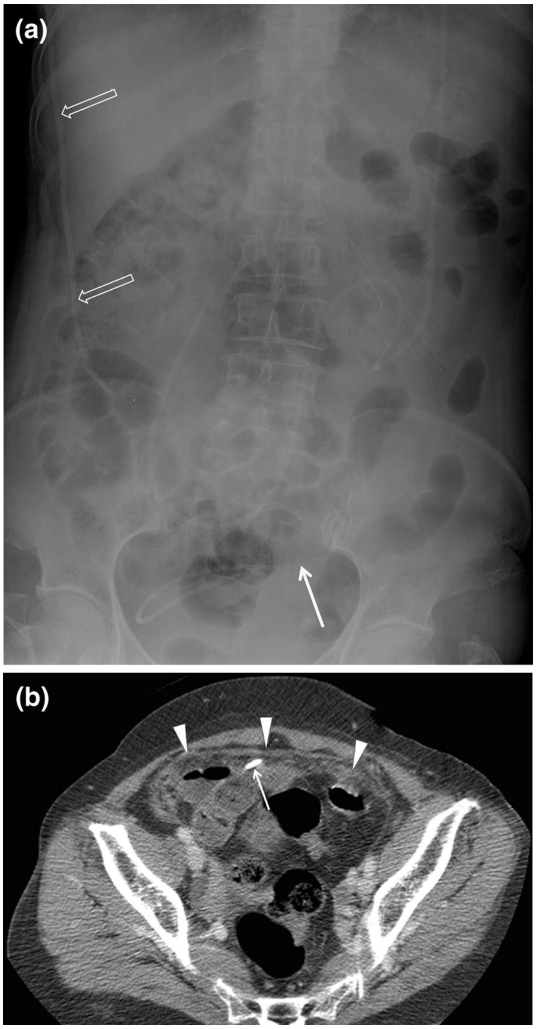

Fig. 21 Infection of a fractured peritoneal segment of a ventriculo-peritoneal shunt catheter in a 61-year-old female with hydrocephalus who had recent abdominal pain. **a** Abdominal radiograph shows a fractured segment (*arrow*) of a ventriculo-peritoneal shunt catheter in the pelvic cavity, which is from the *right* side shunt catheter (*open arrows*). The finding of infection cannot be identified in this plain radiograph. Note the newly inserted ventriculo-peritoneal shunt catheter in the *left* side of the abdomen. **b** Axial CT scan shows dirty infiltration in the greater omentum (*arrowheads*) adjacent to a fractured segment of the shunt catheter (*arrow*), suggesting shunt catheter-related peritonitis. Micrococcus species grew from the shunt catheter

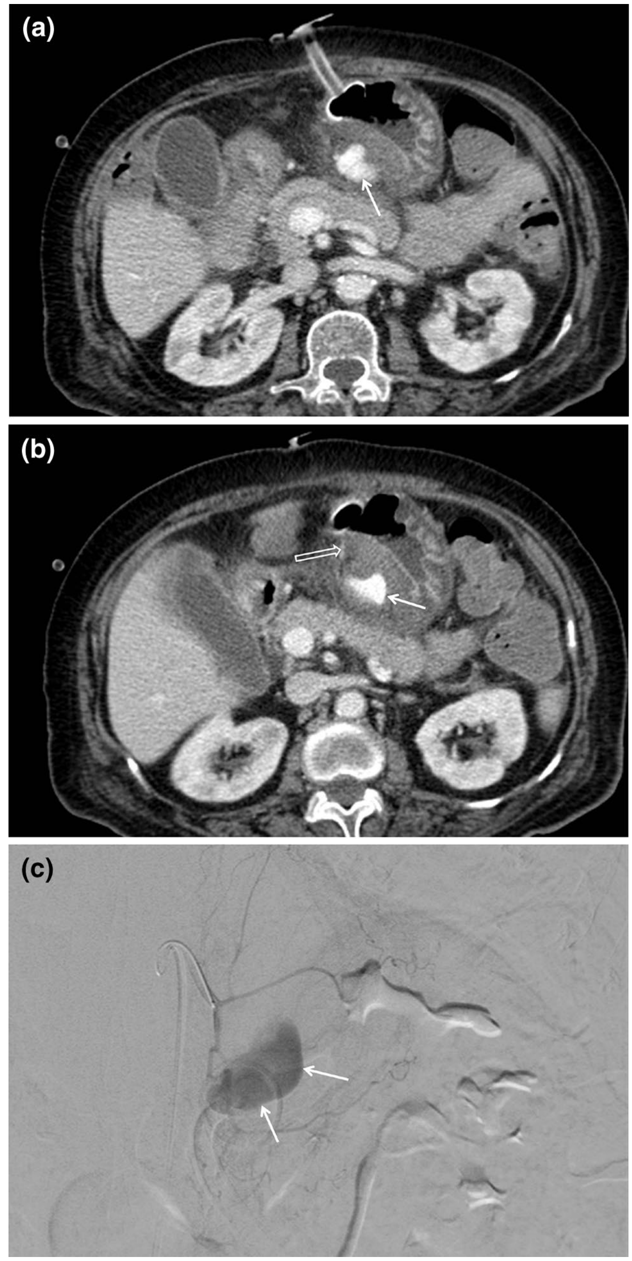

Fig. 22 Bleeding after percutaneous endoscopic gastrostomy in a 73-year-old female with cerebral infarction. **a** Axial CT scan shows high-density bleeding (*arrow*) within the hematoma in the lesser sac. Note the gastrostomy tube. **b** Axial CT scan obtained at an *upper* level shows linear high-density contrast extravasation (*open arrow*) from the gastrostomy tube. Note the irregular-shaped high-density bleeding (*arrow*). **c** Subsequent angiography reveals a pseudoaneurysm (*arrows*) from the branch of the left gastric artery

multidetector CT is an accurate diagnostic modality to detect bleeding (Fig. 22).

Retained surgical sponge

Retained surgical sponges are sponges or towels that are unintentionally left behind in a patient's body after the completion of an operation. The frequency of retention of surgical sponges or swabs in the abdomen and pelvis has been reported as about 0.02–1 % [15]. Retained sponges are usually asymptomatic, but can sometimes result in a granulomatous response with abscess formation, intestinal obstruction or fistula formation. Most retained surgical sponges are usually detectable on plain radiographs because they have radiopaque markers. However, surgical sponges without visible radiopaque markers can only

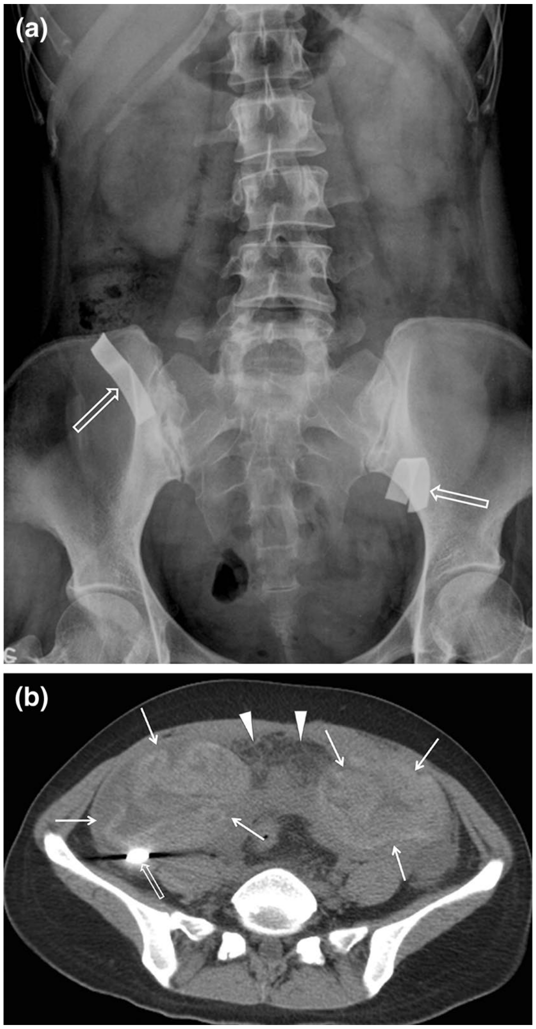

Fig. 23 Retained surgical sponges with peritonitis in a 31-year-old female with history of a cesarean section 1 year earlier. **a** Abdominal radiograph shows two radiopaque sponge markers in the bilateral *lower* abdomen (*open arrows*). **b** Axial CT scan shows two ovoid-shaped masses (*arrows*) with inner subtle high density "whorled' configuration and greater omental infiltration (*arrowheads*) suggesting peritonitis. Note the beam-hardening artifact around the marker (*open arrow*). Sponges were surgically removed

be identified on CT. Although CT appearances of retained surgical sponges are widely variable, a whorled configuration or a spongiform pattern with contained air bubbles is a typical finding (Fig. 23) [15].

Conclusion

With only the slightest attention to medical devices, complications, such as migration, malposition or fracture, can be easily recognized on plain radiographs. CT can also play an important role in detecting and diagnosing other complications such as infection, bleeding, obstruction or organ injury. Familiarity with medical devices and early detection of the complications related to their use by an abdominal radiograph or CT can allow radiologists to provide important information to the clinicians, potentially helping to improve patient management.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical statement All procedures were in accordance with ethical standards for human experimentation and the Helsinki Declaration.

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