Imaging Findings of Acute Abdomen due to Complications of Meckel Diverticulum

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Abstract

Meckel diverticulum is the most common and well-known congenital anomaly of the digestive system. Although most cases are asymptomatic, Meckel diverticulum can have a variety of complications, including gastrointestinal bleeding as a result of peptic ulceration, diverticulitis, and small bowel obstruction. Although the radiologic findings of these complications have been reported, they are difficult to diagnose preoperatively because Meckel diverticulum is a small entity. Computed tomography and scintigraphy play an important role in the diagnosis of Meckel diverticulum and its complications. It is important to be familiar with the radiologic features of acute abdomen due to complications of Meckel diverticulum to be able to manage the condition appropriately.

Keywords: computed tomography; scintigraphy; acute abdomen; Meckel diverticulum; multiplanar reconstruction

Introduction

Meckel diverticulum is the most common and well-known congenital anomaly of the digestive system with a reported occurrence rate of about 2% in the general population (1). It can have a number of complications, including bleeding, inflammation, small bowel obstruction, and perforation, especially in children (2), but is rarely symptomatic in adults (3). Meckel diverticulum is not often encountered in daily practice; therefore, its complications are difficult to diagnose preoperatively. Computed tomography (CT) and scintigraphy are useful for the diagnosis of these complications. When they are correctly diagnosed and appropriately treated at an early stage, they are curable. Therefore, it is essential to be familiar with the radiologic findings of Meckel diverticulum and its complications. The purpose of this article is to describe the radiologic features of acute abdomen due to complications of Meckel diverticulum.

General information

Meckel diverticulum occurs secondary to the remnants of the congenital vitelline duct (1). It is a true diverticulum that involves all three layers of the intestinal wall, i.e., the mucosa, muscularis propria, and adventitia. It may have heterotopic mucosal tissues in the intestinal layers. According to a recent systematic review, the most common site of heterotopic mucosa is the gastric tissue (35.5% in symptomatic patients, 8.8% in asymptomatic patients) followed by the pancreatic tissue (6.0% in symptomatic patients, 2.6% in asymptomatic patients) (4). Some patients (2.1%–5.2%) have been found to have heterotopic mucosa in both gastric and pancreatic tissue (2, 5).

Unlike most other types of bowel diverticula, Meckel diverticulum is generally located at the antimesenteric border of the ileum and within 60–100 cm of the ileocecal valve

(6). In general, it is a sac-like outpouching of the small bowel and has an average length of 3 cm (3) (Fig. 1). The ‘rule of twos’ is the classic description of the clinical features of Meckel diverticulum (1), i.e. (i) the occurrence rate is about 2% in the general population, (ii) there is a male-to-female ratio of 2:1, (iii) it is located within 2 feet of the ileocecal valve, and (iv) the length is about 2 inches, although the size may vary. Meckel diverticulum may manifest as a patent opening through the umbilicus, be connected to the umbilicus by a fibrous cord, or be present as a movable blind pouch (6).

The majority of individuals with a Meckel diverticulum are asymptomatic. In these cases, the diverticulum may be found incidentally on imaging studies performed for other diseases, during surgery, or at autopsy. It has been reported that the lifetime risk of complications associated with Meckel diverticulum is 4%–6%, with the risk being higher in children than in adults (3, 6). According to the recent systematic review, the most common complication is small bowel obstruction (46.7% in children, 35.6% in adults) followed by gastrointestinal (GI) bleeding (25.3% in children, 27.3% in adults) and diverticulitis (19.5% in children, 29.4% in adults) (4).

Diagnostic imaging for evaluation of complications of Meckel diverticulum

GI bleeding

GI bleeding is a common and characteristic complication of Meckel diverticulum, especially in pediatric patients, as a result of peptic ulceration of heterotopic gastric mucosal tissue. Plain radiographs are often ordered as the initial imaging modality for acute abdomen. These may show enteroliths or an abnormal amount of gas in the small bowel in patients with Meckel diverticulum but cannot detect the diverticulum itself.

Ultrasonography is also routinely used for initial evaluation of acute abdomen, especially in children, and can detect Meckel diverticulum; it is a non-invasive imaging modality with high accessibility and does not require iodine-based contrast materials or radiation exposure. However, it is an operator-dependent modality and the results are difficult to interpret retrospectively. CT has higher sensitivity than other imaging modalities for evaluation of complications due to Meckel diverticulum. Given that Meckel diverticulum is a small structure, thin-slice images and multiplanar reconstruction are needed to detect it. Meckel diverticulum can be detected as a blind-ending structure connected to the small bowel and contains fluid or gas. Recent technologic advances have led to CT replacing barium or gastrografin contrast studies as the imaging modality for Meckel diverticulum. CT can reveal heterotopic gastric mucosal tissue within a Meckel diverticulum as well-enhanced nodular areas (6) but they are difficult to detect. CT is a very useful modality for detecting Meckel diverticulum but has some disadvantages, including radiation exposure and difficulty in detection of the bleeding site. ^{99m}Tc pertechnetate scintigraphy, the so-called Meckel scan, is widely used for detection of Meckel diverticulum, especially in patients with GI bleeding. The pertechnetate anion accumulates in mucin-secreting cells in the gastric mucosa. Meckel diverticulum is usually visualized within 30 minutes after intravenous injection of ^{99m}Tc pertechnetate as a small area of uptake in the lower right quadrant of the abdomen (Fig. 2a–2f). It has high sensitivity (80%–100%) and specificity (92%–100%) for detecting Meckel diverticulum in pediatric patients with GI bleeding (4, 7) but is less sensitive in adults because heterotopic gastric tissue is not often seen in symptomatic Meckel diverticulum (8). In the event that ^{99m}Tc pertechnetate scintigraphy is negative, double-balloon enteroscopy or capsule endoscopy can be useful for

detecting Meckel diverticulum (Fig. 3a, 3b). ^{99m}Tc-labeled red blood cell scintigraphy is also useful for localizing the bleeding site in patients with active GI hemorrhage (Fig. 4a–4c). It is sensitive for localization of bleeding but not specific for Meckel diverticulum. Angiography may also be useful for detection of the bleeding site. Meckel diverticulum receives its blood supply from the vitelline artery, which can be detected at the terminal portion of the superior mesenteric artery (3). The disadvantages of angiography include its invasiveness, requirement for iodine-based contrast materials, and radiation exposure. There are some case reports of magnetic resonance imaging being used for detection of Meckel diverticulum (9-11); however, it is not popular at this point in time.

Non-GI bleeding-related acute abdomen

Small bowel obstruction

The most common cause of small bowel obstruction due to Meckel diverticulum is intussusception. An internal hernia can be caused by a fibrous cord (mesodiverticular band) connecting the Meckel diverticulum and umbilicus (Fig. 5a, 5b). CT is the most sensitive modality for diagnosing small bowel obstruction. In patients with intussusception, dilated small bowel loops with an intraluminal mass-like structure are observed on the oral side in the ascending colon. However, it is difficult to identify Meckel diverticulum as the cause of small bowel obstruction in a patient with an internal hernia because the CT findings are similar to those of other etiologies, including postoperative adhesions and band formation. The characteristic CT finding is a transition point between the dilated side oral to the obstruction and the collapsed anal side. It is observed as an acute narrowing of small bowel with a sharp edge where the

band crosses the small bowel (8). If a blind-ending tubular structure is observed at the transition point, it may be possible to diagnose Meckel diverticulum as the cause of the obstruction; however, preoperative diagnosis is often challenging.

Meckel diverticulitis

Meckel diverticulitis is a more common complication in adults than in children (4). It frequently mimics acute appendicitis both clinically and radiologically. Meckel diverticulitis presents as a blind-ended tubular structure with wall thickening and enhancement in the periumbilical region or right lower quadrant with surrounding fat stranding on CT (8). These findings are quite similar to those of acute appendicitis; therefore, detection of a normal appendix is essential for correct diagnosis (Fig. 6a, 6b). Perforation can occur secondary to inflammation. The presence of extraluminal air or a localized abscess on CT suggests perforation.

Inverted Meckel diverticulum

Meckel diverticulum may reverse into the small bowel lumen. Inverted Meckel diverticulum can appear as an intraluminal mass or pedunculated intraluminal polyp with a smooth margin on CT, thereby mimicking an intestinal tumor. It has been reported that the characteristic CT finding for inverted Meckel diverticulum is a central core of fat attenuation surrounded by a layer of soft tissue attenuation (8); however, in atypical cases, preoperative diagnosis is difficult (Fig. 7a, 7b). There have been no reports on fluorodeoxyglucose-positron emission tomography findings for inverted Meckel diverticulum. Our case showed uptake of fluorodeoxyglucose in the mass (Fig. 7c).

Management

The treatment for symptomatic Meckel diverticulum is resection. Laparoscopic resection has been described as a less invasive and safer technique than open laparotomy with an equivalent outcome (12, 13). Management of Meckel diverticulum that has been discovered incidentally remains controversial. Several risk factors for future complications have been reported, including male sex, younger age (<45 or 50 years), a long diverticulum (>2 cm), presence of a fibrous band, and abnormal findings in the diverticulum (14, 15). These risk factors may need to be taken into account when considering prophylactic resection, even in asymptomatic cases.

Conclusion

Although Meckel diverticulum is the most common and well-known congenital anomaly of the digestive system, it is nevertheless rare. Preoperative diagnosis of Meckel diverticulum may be difficult because the clinical and radiologic findings are similar to those of other acute abdominal diseases. However, there are some key points to consider with Meckel diverticulum, including GI bleeding in children, small bowel obstruction without a history of abdominal surgery in younger patients, and pain in the right lower quadrant with a normal-sized appendix. Complications arising as a result of Meckel diverticulum can be correctly diagnosed if clinicians are familiar with the characteristic radiologic features.

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Figure legends

Figure 1. Gross specimen of Meckel diverticulum. In general, Meckel diverticulum is a sac-like outpouching of the small bowel. The average length is 3 cm.

Figure 2. Imaging findings of ^{99m}Tc pertechnetate scintigraphy (Meckel scan). (a–f) Images of ^{99m}Tc pertechnetate scintigraphy (a, 5 minutes; b, 10 minutes; c, 20 minutes; d, 30 minutes; e, 45 minutes; f, 60 minutes after injection). Meckel diverticulum usually appears within 30 minutes after intravenous injection of ^{99m}Tc pertechnetate as a small round area of uptake in the right lower quadrant (arrows). The dotted arrows indicate normal uptake in the stomach.

Figure 3. Meckel diverticulum complicated by gastrointestinal bleeding in a 17-year-old male patient with a complaint of melena. (a) Enteroscopic image of fresh blood in the small intestine. (b) An exposed vessel (dotted arrow) is clearly shown in a Meckel diverticulum (arrow) by double-balloon enteroscopy. (c) An image from a small bowel enema with gastrografin showing a Meckel diverticulum (arrow). (d) Gross specimen of the unopened resected Meckel diverticulum (arrows).

Figure 4. Meckel diverticulum complicated by gastrointestinal bleeding in a 28-year-old man with a complaint of painless rectal bleeding. (a–c) Images of ^{99m}Tc-labeled red blood cell scintigraphy (a, 3 hours; b, 6 hours; c, 24 hours after injection). Images acquired at 3 and 6 hours after injection show no abnormal uptake (a) (b). An image acquired at 24 hours after injection shows uptake from the ascending colon to the descending colon (c, arrows), meaning that there was active bleeding on the oral side of

the ascending colon between 6 and 24 hours after injection.

Figure 5. Meckel diverticulum complicated by bowel obstruction in a 50-year-old man with a complaint of lower abdominal pain. (a) Coronal contrast-enhanced computed tomography shows a closed loop obstruction of the small bowel (arrows). (b) A ventral slice of (a) shows a Meckel diverticulum producing an internal hernia by band formation (dotted arrow).

Figure 6. Meckel diverticulum complicated by Meckel diverticulitis in a 24-year-old woman with a complaint of lower abdominal pain. (a) Axial and (b) coronal contrast-enhanced computed tomography scans show a rim-enhancing tubular structure with surrounding inflammatory changes (arrows). A normal appendix is recognizable (dotted arrow) in addition to the rim-enhancing tubular structure.

Figure 7. An inverted Meckel diverticulum in a 55-year-old man with a complaint of melena. (a) Axial and (b) coronal contrast-enhanced computed tomography scans show an intraluminal mass in the small intestine (arrows). (c) Fluorodeoxyglucose-positron emission tomography shows uptake of fluorodeoxyglucose in the mass. The maximum standardized uptake value is 3.88.

Figure 1

Figure 2

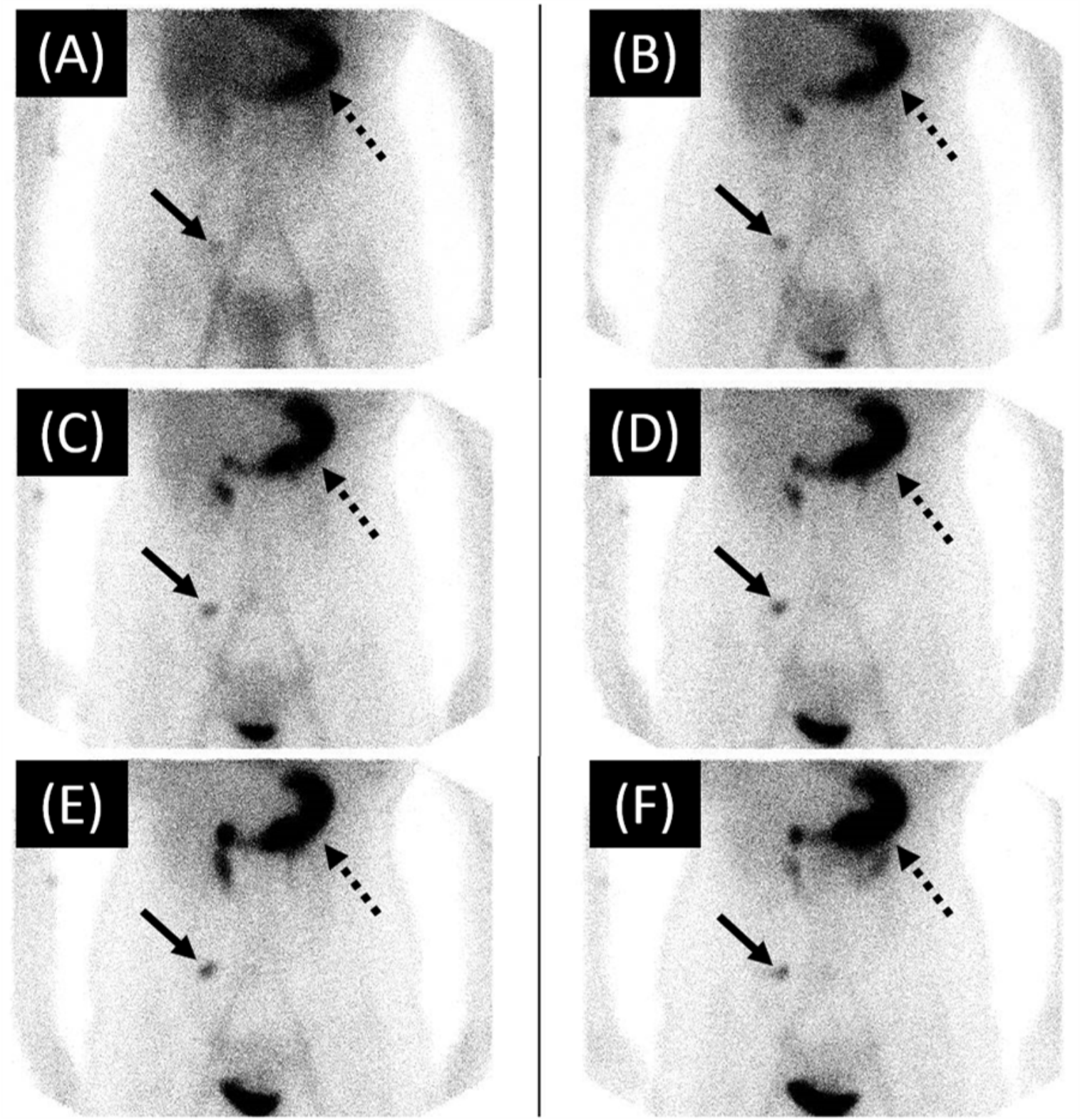

Figure 3

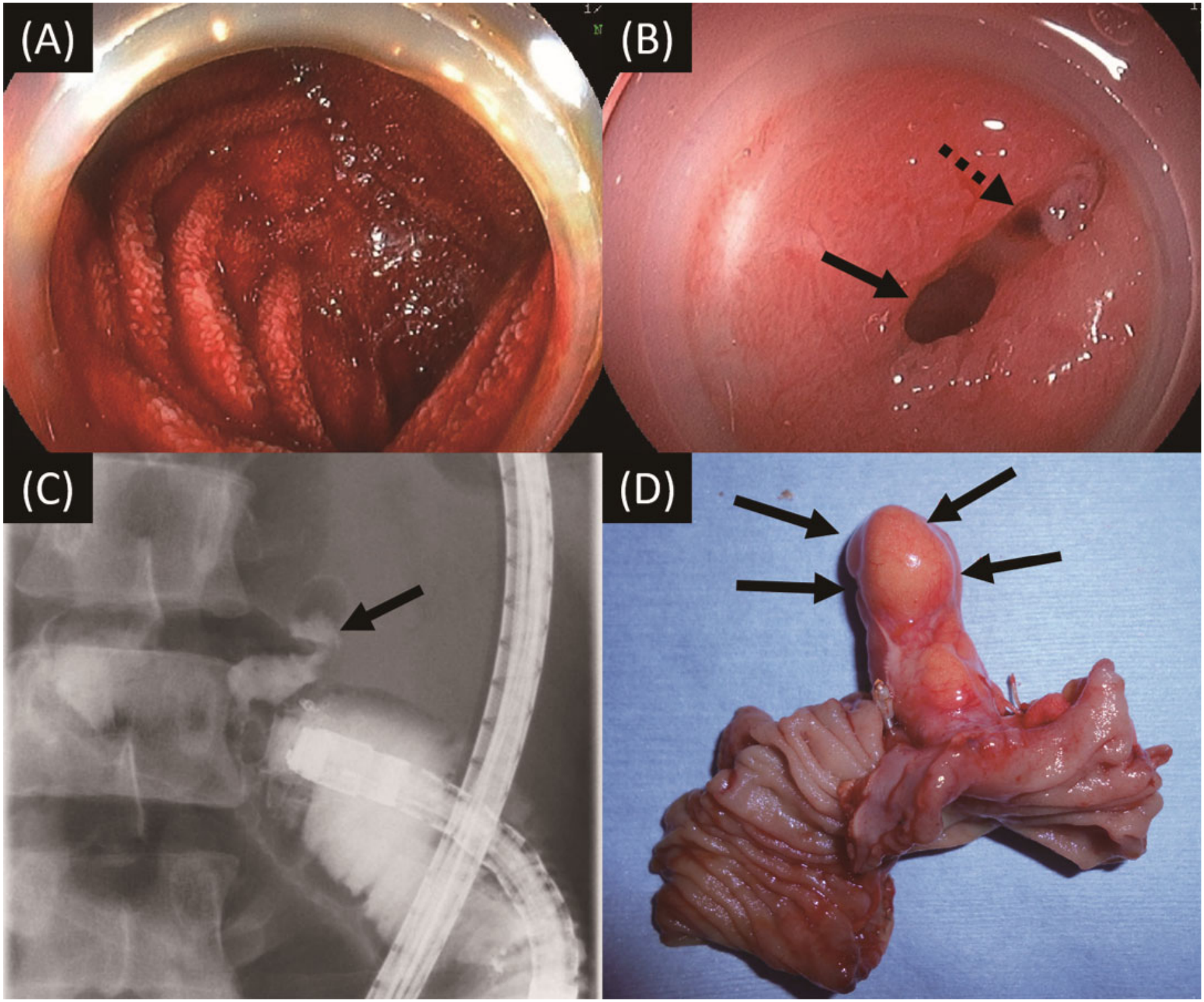

Figure 4

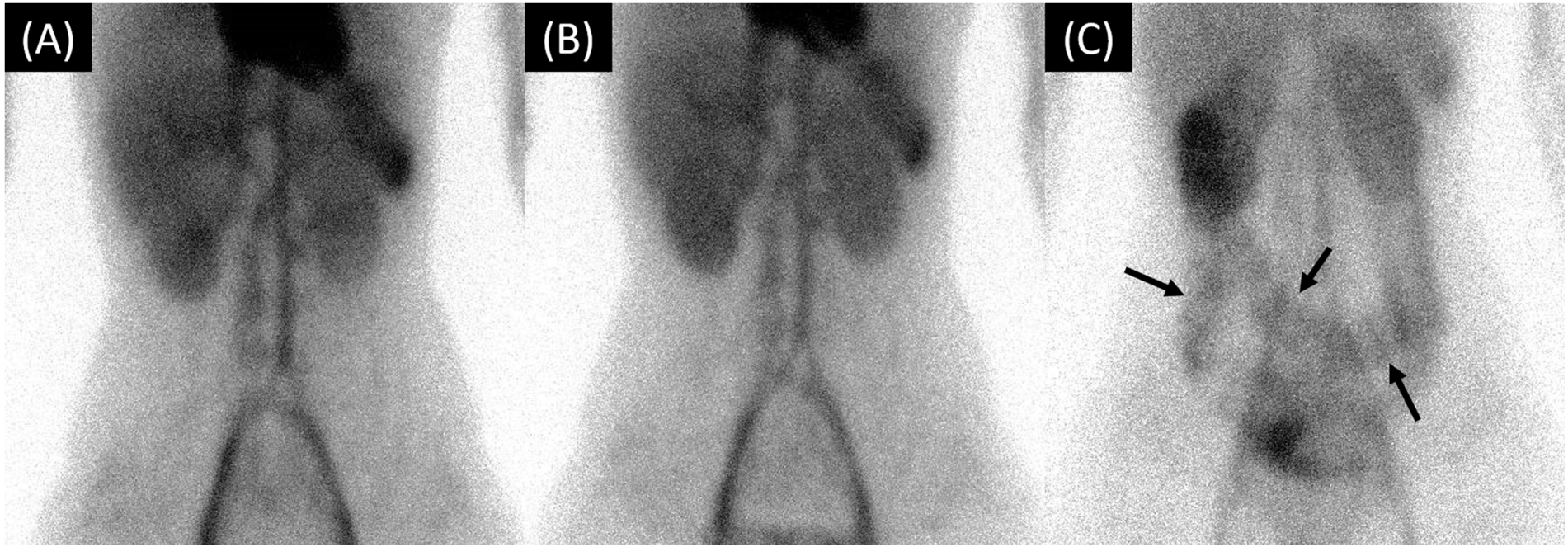

Figure 5

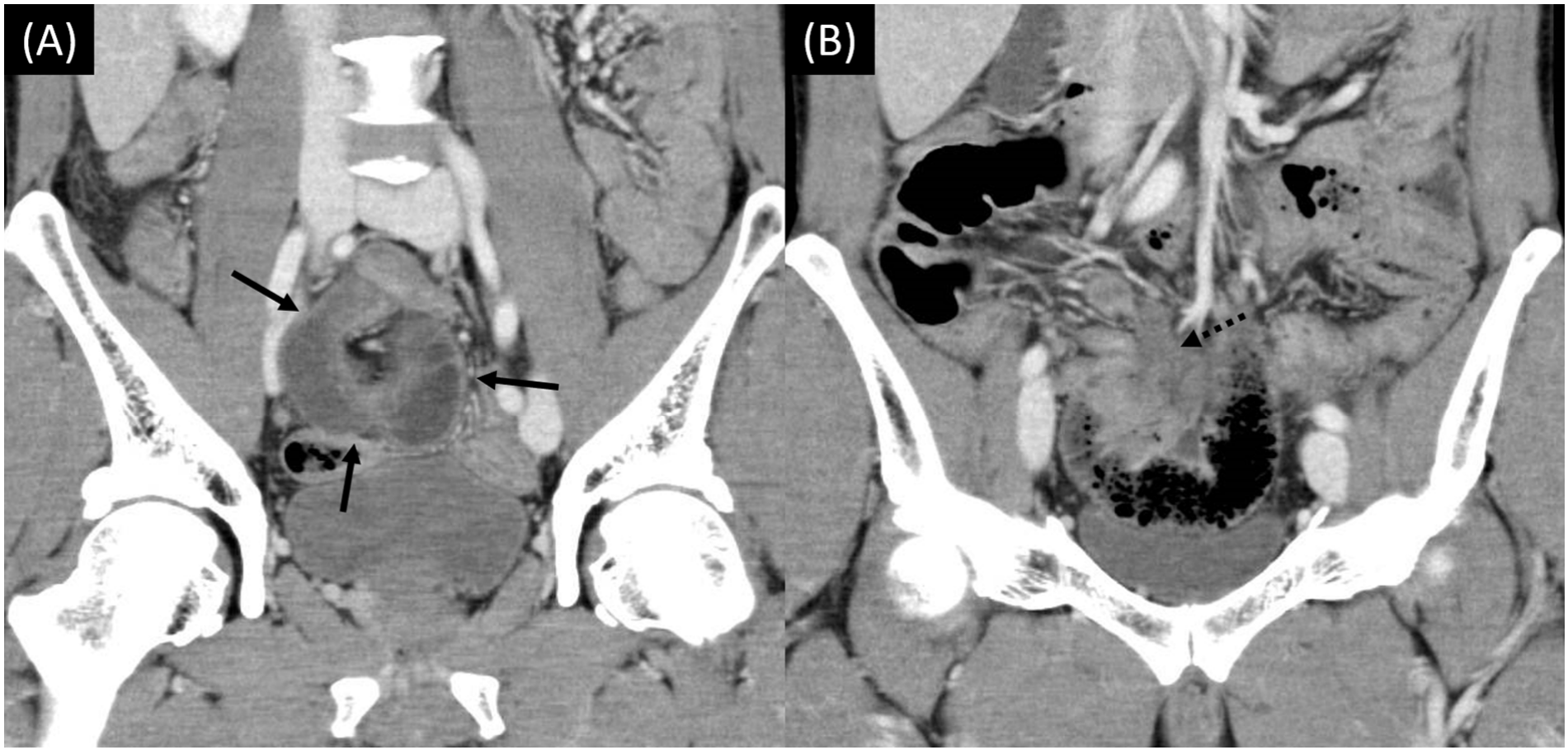

Figure 6