When, How and Why we Should Suspect a Complicated Meckel's Diverticulum Imaging Features

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To recognize complicated Meckel's diverticulum as a possible etiology of acute abdominal pain.

To identify and become familiar with both ultrasound imaging findings on MDCT as Meckel's diverticulum and its complications (bowel obstruction, hemorrhage, enterolith formation, inflammation, perforation and neoplasm).
Introduction

Meckel diverticulum, the most common congenital anomaly of the gastrointestinal tract, occurs due to non obliteration of the omphalomesenteric duct, it represents a true diverticulum as it is composed of all the layers of the intestinal wall.

Meckel’s diverticula are found within 100 cm of the ileocecal valve.

Meckel’s diverticula are typically asymptomatic and usually are found incidentally, with a lifetime risk of complications reported to be 4–40%.

The purpose of this electronic Exhibit is to familiarize the radiologist with the current imaging of Meckel’s diverticulum and its presenting complications.
The omphalomesenteric duct is the embryonic communication between the yolk sac and the developing midgut during the 6th week of embryogenesis, the midgut elongates and herniates into the umbilical cord. Within the umbilical cord, the midgut rotates 90° counterclockwise around the axis of the superior mesenteric artery.

By the 10th week of embryogenesis, the omphalomesenteric duct becomes a thin fibrous band, which eventually disintegrates and is absorbed. Simultaneously, midgut elongates to form jejunum and ileum, and the lumen of the omphalomesenteric duct closes.

Incomplete atrophy of the omphalomesenteric duct may result in:

- Umbilicoileal fistula
- Omphalomesenteric duct sinus
- Omphalomesenteric duct cyst
- Fibrous connection of the ileum to the umbilicus
- *Meckel diverticulum*
Meckel’s diverticulum arises from the antimesenteric border of the distal small bowel, typically 40–100 cm from the ileocecal valve.

Size: Length of up to 5 cm and diameter of up to 2 cm. It is a true diverticulum containing three layers of gut wall.

The arterial blood supply and venous drainage of a Meckel diverticulum are through remnants of the embryologic omphalomesenteric (vitellointestinal) artery.

It is lined by normal small intestinal mucosa. It frequently contains heterotopic gastric and pancreatic mucosa and less commonly, duodenal, colonic, or biliary mucosa.
Imaging Findings: Sonography

Usually shows a fluid-filled structure in the right lower quadrant having the appearance of a blind-ending, thick-walled loop of bowel, with the typical gut signature and a clear connection to a peristaltic, normal small-bowel loop.
Figure. (A) Transverse and (B) longitudinal sonograms show a blind-ending Meckel’s diverticulum (black arrow) in right lower quadrant. Cecum (*) and iliac vessels (white arrow).
Meckel’s diverticulum is difficult to distinguish from normal small bowel in uncomplicated cases.

Figure. Meckel’s diverticulum. (A) Coronal and (B) sagittal contrast-enhanced CT shows a blind-ending rounded structure (arrows) attached to the adjacent ileum.
Imaging Findings: CT

Figure. (A) Axial CT image of the pelvis shows a Meckel diverticulum (arrow) as a blind-ending tubular segment of bowel. (B) Axial CT image of the pelvis shows an enterolith (arrow) in a dilated and infected Meckel’s diverticulum.
The rate of complications of Meckel's diverticulum ranges from 4 to 40%. Occur more commonly in children than adults.

60% of Meckel diverticula become symptomatic before patients reach 10 years of age.

We will review the findings of complications of Meckel's diverticulum:

- Hemorrhage
- Intestinal obstruction
- Enterolith formation
- Inflammation (diverticulitis or ulceration)
- Neoplasm
Hemorrhage is the most frequent complication of Meckel diverticulum in the pediatric population.

Accounts for up to 30% of symptomatic Meckel cases.

Hemorrhage usually occurs secondary to ectopic gastric mucosa.

Technetium-99m pertechnetate scintigraphy is the modality of choice for evaluating pediatric patients with gastrointestinal hemorrhage and a suspected Meckel diverticulum.

Angiography is usually used to diagnose hemorrhage secondary to the bleeding Meckel’s diverticulum.
Figure. Meckel diverticulum in a 17-year-old man with hematochezia. Axial unenhanced CT demonstrates a hyperdense bowel loop located in the right lower quadrant (arrow). Resected surgical specimen shows a hemorrhagic Meckel diverticulum
Other causes of lower gastrointestinal bleeding in children include polyps, clotting disorders, arteriovenous malformations, and Crohn disease.

Angiography may be useful in the evaluation of an adult patient with occult or intermittent gastrointestinal bleeding for the localization of the site of bleeding, specific diagnosis, and therapeutic preoperative embolization.

Meckel diverticulum receives arterial blood supply from a remnant of the omphalomesenteric (vitellointestinal) artery, and demonstration of this artery is diagnostic of Meckel diverticulum. In some patients, the primary blood supply may also come from branches of the ileocolic artery.
Bowel obstruction accounts for up to 40% of symptomatic Meckel’s diverticula, is the second most common complication.

The diagnosis can be made with certainty only if the diverticulum is visualized at the site of obstruction.

Obstruction has been found to occur more frequently with a giant Meckel's diverticulum, other causes include;

- Intussusception
- Volvulus
- Adhesions
- Congenital mesodiverticular bands
- Diverticulitis
- Foreign body impaction
- Inclusion of the diverticulum into a hernia
- Neoplasm
- Formation of a true knot

MDCT is a sensitive technique for diagnosing small-bowel obstruction.
Bowel obstruction secondary to a Meckel's diverticulum in a 70-year-old man with abdominal pain and vomiting. (A) Coronal and (B) sagittal intravenous contrast-enhanced CT show a fluid-filled dilated small intestine that is oriented in a radial distribution surrounding small bowel mesentery and vessels and signs of intestinal ischemia (arrows). At surgery, it was seen that the Meckel diverticulum caused a kink in the intestine, thus producing the obstruction and intestinal ischemia.
Figure. Inverted Meckel diverticulum in a 8-year-old boy with history of abdominal pain and nonbilious vomiting. Longitudinal sonogram of the right lower abdomen shows an intraluminal mass within the small intestinal (white arrow). Iliac vessels (black arrow). At surgery, it was seen a Meckel diverticulum with intussusception.
Figure. Torsion of a Meckel diverticulum causing small intestinal obstruction in a 63-year-old man with history of abdominal pain and vomiting. (A) Axial contrast-enhanced CT image shows a blind-ending fluid-filled structure (arrow) resulting in small-bowel obstruction (.). (B) Axial contrast-enhanced CT image shows normal appendix (arrow) and small-bowel obstruction (.). Operative findings confirmed torsion of Meckel's diverticulum.
Enterolith formation is an uncommon complication of Meckel’s diverticulum despite diverticula being the most likely sites of a small-bowel enterolith.

Enteroliths can be seen in 3–10% of Meckel’s diverticula. Enteroliths are thought to form as a result of stasis.

The enteroliths will be present within the inflamed diverticulum.

Approximately 50% of enteroliths can be seen on radiography. However, unenhanced CT should be more valuable in detecting an enterolith. Enteroliths manifest as peripheral calcification with a radiolucent center and less often have a laminated appearance.
Figure. Enterolith in a Meckel diverticulum in a 45-year-old man with abdominal pain and fever. (A) Axial and (B) Coronal CT show an inflammatory process in right lower quadrant (arrowheads), with free intraperitoneal air, enterolith (arrows) in neck of diverticulum and diffuse small intestinal dilatation (*). At surgery, these findings proved to represent Meckel Diverticulitis, enterolith and intestinal perforation. (C) Intraoperative photograph shows a Meckel's diverticulum (white arrow) with perforation in the neck (arrowhead) secondary to enterolith (black arrow).
Figure. Enterolith in a Meckel diverticulum in a 40-year-old man with abdominal pain. Axial contrast-enhanced CT shows a Meckel diverticulum (*) as a blind-ending tubular segment of bowel in the right pelvis that contains a calcified enterolith (black arrow). With associated free fluid (white arrow). Laparotomy demonstrated an inflamed Meckel’s diverticulum and multiple enteroliths.
Diverticulitis accounts for up to 30% of symptomatic cases.

Diverticulitis commonly occurs secondary to;

- Acid secretion from ectopic gastric mucosa
- Obstruction by enteroliths
- Foreign bodies
- Neoplasm

The CT diagnosis of Meckel diverticulitis relies on the identification of a blind-ending tubular, round or oval structure in the right lower quadrant or periumbilical region with surrounding inflammation. The diverticulum may contain an air-fluid level, fluid only, or fecal-like material.

The presence of a pouchlike structure attached to the adjacent small intestine is a helpful clue to the diagnosis.

Other features that are helpful with the diagnosis include the presence of a secondary small intestinal obstruction and visualization of a normal appendix.
Sonography may be of value in the evaluation of children with a suspected Meckel diverticulum. Meckel diverticulitis appears as a round or tubular, cystlike structure with a thick, irregular hyperechoic internal wall and a hypoechoic external wall. This mural pattern of echogenicity has been called the gut signature. The outer hypoechochogenic layer corresponds to the muscularis propria of the intestinal wall, and the inner hyperechogenic layer corresponds to the mucosa and submucosal layers.

The presence of peristalsis and air within the diverticulum gives it the appearance of small intestine, making the diagnosis of Meckel diverticulum more difficult. Color Doppler sonography may demonstrate hyperemia within the wall of the diverticulum or anomalous vessels. Echogenic foci in the lumen may represent enteroliths, fecoliths, or inflammatory debris.

The differential diagnosis of Meckel diverticulitis on cross-sectional images includes appendicitis, inflammatory bowel disease, colonic diverticulitis, perforated neoplasm, and pelvic inflammatory disease in female patients. If findings are limited to the periumbilical region, complications of a urachal remnant should also be considered in the differential diagnosis.
Figure. Meckel diverticulitis in a 35-year-old man with abdominal pain, vomiting and fever. (A) axial, (B) coronal and (C) sagittal contrast-enhanced CT show a blind-ending Meckel’s diverticulum with thickened mucosal folds (arrows). There are surrounding inflammatory changes, thickening of the subjacent small intestine and free fluid (•).
Figure. Meckel diverticulitis in a 42-year-old man with abdominal pain. Axial contrast-enhanced CT shows a blind-ending Meckel’s diverticulum with thickened mucosal folds (arrow) with small-bowel obstruction (·). Normal appendix (not shown).
Figure. Meckel diverticulitis in a 54-year-old man with abdominal pain. (A) coronal and (B) sagittal contrast-enhanced CT show inflammatory process in right lower quadrant (arrows), with free intraperitoneal air. Laparotomy confirmed perforated Meckel’s diverticulitis.
Neoplasms arising in Meckel’s diverticula are rare, accounting for up to 3% of complicated cases.

The most frequently reported neoplasm complicating a Meckel’s diverticulum is carcinoid tumor. Other reported tumors include:
- Leiomyoma
- Leiomyosarcoma
- Angioma
- Lipoma
- Carcinosarcoma
- Adenocarcinoma

Carcinoids in Meckel diverticula are usually single, small, and asymptomatic.
They are most often incidentally discovered at histopathologic evaluation of a resected Meckel diverticulum or at autopsy.

The imaging features of these tumors are relatively nonspecific and depend on tumor size. Gastrointestinal stromal tumors in Meckel diverticula have been reported to manifest at CT as lobulated masses of heterogeneous attenuation with central areas of necrosis.

The tumor may extend to invade adjacent mesenteric fat and organs such as the bladder.
Figure. Carcinoid arising in a Meckel diverticulum in a 62-year-old man with nonspecific abdominal pain and diarrhea. (A) axial and (B) coronal intravenous and oral contrast-enhanced CT show a diffusely thickened of the distal ileum (arrows). At pathology, carcinoids in Meckel diverticula was confirmed.
Abdominal pain in the right iliac fossa represents a challenge for radiological diagnosis. Therefore, the radiologist must have a high degree of suspicion on the complications of a Meckel’s diverticulum when the patient presents symptoms of abdominal pain which are not compatible with the most common causes.

The radiologist must be familiar with the radiological findings of the complications of complicated Meckel’s diverticulum.

The most common complications are hemorrhage, intestinal obstruction and inflammation. The formation of an enterolith and neoplasia are less common.


