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REVIEW ARTICLE

Radiologist's perspective for the Meckel's diverticulum and its complications

¹V K KOTHA, MD, ²A KHANDELWAL, MD, ²S S SABOO, MD, FRCR, ³A K P SHANBHOGUE, MD, ⁴V VIRMANI, MD, FRCR, ⁵E C MARGINEAN, MD, FRCPC and ⁶C O MENIAS, MD

¹Department of Medical Imaging, St Michael's Hospital, University of Toronto, Toronto, ON, Canada

²Department of Radiology, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA

³Department of Radiology, Beth Israel Medical Center, New York, NY, USA

⁴Department of Radiology, Dr Everett Chalmers Hospital, Fredericton, NB, Canada

⁵Department of Pathology and Laboratory Medicine, The Ottawa Hospital, General Campus, Ottawa, ON, Canada

⁶Department of Radiology, Mayo Clinic, Scottsdale, AZ, USA

Address correspondence to: Dr Ashish Khandelwal

E-mail: drashish83@gmail.com

ABSTRACT

The Meckel's diverticulum is the commonest congenital anomaly of the gastrointestinal tract, often presenting with complications such as gastrointestinal bleeding, intussusception, bowel obstruction and diverticulitis, which are often misdiagnosed. Imaging plays an important role in the early diagnosis and characterization of these conditions and is very helpful in decision making. The Meckel's diverticulum and its complications have myriad presentations and appearances on various imaging modalities. Thus, sound knowledge of the anatomy, embryology, clinical presentation, imaging characteristics and complications is crucial to the practice of abdominal imaging. We present a review of the literature and current radiological practices in the diagnosis and management of the Meckel's diverticulum and its various complications with special emphasis on the imaging of various complications, mimickers and pathological correlation.

The Meckel's diverticulum is the commonest congenital anomaly of the gastrointestinal tract. It is a true diverticulum having all the layers of the intestinal wall.^{1,2} It occurs as a spectrum of abnormalities that result from the persistence of the vitellointestinal duct, which includes the umbilico-ileal fistula, umbilical sinus, umbilical cyst and, rarely, a thin fibrous band connecting the ileum to the umbilicus. Meckel's diverticulum is named after Johann Friedrich Meckel the Younger, who first described its embryological origin in 1809.³ In general, it is usually asymptomatic with a 4.2–6.4% lifetime risk of complication.⁴ The Meckel's diverticulum manifests more commonly in children. However, complications can occur in adults, including gastrointestinal bleeding, intussusception, obstruction and diverticulitis. The well-known “rules of 2” state that the Meckel's diverticulum occurs in about 2% of the population, it is about 2 inches in length, is usually located within 2 feet of the ileocaecal valve and usually presents before 2 years of age.⁵ The diagnosis of the Meckel's diverticulum-related diseases is often challenging with imaging playing the pivotal role in their prompt recognition and differentiation from other common conditions that can have a similar clinical presentation. The

purpose of this article is to review embryology, pathology, clinical and radiological manifestations along with varied complications of the Meckel's diverticulum with emphasis on differentiating them from their common mimickers.

EMBRYOLOGY AND ANATOMY

The Meckel's diverticulum is a remnant of the omphalomesenteric (vitellointestinal) duct, which in foetal life connects the yolk sac with developing midgut. During embryogenesis, the midgut returns to the abdominal cavity between the 10th and 12th week of gestation.⁶ During this time, the omphalomesenteric duct involutes into a thin fibrous band before being gradually absorbed.⁷ However, failure of the omphalomesenteric duct to completely involute at its midgut end results in the Meckel's diverticulum; incomplete atrophy of the duct at its midgut side results in an umbilical sinus at its umbilical end, whereas incomplete atrophy at both ends results in an omphalomesenteric cyst and complete failure of atrophy results in an ileo-umbilical fistula.⁷ Although, the ileo-umbilical fistula usually presents early as a result of faecal discharge at the umbilicus, the other anomalies are usually difficult to detect unless associated with some complications.

Figure 1. A 45-year-old asymptomatic male with staging CT for lymphoma. Coronal contrast-enhanced CT image showing the Meckel's diverticulum as a tubular structure arising from the antimesenteric border of the ileum pointing in the pelvis (white arrow).

Rarely, the omphalomesenteric duct atrophies into a thin fibrous cord, which may cause intestinal obstruction.⁸ Of these anomalies, the Meckel's diverticulum is the commonest, accounting for nearly 98% of the cases of omphalomesenteric duct anomalies⁹ and is usually located in the pelvic or periumbilical region or right iliac fossa (Figure 1). The diverticulum arises from the anti-mesenteric border of the terminal ileum and is usually supplied by the vitelointestinal artery originating from the ileal branches of the superior mesenteric artery. The diverticulum has a separate fold of mesentery, which carries the supplying vessels.^{10,11}

CLINICAL MANIFESTATIONS

The Meckel's diverticulum may be asymptomatic and often detected incidentally during surgery for some other indication. There is no known gender predisposition of asymptomatic Meckel's diverticula; however, symptomatic diverticula are more common in males than in females.¹² The Meckel's diverticulum usually presents early in childhood before 10 years of age.¹³ On imaging, the Meckel's diverticulum is commonly diagnosed in a patient with its complication. The common symptoms depend on the complication, and include bleeding per rectum due to intestinal haemorrhage, abdominal pain, vomiting and distension resulting from obstruction or perforation and abdominal pain with fever due to diverticulitis.¹² Rarely, tumours may present with chronic intestinal obstruction. Some patients may also present with chronic relapsing pain.

Figure 2. A 60-year-old male with acute severe abdominal pain and vomiting. Plain film showing multiple dilated small bowel loops with transition in the ileum (arrow). Inflamed Meckel's diverticulum with adhesion was found intra-operatively as the cause of obstruction. Spinal fixation hardware from prior surgery is also noted.

IMAGING FEATURES

Conventional radiography

Conventional radiography has no real value in detecting the Meckel's diverticulum. However, rarely, an enterolith or dilated bowel loops with air–fluid level within the Meckel's diverticulum

Figure 3. Ultrasonographic image of the right lower quadrant for abdominal pain in a 39-year-old female shows the Meckel's diverticulum (arrow) as a cystic non-compressible structure with thick irregular wall.

Figure 4. A 19-year-old male with painless rectal bleeding. ^{99m}Tc -pertechnetate scintigraphy showing uptake (arrows) of ectopic gastric mucosa in a Meckel's diverticulum.

may be seen on conventional radiographs¹⁴ (Figure 2). Moreover, such an enterolith is often indistinguishable from an appendicolith.

Barium studies

On barium studies, the Meckel's diverticulum may be detected as a blind-ending tubular or saccular structure arising from the antimesenteric border of the terminal ileum. The diverticulum is directed away from the axis of the root of the mesentery, proving its antimesenteric location.¹³ The base of the Meckel's diverticulum may reveal a mucosal triangular plateau or a tri-radiate fold pattern on barium examination, which probably represents the attachment site of the embryonic omphalomesenteric duct with the midgut.¹⁵ Sometimes, mucosal irregularity may be seen due to ectopic gastric mucosa,¹⁶ while filling defects can occur from blood clots in a bleeding Meckel's

diverticulum.¹⁷ Enteroclysis is more reliable than conventional barium studies in detecting the Meckel's diverticulum. In a large study consisting of 415 enteroclysis examinations, 11 out of the 13 histopathologically confirmed cases of Meckel's diverticulum were correctly identified on enteroclysis with only one false-positive result.¹⁵

Ultrasonography

On ultrasonography, the Meckel's diverticulum usually appears as a tubular blind-ending structure arising from the ileal loops (Figure 3) with a thick wall and the typical "gut signature" sign, as its wall consists of all the layers of a normal bowel wall. Demonstration of a clear communication between this blind-ending structure and the small bowel can be done by applying pressure over it and expressing its contents into the ileal lumen,¹⁸ which can help to differentiate it from an enteric

Table 1. Approximate incidence of Meckel's diverticulum-related complications^{30,31}

Complications	Percentage (%)
Intestinal haemorrhage	15–28
Intussusception	13
Intestinal obstruction	12–23
Perforation	11–15
Strangulation due to a mesodiverticular band	8
Diverticulitis	5–19
Volvulus	6
Hernia	1.5–4
Neoplasm	1
Enterolith	0.3
Chronic relapsing pain	10

duplication cyst, which also has an echogenic wall without any direct communication with the ileal loops.

Computed tomography

On CT scan, the Meckel's diverticulum may be seen as a tubular blind-ending structure arising from the antimesenteric border of the terminal ileum. However, in uncomplicated cases, the diverticulum is often mistaken for a normal small bowel loop, thus limiting its detection.¹⁴ With the advent of multidetector CT (MDCT), the principles and techniques of abdominal imaging underwent tremendous changes¹⁹ and the sensitivity of diagnosing

Figure 5. A 17-year-old female with abdominal pain and rectal bleeding. Contrast blush (arrow) is seen surrounding one of the branches of the superior mesenteric artery consistent with a bleeding Meckel's diverticulum.

Figure 6. A 48-year-old male with 1 week of abdominal pain presented with acute worsening of pain. Axial (a, b) and coronal (c) CT images show a rounded mass in the right lower quadrant and active extravasation (arrow) with large haematoma (*). Pre-operative possibility of bleeding due to rupture of a Meckel's diverticulum or from a mesenteric mass was raised. Intra-operatively, the source of bleeding was confirmed to be from a Meckel's diverticulum and subsequent pathology revealed a gastrointestinal stromal tumour.

the Meckel's diverticulum has increased owing to the availability of higher spatial resolution and multiplanar isotropic reconstruction ability of the latest MDCT scanners, which allow visualization of the small bowel in various planes similar to that in barium studies.²⁰ Furthermore, CT enterography and enteroclysis combine the advantages of CT scanning with those of conventional barium enteroclysis studies, thus increasing their reliability in detecting the Meckel's diverticulum.²¹ CT is very useful in diagnosing and assessing the complications associated with the Meckel's diverticulum, particularly intra-abdominal abscess formation, obstruction and perforation, tumours and,

Figure 7. A 50-year-old male following gastric bypass 9 months previously presented with acute abdominal pain and emesis. Coronal (a) and axial (b) contrast-enhanced CT shows small bowel obstruction with a transition point in the proximal ileum. At surgery, the small bowel obstruction was secondary to adhesion adjacent to a Meckel's diverticulum. The Meckel's diverticulum was 2 feet from the ileocaecal valve and seen extending into a right inguinal hernia confirming Littre's hernia (arrow).

Figure 8. A 40-year-old male who presented with abdominal distension and vomiting. Coronal (a) and axial (b) CT images show multiple fluid-filled dilated small bowel loops (*) with transition in the ileum in the right lower quadrant. Hyperdense enterolith (arrow) within the Meckel's diverticulum as a cause for obstruction was identified.

sometimes, in detecting active extravasation of intravenously injected contrast medium in cases with active intestinal haemorrhage. Pertinent to the latter is the development of dual energy CT technology, which can provide images of higher inherent resolution with increased signal from iodinated contrast medium at a lower injection dose thus facilitating detection of small amounts of obscure haemorrhage.²² Also, virtual non-enhanced images from dual energy CT acquisition can potentially obviate the need for true non-enhanced images acquired with routine MDCT for detection of haemorrhage.²³

Scintigraphy

Scintigraphy can be a useful tool in detecting the Meckel's diverticulum containing an ectopic gastric mucosa (Figure 4). ^{99m}Tc-pertechnetate is taken up by the mucin-secreting cells in

the gastric mucosa and thus any intra-abdominal uptake exactly following gastric mucosal uptake may suggest this entity. This test has higher sensitivity of 85–90% in the paediatric population, while having relatively lower sensitivity in the adult population, of around 60%.²⁴ The sensitivity of a Meckel's scan can be increased by administering pentagastrin, glucagon or H₂ antagonists²⁵ or by imaging with single-photon emission CT instead of the usual planar imaging.²⁶ False-positive results are due to the presence of ectopic gastric mucosa elsewhere in the bowel, to gastric or intestinal duplication and to several inflammatory processes such as ulcerative colitis or Crohn's disease,²⁷ whereas the false-negative results are due to the normal delayed intestinal activity, which masks the activity of ectopic gastric mucosa in the diverticulum.²⁸ The Meckel's diverticulum may also be identified incidentally on a positron emission tomography CT scan²⁹ as a fludeoxyglucose-avid focus in the presence of inflammation.

Digital subtraction angiography

Digital subtraction angiography can help in detecting a persistent vitellointestinal artery in the case of bleeding from the Meckel's diverticulum¹¹ and in the planning of embolization of this artery.

COMPLICATIONS

The Meckel's diverticulum is usually detected by imaging studies when patients present with a complication. Major complications reported in the literature are tabulated with their approximate occurrence rate in Table 1.^{30,31}

Figure 9. A 57-year-old male with a history of chronic right lower quadrant pain and occult blood loss. Axial CT images (a, b) reveal an inverted Meckel's diverticulum intussuscepting into the ileum, resulting in the "pseudolipoma" sign (arrow) as a result of invagination of the mesentery of the Meckel's diverticulum into the terminal ileum. Further barium enteroclysis (c) also showed a lead point which is seen as a low-attenuation area (arrow). The patient underwent surgical resection, and pathology revealed the diverticulum, which was lined by small intestinal mucosa with focal gastric heterotopic mucosa (d) (haematoxylin and eosin, ×20).

Figure 10. A 44-year-old female with intermittent abdominal pain. Axial contrast-enhanced CT (a, b) reveals intussusception involving the small bowel loops with an intraluminal fat density mass in the intussusceptum (arrow) suggesting lipoma as the lead point. Subsequent pathology (c) confirmed the presence of a submucosal lipoma with the overlying small intestinal mucosa that shows marked ischaemic changes and haemorrhage (haematoxylin and eosin, $\times 40$).

(a)

(b)

(c)

INTESTINAL HAEMORRHAGE

The commonest cause of intestinal bleeding from a Meckel's diverticulum is the presence of ectopic gastric mucosa. ^{99m}Tc -pertechnetate scintigraphy is the most sensitive method to

identify the ectopic gastric mucosa in a Meckel's diverticulum. ^{99m}Tc -labelled red blood cells or ^{99m}Tc -labelled sulfur colloid are alternative tracers for imaging. Although these tests are not specific for any particular cause of intestinal haemorrhage, scintigraphy with ^{99m}Tc -pertechnetate-labelled red blood cells can detect bleeding at a rate as low as 0.1 ml min^{-1} .³² The presence of active haemorrhage, blood clots or barium can often mask the activity of the ectopic mucosa, thus producing false-negative results.³³ Nonetheless, nuclear studies are helpful in detecting small amounts of intestinal haemorrhage and approximately localizing the site of haemorrhage.

Mesenteric catheter angiography is often useful in accurately detecting the culprit vessel and therapeutically embolizing it for

Figure 11. (a) A 10-year-old female with an acute onset of abdominal pain with an episode of emesis. On plain abdominal radiographs, multiple dilated loops of small bowel (*) centred in the abdomen with pseudofaeces sign raised suspicion for a small bowel obstruction. (b, c) Coronal and axial contrast-enhanced CT scan images with oral contrast show multiple, dilated, contrast-filled loops of the small bowel (*) proximally, findings consistent with a small bowel obstruction. There appears to be a transition point in the right lower quadrant where a fluid-filled loop of bowel is identified (arrow). Adjacent non-contrast filled loops of small bowel contain faecal material giving the pseudofaeces sign. The possibility of a Meckel's diverticulum vs an ileal duplication cyst causing small bowel obstruction was raised. (d) Intra-operative photograph shows an inflamed Meckel's diverticulum (arrow) with the tip adherent to the mesentery around the small bowel, creating complete bowel obstruction with internal hernia and volvulus. The adherent band was divided and diverticulectomy performed.

(a)

(b)

(c)

(d)

Figure 12. (a) Ultrasonographic and (b) CT images of a cystic structure (*) with a thick wall showing a classic “gut signature”. (c) Histopathological correlation of bowel wall (arrow) confirming the diagnosis of an intestinal duplication cyst. Cross-section through a small intestinal duplication, showing two complete intestinal walls side by side. The segments share a common muscularis propria (haematoxylin and eosin, $\times 40$).

definitive treatment of the haemorrhage. Superselective catheterization of the mid- and distal ileal arteries may be required to locate this vessel. A bleeding rate of $>0.5 \text{ ml min}^{-1}$ is required for angiographic detection of bleeding from a Meckel's diverticulum. Ectopic gastric mucosa may produce a blush on angiography¹⁴ (Figure 5).

Non-invasive multiphasic MDCT angiography is an effective alternative tool with acceptable sensitivity and specificity in the investigation of intestinal haemorrhage, where bleeding can be seen as active extravasation of intravenous contrast.³⁴ In addition, CT can diagnose associated complications including perforation or haematoma (Figure 6).

Figure 13. Acute Meckel's diverticulitis (arrow), in a 35-year-old male with symptoms of acute lower abdominal pain and fever. Contrast-enhanced coronal (a) and axial (b) CT images show a blind-ending rounded structure attached to the ileum with surrounding inflammatory changes and thickening. Subsequent surgery confirmed acute Meckel's diverticulitis.

INTESTINAL OBSTRUCTION

The Meckel's diverticulum as a cause of intestinal obstruction is rarely diagnosed prospectively by imaging and is usually found during surgery. The Meckel's diverticulum can be the cause of intestinal obstruction in several ways, including:

- Meckel's diverticulum acting as a lead point for intussusception
- its inversion
- Meckel's diverticulitis with or without abscess formation
- enterolith formation within the Meckel's diverticulum
- tumours of the diverticulum
- fibrous cord from the diverticulum to the umbilicus or that of congenital mesodiverticular bands which may lead to intestinal obstruction or predispose to volvulus and rarely a true knot³⁵
- Meckel's diverticulum may also be found within an intestinal hernia (Littre's hernia), which may get obstructed³⁶ (Figure 7).

Enterolith

Plain radiography is usually the first modality for imaging of suspected intestinal obstruction. In addition to features of intestinal obstruction, the only feature that may suggest the possibility of a Meckel's diverticulum may be the presence of enteroliths in the pelvis or right lower quadrant of the abdomen. Enteroliths have been reported in 3–10% of all Meckel's diverticula, of which half are visualized on plain radiographs.³⁰ They are thought to be formed as a result of stasis of bowel contents within the diverticulum.¹⁴ They appear as radio-opacities with central radiolucency, while some may be laminated.³⁷

On CT images, the Meckel's diverticulum appears as a tubular blind-ending structure communicating with the small bowel usually at the site of the transition zone of the obstructed bowel, which can reveal enteroliths within the lumen (Figure 8). This may be associated with adjacent mesenteric fat stranding or an abscess in the case of complication with acute diverticulitis.³⁸

Figure 14. A 70-year-old male with severe abdominal pain, fever and leucocytosis. Axial (a) and coronal (b) CT shows a perforated Meckel's diverticulum with abscess/phlegmon formation (arrow) in the right lower quadrant mesentery. Corresponding histopathology slide (c) shows terminal ileum with diffuse mucosal ischaemic necrosis (short arrow) and adjacent Meckel's diverticulum (long arrow). The diverticulum shows marked congestion of the submucosal blood vessels and contains intraluminal fat (hematoxylin and eosin, $\times 20$).

Figure 15. A 36-year-old female with chronic diarrhoea and abdominal pain. Axial CT examination shows a banana-shaped, low-attenuation, well-circumscribed lesion (arrow) within the pelvis continuous with the bowel. Post-operatively, this was found to be a mucocele of the Meckel's diverticulum. The patient also had Crohn's disease with bowel wall thickening involving the large bowel (*).

Inverted diverticulum

The inverted diverticulum appears as a central fatty hyper-echogenicity surrounded by an echo-poor bowel wall on the ultrasonogram.³⁹ A “double target appearance” on ultrasonography in an inverted Meckel's diverticulum represents alternating concentric rings of echo-poor diverticular and surrounding small bowel walls with echogenic mesenteric fat separating the two.⁴⁰ The barium small bowel follow-through studies and enteroclysis appearance of an inverted Meckel's diverticulum include an elongated filling defect within the terminal ileum along the long axis of the small bowel usually with a club-like or bulbous tip,³⁹ thus resembling a pedunculated intestinal polyp⁴⁰ (Figure 9).

An inverted Meckel's diverticulum on CT appears as an intraluminal fat density lesion owing to the adjacent mesenteric fat, which gets dragged in along with the diverticulum during invagination surrounded by a soft-tissue collar due to the inverted diverticulum and the surrounding small bowel walls⁴¹ (Figure 9). The inverted Meckel's diverticulum, which can resemble intestinal lipoma on CT scanning, can be differentiated as a typical lipoma lacks a soft-tissue collar^{13,42} (Figure 10).

Figure 16. A 79-year-old male with acute right lower quadrant pain and tenderness. Contrast-enhanced coronal CT image revealed Meckel's diverticulitis with wall thickening and surrounding stranding (arrow). Suspicion for localized perforation was raised owing to the presence of extraluminal air foci, which was confirmed at surgery.

It is important to remember that an inverted Meckel's diverticulum can act as a lead point for an intussusception with the diverticulum detected at the centre of an ileo-ileal or ileo-colic intussusception on cross-sectional imaging.⁴³

Others

Other causes of intestinal obstruction, including the presence of bands and adhesions, are difficult to detect on imaging and are often diagnosed during surgery (Figure 11). Sometimes, diverticulitis with or without abscess formation leads to intestinal obstruction and is discussed in further detail later.

MECKEL'S DIVERTICULITIS

Meckel's diverticulitis most often occurs as a result of acid secretion from ectopic gastric mucosa within the Meckel's diverticulum, while other causes include obstruction of the diverticulum with a foreign body or a tumour.¹⁴ Ultrasound is usually the first modality for investigation of acute abdominal pain where an inflamed Meckel's diverticulum appears as a thick-walled, tubular, non-compressible, cystic lesion in the right iliac fossa or pelvis with a "gut signature" of the wall communicating with the small bowel, and surrounding mesenteric echogenic inflammatory change.⁴⁴ However, these features often simulate those of acute appendicitis, thus commonly leading to misdiagnosis which is reflected in a review of 10 patients with operative diagnosis of Meckel's diverticulitis of which six had a pre-operative ultrasound diagnosis of acute appendicitis.⁴⁵ An inflamed Meckel's diverticulum may also resemble an intestinal duplication cyst (Figure 12). However, the latter usually has a smooth internal wall as compared with the thicker, more irregular or crenated wall of the inflamed diverticulum.⁴⁴ Acute Meckel's diverticulitis on CT appears as a blind-ending, tubular, thick-walled structure with wall

Figure 17. (a) A 66-year-old male with intermittent abdominal pain had a CT scan which revealed an inflamed Meckel's diverticulum, which showed evidence of acute chronic pancreatitis within the heterotopic pancreatic tissue component within the Meckel's diverticulum on surgical pathology. On imaging, it is indistinguishable from acute Meckel's diverticulitis. (b) Histopathology confirmed a Meckel's diverticulum with pancreatic heterotopia (black arrow) and gastric heterotopia (white arrow). Mucosal erosion and purulent exudate is present on the left side of the image (haematoxylin and eosin, $\times 20$).

(a)

(b)

enhancement in the right iliac fossa or in a periumbilical location with soft-tissue stranding of the adjacent mesenteric fat (Figure 13). Fluid collections or a frank abscess may be seen in its vicinity (Figure 14). Identification of a normal appendix strengthens the confidence of diagnosis. Enteroliths may be identified within the inflamed diverticulum.⁴⁶ Chronic Meckel's diverticulitis may rarely result in mucocoele formation and may be a cause of chronic right lower quadrant pain (Figure 15).

Figure 18. A 65-old-year female with anorexia, weight loss and abdominal discomfort. The patient underwent CT, which showed (a, b) avid enhancement of a mass arising from a Meckel's diverticulum (arrow) and localized perforation as suggested by extraluminal gas foci. (c) Histopathology revealed a gastrointestinal tumour of the Meckel's diverticulum (arrow). The Meckel's diverticulum is lined by small intestinal mucosa. In the submucosa, there is a spindle cell neoplasm, composed of interlacing fascicles of elongated cells, with spindle, bland nuclei and prominent vasculature, consistent with a gastrointestinal stromal tumour. The tumour was CD117 and DOG1 positive (not shown) (hematoxylin and eosin, $\times 100$).

PERFORATION

Intestinal perforation is a serious and often life-threatening complication, usually secondary to diverticulitis, gangrene or peptic ulceration due to ectopic gastric mucosa. Free intraperitoneal gas and free fluid on imaging are diagnostic pointers to intestinal perforation (Figure 16). However, even in these cases, a perforated Meckel's diverticulum is usually found only during surgery. Kusumoto *et al*,³⁰ in a review of 776 Japanese patients, reported that perforation accounted for 10.8% (84 of 776) of complications associated with the Meckel's diverticulum.

Ectopic tissue and neoplasm

In a review of 806 asymptomatic adults who underwent Meckel's diverticulectomy for an unrelated indication, ectopic gastric

Table 2. Differential diagnosis of conditions simulating presentation to that of a Meckel's diverticulum

(1) Appendicitis
(2) Ileal/colonic diverticulitis
(3) Regional enteritis/colitis
(4) Calcification/tooth in dermoid
(5) Ureteric stone
(6) Enteric duplication cyst
(7) Intussusception due to lipoma or polyp (Peutz-Jeghers syndrome or inflammatory fibroid polyps)
(8) Angiodysplasia and bowel malignancy presenting with bleeding
(9) Pelvic inflammatory disorders in female

Table 3. Summary of key features to diagnose a Meckel's diverticulum on imaging

(A) Positive findings
(1) Antimesenteric location with communication with the bowel—differentiate from ileal diverticulitis
(2) More irregular mucosa—helps differentiate from an enteric duplication cyst which has more smooth mucosa and does not communicate with the bowel
(3) Persistent vitellointestinal artery arising from the superior mesenteric artery—may help to differentiate from other causes of lower gastrointestinal bleeding such as angiodysplasia, visceral aneurysm, arteriovenous malformation
(4) Inverted Meckel—central core of fat attenuation (pseudolipoma sign) surrounded by a collar of soft-tissue attenuation which is absent in cases of lipoma; “double target” sign on ultrasonography
(B) Negative findings
(1) Identification of normal appendix—rule out appendicitis
(2) Involvement of other regions of bowel—points to bowel pathology such as colitis/enteritis
(3) Associated dilatation of pelvicalyceal system—urinary stone
(4) Connection to the umbilicus—points towards vitellointestinal duct abnormality

mucosa was found in 8.3% of the cases,¹ whereas the pancreatic tissue and ectopic duodenal mucosa were seen in 2.7% and 0.6% of the cases, respectively. They also reported the presence of tumours in the Meckel's diverticulum, including carcinoid in 2.1%, lipoma in 0.2%, mucocele in 0.1%, leiomyoma in 0.1% and metastatic adenocarcinoma in 0.1% of the cases.¹

Histologically, the ectopic gastric mucosa may be identified by the presence of parietal, chief and mucus-secreting cells beneath a simple columnar epithelium, while the pancreatic tissue is identified by the presence of pancreatic acini, ducts and islet cells (Figure 17). Rare ectopic tissues found include duodenal, colonic and biliary tissues.

Scintigraphy is useful in the diagnosis of an inflamed Meckel's diverticulum in the presence of ectopic gastric mucosa. On a ^{99m}Tc-pertechnetate scan, this may be seen as a focus of high uptake representing the gastric mucosa surrounded by a zone of low uptake representing the inflammatory process in the walls and adjacent tissue.²⁶

The Meckel's diverticulum is a high-risk entity for development of cancer in the ileum.⁴⁷ Most diverticular tumours present with obstruction or haemorrhage. The incidence of Meckel's diverticular tumours increases with age with the mean age of diagnosis being 60 years.⁴⁷

Tumours arising in a Meckel's diverticulum are rare with carcinoid being the commonest. Carcinoids that occur in the Meckel's diverticulum have been described as small, solitary and usually asymptomatic mass lesions.⁴⁸ Gastrointestinal stromal tumour and adenocarcinoma are other rare tumours that are known to occur in the Meckel's diverticulum^{42,49,50} (Figure 18).

MIMICKERS OF MECKEL'S DIVERTICULUM-RELATED DISEASES

A diagnosis of symptomatic or complicated Meckel's diverticulum is difficult to confirm on the basis of history, physical examination, laboratory findings and imaging. A variety of conditions can mimic the Meckel's diverticulum both clinically and radiologically. Some of these conditions are mentioned in Table 2.⁴² The key imaging features pointing towards underlying Meckel's diverticulum pathology are summarized in Table 3.

MANAGEMENT

In spite of significant advancements in technology, there is still a lot of truth to the age-old saying credited to Charles W. Mayo that "Meckel's diverticulum is frequently suspected, often looked for and seldom found" in clinical practice.⁵¹ Surgical removal of a Meckel's diverticulum is the current management of choice in a patient symptomatic for a Meckel's diverticulum or for any of its complications. Laparoscopy is safe and is generally preferred over laparotomy because of the lower complication rates. But the controversy surrounding surgical removal of an

incidentally detected Meckel's diverticulum still continues today. In one study, the authors suggested four features associated with symptomatic diverticula—age <50 years, male sex, diverticulum length >2 cm and the presence of ectopic or abnormal features within the diverticulum—and recommended that the presence of any of these four criteria should warrant removal of the Meckel's diverticulum.¹

CONCLUSION

The Meckel's diverticulum is the most common anomaly of the gastrointestinal tract and can present with a wide range of clinical and imaging manifestations from benign indolent findings to acute life-threatening conditions. Knowledge of its salient anatomy, clinical features and imaging manifestations is crucial in making an appropriate radiological diagnosis. Thus, familiarity with imaging appearances allows an accurate diagnosis to initiate timely management of the Meckel's diverticulum and its varied guises when evaluating unexplained acute or intermittent abdominal pain, nausea and vomiting, rectal bleeding, peritonitis or obstruction in adult patients.

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