


Angiographic diagnosis of Meckel's diverticulum in an adult patient with negative scintigraphy

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ABSTRACT

A Meckel's diverticulum was diagnosed by mesenteric angiography in a 34 year-old patient who presented with hematochezia and dropping hemoglobin. The case demonstrates the challenges often encountered in workup of occult gastrointestinal (GI) bleeding, and shows that angiographic diagnosis of Meckel's diverticulum is possible, even in the absence of angiographic evidence of active extravasation. Our patient had a previous non-diagnostic workup including upper and lower endoscopy, videocapsulography, and Technetium-99m pertechnetate (Tc-99m) scintigraphy. Visceral angiogram demonstrated the presence of a persistent vitelline artery, diagnostic of Meckel's diverticulum. While no active extravasation was seen at the time of the angiogram, operative specimen demonstrated a Meckel's diverticulum with ectopic gastric mucosa and intraluminal hemorrhage.

CASE REPORT

CASE REPORT

Clinical history

A 34 year old previously healthy male was admitted to the hospital with a 4 day history of worsening hematochezia. Esophagogastroduodenoscopy performed the evening of admission was normal. Subsequent colonoscopy including intubation through the ileocecal valve to the terminal ileum demonstrated no morphologic or mucosal abnormality. There was no evidence of active bleeding, although small blood clots were present throughout the proximal colon. Hemoglobin on admission was low at 12.9 g/dL (Normal is 13.5 - 17.5 g/dL) and dropped to 9.3 g/dL over the next several days. Videocapsulography demonstrated active bleeding in the small bowel without definite mucosal abnormality or diverticulum identified. Tc99-m scintigraphy was performed which demonstrated no increased activity in the right lower quadrant or elsewhere (negative scan). Visceral angiogram was then

performed to evaluate for the presence of a bowel abnormality which could be a cause of bleeding.

Imaging Findings

The initial imaging study performed was Tc99-m scintigraphy, the Meckel's scan. This demonstrated no evidence of abnormal uptake in the expected region of a Meckel's diverticulum, suggesting that there was no ectopic gastric mucosa present. Visualized on the images was normal expected uptake in the stomach with normal excretion into the kidneys and urinary bladder (Figure 1).

A mesenteric angiogram was then performed as part of further workup of the patient's occult bleeding. Selective superior mesentery artery digital subtraction angiogram demonstrated an artery in the lower abdomen / upper pelvis just right of midline which arose from the distal ileal branch of the superior mesenteric artery and which extended beyond the

course of the other jejunal arteries (Figures 2a, 2b). It did not follow the normal branching pattern and arcades of the jejunal arteries and terminated in a blind ending stump consistent with a persistent vitelline artery. No active extravasation was seen at the time of the examination.

A Computed Tomography (CT) scan previously obtained and evaluated retrospectively demonstrated an air-filled stump-like structure in the right / midline lower pelvis which arises from the ileum, representing the Meckel's diverticulum (Figures 3a and 3b, coronal and axial contrast-enhanced CT scans, respectively). The examination was otherwise unremarkable. The patient went on to laparoscopy which confirmed the presence of a Meckel's diverticulum which was resected. Sectioning of the surgical specimen also demonstrated characteristic features of a Meckel's diverticulum. A low power image demonstrated the Meckel's diverticulum to be a true diverticulum (containing all layers of the bowel wall) arising from the distal ileum (Figure 4a). Gastric type mucosa was seen to line the diverticulum, best appreciated on the high power images (Figure 4b). Atrophic and ulcerated appearance of adjacent small bowel (Figure 4a, 4c), consistent with acid secretion from ectopic gastric mucosa within the Meckel's diverticulum. This may have been secondary to the acid production from the ectopic gastric mucosa of the Meckel's diverticulum affecting the adjacent small bowel mucosa. Some intraluminal blood was also seen within the distal aspect of the diverticulum.

Management

The presence of a Meckel's diverticulum was confirmed at laparoscopic surgery. An 8 cm region of small bowel including the diverticulum was resected. The diverticulum itself measured 5.0 cm in length x 1.0 cm in average outer diameter.

Followup

The patient's hemoglobin stabilized following surgery.

DISCUSSION

Etiology & Demographics:

Meckel's diverticulum occurs in 2-3% of the population, and is the most common congenital anomaly of the GI tract [1]. It results from improper closure and absorption of the omphalomesenteric duct. Complications occur in 20-30% of patients, and include peptic ulceration of the mucosa with hemorrhage, intussusception, diverticulitis, and small bowel obstruction [2]. 60% of patients come to medical attention before the age of 10 years, with the remainder of cases presenting in adolescence and adulthood [1]. In children less than 3 years old, Meckel's diverticulum is responsible for more than 50% of all cases of lower GI bleeding [3]. In symptomatic patients, heterotopic gastric or pancreatic mucosa is frequently found within the diverticulum.

Clinical & Imaging Findings:

In the pediatric patient, the radioisotope Meckel's scan is the gold standard for diagnosis of Meckel's diverticulum, based on its strong performance, with a sensitivity of 85%, specificity of 95%, and overall accuracy of 90% [1,4,5]. However, in adult patients the diagnostic accuracy of the Meckel's scan is reported to be much lower [1,3,4,5], and multiple modalities are often employed before a correct diagnosis of Meckel's diverticulum is reached.

As in our case, the workup of occult bleeding may begin with upper endoscopy which would not make the diagnosis due to the distal ileal location of the Meckel's diverticulum. Colonoscopy with intubation of the ileocecal valve could possibly detect a Meckel's diverticulum, but did not in our case, possibly due to the diverticulum being past the furthest reach of the endoscope. Videocapsulography is another modality that could be employed in the workup of occult GI bleeding, which in our case did demonstrate evidence of small bowel bleeding but without a definite source identified.

As mentioned above, the radioisotope Meckel's scan is another modality that may be used if the diagnosis of bleeding Meckel's diverticulum is suspected, however performance in adults is significantly worse than in pediatric patients. The scan depends on the uptake of 99m Technetium pertechnetate by ectopic gastric mucosa within the diverticulum. In a literature review performed by Schwartz and Lewis, the results of 20 case reports and four series containing 184 adult patients who underwent Meckel's scans were reviewed. Ultimately 35 adult cases with corroborating surgical findings qualified for the study. For this small group of adult patients, results showed that Meckel's scan has a 63% sensitivity and 9% specificity, as well as an accuracy of 46%. The positive predictive value of Meckel's scanning in adults in this study was 60% [3].

False negative Meckel's scans in adults (or in children) may be due to poor technique, tracer pooling in the stomach or bladder, or a paucity of ectopic gastric mucosa. The most common reason for failure to detect a Meckel's diverticulum is the absence or paucity of ectopic gastric mucosa [3]. Among symptomatic Meckel's diverticula, 60-70% are found to contain ectopic gastric mucosa, and nearly 90% of bleeding Meckel's diverticula contain ectopic gastric tissue [3]. It is also worth noting that the complicated Meckel's diverticula that contain ectopic pancreatic, duodenal, jejunal, or colonic mucosa instead of ectopic gastric mucosa would also not be detected on the Meckel's scan. Modifications that may be used to improve the diagnostic yield are premedication with histamine receptor antagonist with or without pentagastrin, nasogastric suctioning, and bladder lavage [5]. In our case, Tagamet (histamine receptor antagonist) only was used as part of the Meckel's scan.

Conventional mesenteric angiography is another technique that may be used in the workup of occult GI bleeding, and lead to a diagnosis a Meckel's diverticulum, which is often unsuspected. It was the modality which led to

the diagnosis in our case. The arterial blood supply to the Meckel's diverticulum is via the vitelline artery, which is a remnant of the embryologic omphalomesenteric system [1]. The vitelline artery is an elongated vessel with few or no branches which usually arises from a distal ileal branch of the superior mesenteric artery [1, 2]. Visualization of this artery on arteriography is diagnostic for Meckel's diverticulum. In one case reported by Okazaki et al [6], methylene blue was injected intraoperatively into the vitelline artery through a previously placed angiographic catheter. This demonstrated staining only of the vitelline artery and Meckel's diverticulum but not the mesentery or surrounding ileum.

It is also characteristic to see a group of dilated tortuous vessels at the distal portion of the vitelline artery without branches [6]. Superselective vitelline arteriography facilitates the visualization of these distal most findings. Other angiographic evidence for Meckel's diverticulum includes a vascular blush (which may relate to the presence of ectopic gastric mucosa) or active hemorrhage, as evidenced by extravasation of contrast into the bowel lumen [1,7]. It should be emphasized that angiography can detect Meckel's diverticulum even in the absence of acute bleeding via visualization of the vitelline artery.

Few authors have reported the importance of conventional angiographic findings such as demonstration of the vitelline artery for the diagnosis of Meckel's diverticulum. Literature on the subject is limited to individual cases and case series [6-10], and to our knowledge no definite statistical performance data has yet been reported.

Radionuclide bleeding scan such as the Tc99-m labeled Red Blood Cell (RBC) scan represents another approach to diagnosing occult GI bleeding, and although this test is more sensitive for detection of extravasation as compared to conventional angiography (approximately 0.1 cc/min rate of bleeding for radionuclide scan vs. approximately 1 cc/min for conventional angiography), it is not specific as to the etiology as there are multiple bleeding entities that can occur in the expected location of a Meckel's diverticulum.

Treatment & Prognosis:

Symptomatic Meckel's diverticula should be surgically excised, and laparoscopic resection has been shown to be safe, cost-effective, and less invasive than traditional laparotomy [1]. Management of asymptomatic, incidentally discovered Meckel's diverticula is somewhat controversial, but most authors do not recommend prophylactic surgical excision [1]. Lifetime complication rate for laparoscopic resection of Meckel's diverticulum is reported to be low, approximately 4% in patients up to 20 years of age and 2% in patients up to 40 years of age [1]. The major possible complications include anastomotic leak, partial bowel obstruction secondary to ileal narrowing, adhesions leading to bowel obstruction, and persistent GI bleeding [11].

Differential Diagnosis:

The differential diagnosis for causes of GI blood loss in adults originating from the region of the distal small bowel includes vascular ectasia, small bowel carcinoid, Meckel's diverticulum, Crohn's disease, and polyposis syndromes [5].

Vascular ectasia, also known as angiodysplasia, has a characteristic imaging appearance on conventional angiogram, demonstrating a cluster or tangle of small arteries seen in arterial phase, with early filling and delayed emptying of dilated veins. On CT Enterography, vascular ectasia may present as punctate or discoid areas of enhancement <5 mm, or bulbous swelling of the intramural vessels in the wall of the small bowel (especially jejunum).

Small bowel carcinoid on CT may present as a polypoid or intramural mass which may demonstrate arterial hyperenhancement. Carcinoid often also presents on CT as mesenteric mass with calcifications and associated desmoplastic reaction. On barium small bowel follow through, carcinoid may be seen as polypoid intramural or intraluminal mass with focal ulceration, evidenced as pooling of contrast if ulcer is dependent. On an Indium-111 octreotide nuclear medicine scan, carcinoid is evidenced with focal radioisotope accumulation in the lesion.

As described above in greater detail, Meckel's diverticulum on conventional angiogram is evidenced by visualization of the vitelline artery with possible tortuous vessels at its distal end. A vascular blush or active extravasation may also be associated. On CT, a Meckel's diverticulum may be seen as a blind-ending pouch with connection to the ileum, which may contain fluid, air and/or particulate matter. Radionuclide bleeding scan such as the Tc99-m labeled RBC scan demonstrates a Meckel's diverticulum as an accumulation of radioisotope in the right lower quadrant. On a barium small bowel follow-through, one may rarely visualize a Meckel's diverticulum as an outpouching on the antimesenteric side of the ileum, filling with contrast.

Crohn's disease has a characteristic appearance on barium small bowel follow through where it may demonstrate a "target" or "bull's eye" appearance of shallow aphthous ulcerations in early disease. In late disease one may see "cobblestoning" or the "string sign" -- luminal narrowing and ileal stricture. Sinus tracts, fissures, and fistulas may also be visualized on small bowel follow through. On CT, with Crohn's disease one may see the "fat halo sign" -- fatty infiltration of the submucosa in the involved region of bowel. Other CT signs include the "comb sign" (hypervascular mesentery resembling a comb), and skip lesions of asymmetric bowel wall enhancement / thickening. Strictures, fistulas, and abscesses may also be seen with CT.

Polyposis syndromes are also on the differential for occult causes of GI bleeding arising from the region of the distal small bowel, and may be evidenced on barium small bowel follow through or on CT as intraluminal filling defects / masses involving the small bowel.

TEACHING POINT

For patients with occult GI bleeding and negative endoscopic and scintigraphic studies, conventional angiography can make the diagnosis of Meckel's diverticulum, even in the absence of active hemorrhage. Visualization of the vitelline artery, an abnormal elongated artery originating from the distal ileal branch of the superior mesenteric artery, is diagnostic for Meckel's diverticulum.

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FIGURES

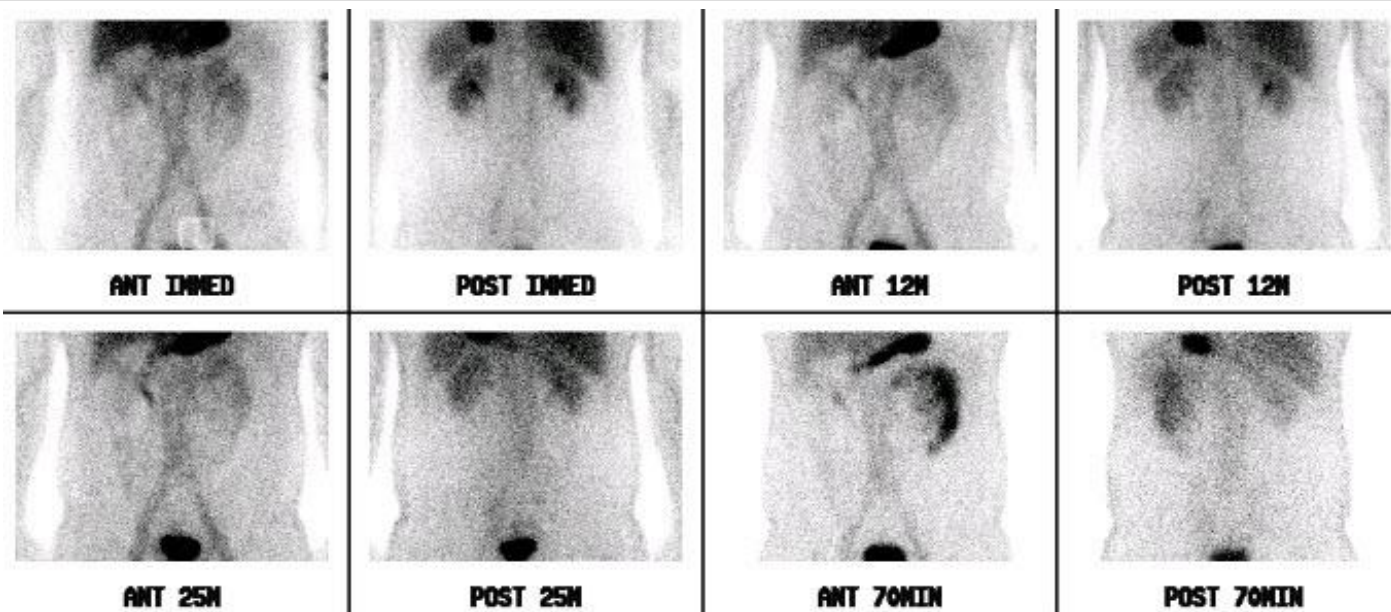


Figure 1: Tc99-m scintigraphy (Meckel's scan) in a 34 year old male with occult GI bleeding.
FINDINGS: The study shows normal uptake in the stomach. There is normal excretion into the kidneys and urinary bladder. No evidence of abnormal uptake in the expected region of a Meckel's diverticulum to suggest ectopic gastric mucosa.
TECHNIQUE: 5 mCi of Tc-99m was injected intravenously and dynamic and static images were obtained for 30 minutes. Delayed images at 70 minutes were also obtained.

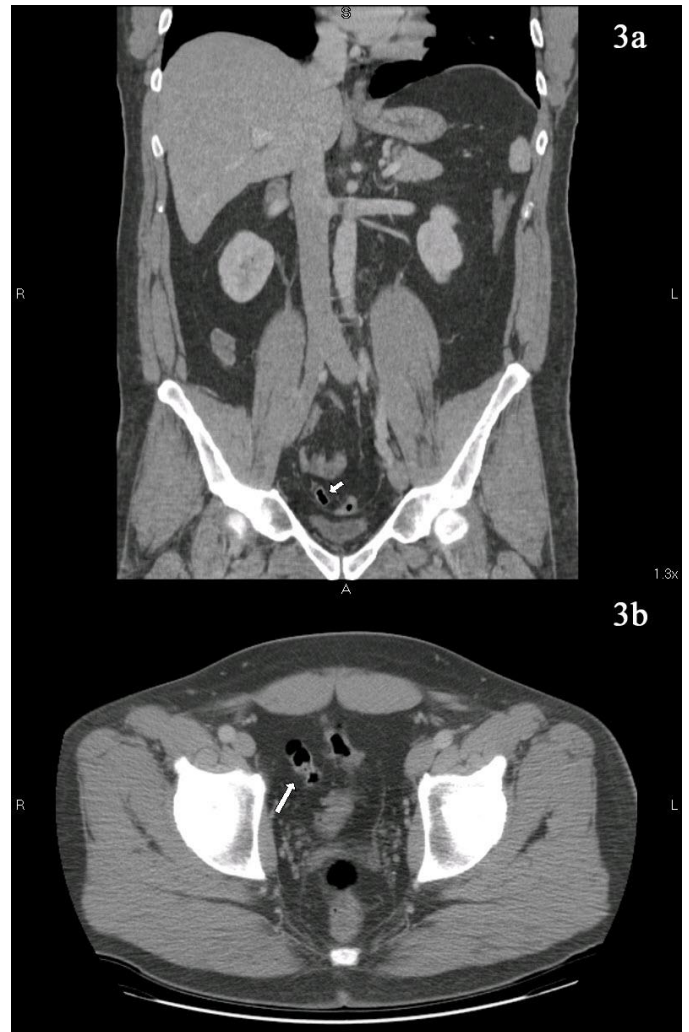
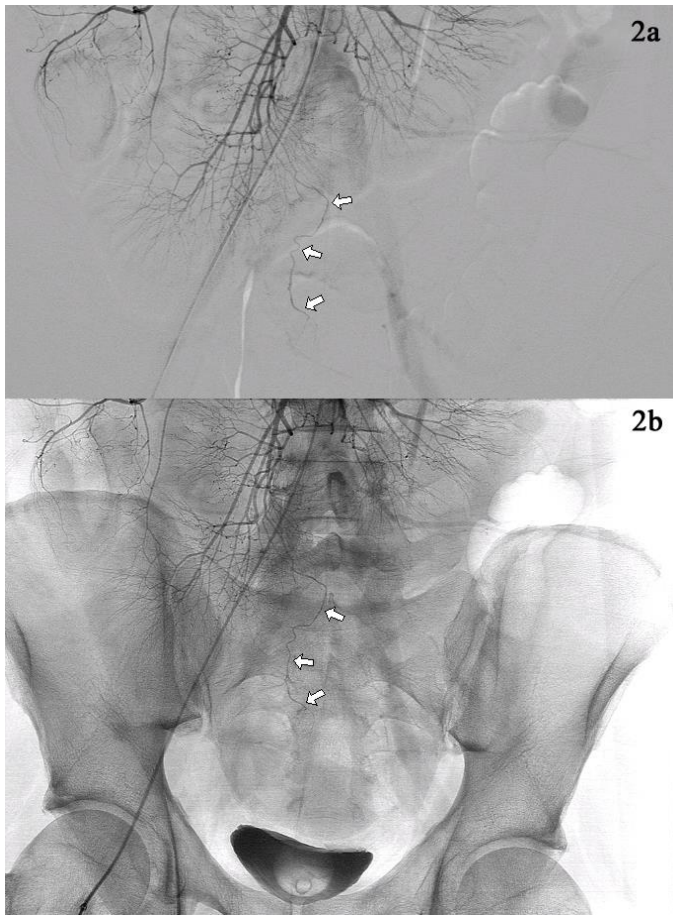


Figure 2: Digital subtraction angiography in a 34 year old male with occult GI bleeding.

FINDINGS: Images demonstrate the vitelline artery which arises from a distal ileal branch of the superior mesenteric artery. This artery extends beyond the course of the other jejunal arteries and feeds a blind ending loop of bowel which is the Meckel's diverticulum. This is demonstrated on subtracted (2a) and unsubtracted (2b) images. It does not follow the normal branching pattern and arcades of the jejunal arteries and terminates in a blind ending stump consistent with a persistent vitelline artery. No active extravasation was seen at the time of the examination.

TECHNIQUE: Selective superior mesenteric artery digital subtraction angiogram was performed in the usual manner.

Figure 3: CT scan in a 34 year old male with occult GI bleeding.

FINDINGS: Coronal (Figure 3a) and axial (Figure 3b) contrast enhanced CT images of the abdomen and pelvis demonstrates a blind-ending stump-like structure in the pelvis, right of midline, which is separate from the appendix and which originates from the distal ileum. This is consistent with a Meckel's diverticulum.

TECHNIQUE: Axial CT images obtained with intravenous contrast administered (94 cc of Omnipaque) and no oral contrast. Scanner was GE 64 slice Lightspeed, settings were 140 kV and 359 mA, TF: 13.5 / Pitch 1.35, FOV 40 cm, with 5 mm slices displayed. 1.3 mm coronal reformatted images were also produced.

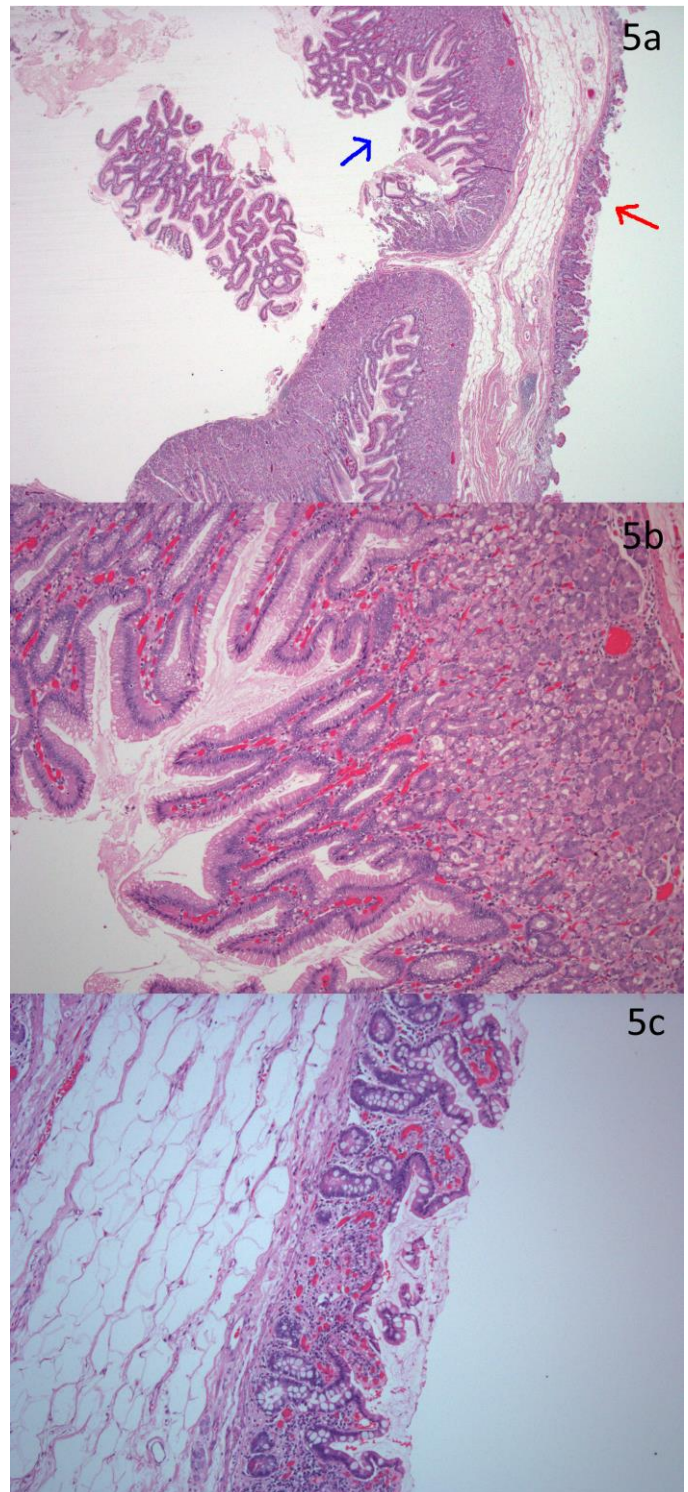
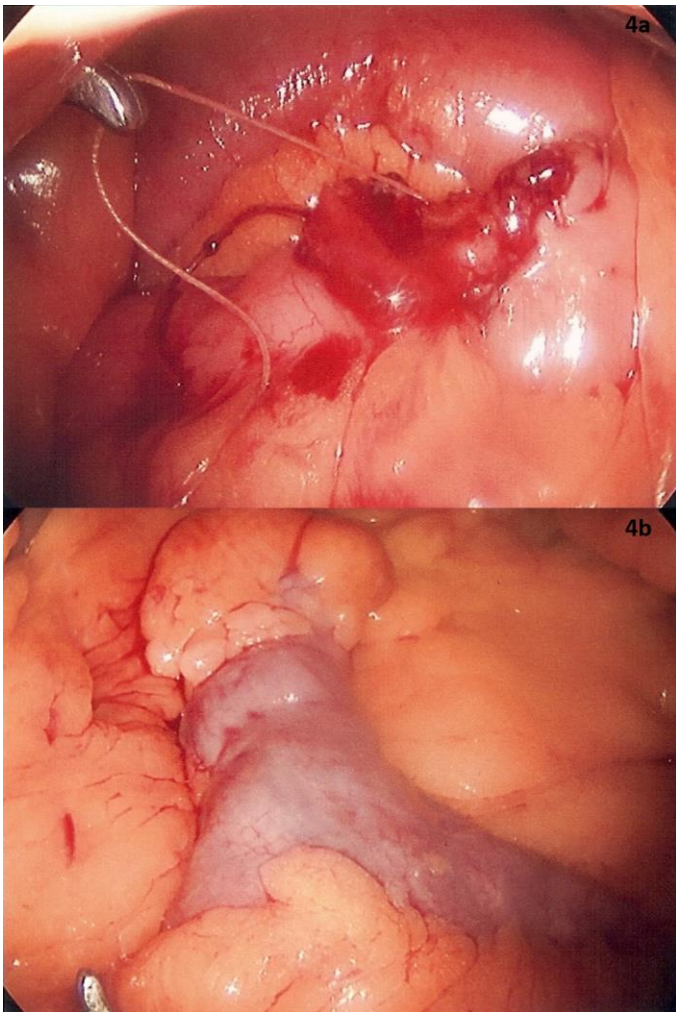


Figure 4: Images obtained during laparoscopic resection of Meckel's diverticulum in a 34 year old male.

FINDINGS: Intraoperative digital images taken during laparoscopic resection of Meckel's diverticulum. Figure 4a demonstrates ligation of the base of the diverticulum with the diverticulum pointing towards the bottom left of the image. Figure 4b demonstrates small bowel traversing the bottom of the image with the diverticulum projecting superiorly.

TECHNIQUE: Digital images acquired during laparoscopic surgery.

Figure 5 (right): 34 year old male with occult GI bleeding.

FINDINGS: Pathologic examination of surgical specimen obtained at laparoscopy. Hematoxylin & eosin (H&E) stain of sections shown. Figure 5a is a low power magnification view which demonstrates globally that the finding represents a true diverticulum containing all walls of bowel. This is seen to arise from the ileum. Ectopic gastric type mucosa is noted lining the diverticulum (Figure 5a), consistent with a Meckel's diverticulum. Also noted on this image is atrophic and ulcerated appearing adjacent small bowel mucosa (red arrow). Figure 5b is a high power magnification image further demonstrating the typical appearance of ectopic gastric-type mucosa. Figure 5c is a high power magnification image further demonstrating the atrophic and partially ulcerated small bowel mucosa of the adjacent ileum.

TECHNIQUE: The gross surgical specimen was sectioned and stained with Hematoxylin and eosin. Low and high power magnification images were obtained.

Etiology	Remnant of omphalomesenteric duct
Prevalence	2-3% of the population
Gender ratio	Symptomatic patients M:F ratio approximately 2-3:1
Age predilection	60% of symptomatic patients present before age 10 years of age, with the remainder coming to medical attention in adolescence or adulthood
Treatment	Surgical excision of symptomatic Meckel's diverticula is recommended
Imaging findings	<p><u>Conventional angiography:</u> Visualized vitelline artery (abnormal elongated artery originating from the distal ileal artery with few or no branches), tortuous vessels at the distal end of a visualized vitelline artery without branches, vascular blush, active extravasation;</p> <p><u>Small bowel follow through:</u> Rarely demonstrates an outpouching on the antimesenteric side of the ileum, filling with contrast;</p> <p><u>CT:</u> Blind-ending pouch with connection to the ileum, may contain fluid, air, or particulate matter;</p> <p><u>Tc99m exam:</u> Accumulation of radioisotope in the right lower quadrant</p>

Table 1: Summary table for Meckel's diverticulum.

Meckel's diverticulum Rule of 2's
~2% of population
Located within 2 feet from the ileocecal valve
Length of 2 inches
Usually symptomatic before age 2
2 types of common ectopic mucosa (gastric and pancreatic)
Approximately 2:1 M:F ratio for symptomatic lesions

Table 2: Meckel's diverticulum Rule of 2's.

Most common causes of occult GI bleeding arising from the region of the distal small bowel	Imaging finding			
	Barium small bowel follow through	CT	Conventional angiogram	Nuclear medicine studies
Crohn's disease	"Target" or "bull's eye" appearance of shallow aphthous ulcerations in early disease, "cobblestoning", "String sign" -- luminal narrowing and ileal stricture in late disease, sinus tracts, fissures, fistulas	"Fat halo sign" (fatty infiltration of submucosa), "comb sign" (hypervascular mesentery resembling a "comb"), skip lesions of asymmetric bowel wall enhancement / thickening, strictures / fistulas, abscesses	No characteristic imaging findings for this modality	No characteristic imaging findings for this modality
Meckel's diverticulum	Rarely demonstrates an outpouching on the antimesenteric side of the ileum, filling with contrast	Blind-ending pouch with connection to the ileum, may contain fluid, air, and/or particulate matter	Visualized vitelline artery (elongated artery arising from the distal ileal artery with few or no branches), tortuous vessels at the distal end of a visualized vitelline artery without branches, vascular blush, active extravasation	Tc99m exam -- accumulation of radioisotope in the right lower quadrant
Polyposis syndromes	Filling defects (polyps)	Polypoid luminal mass(es).	No characteristic imaging findings for this modality	No characteristic imaging findings for this modality
Small bowel carcinoid	Polypoid filling defect (intraluminal mass) or intramural mass with focal ulceration (pooling contrast)	Polypoid or intramural mass, may demonstrate arterial hyperenhancement; other appearance is mesenteric mass with calcifications / desmoplastic reaction	No characteristic imaging findings for this modality	Indium-111 octreotide -- focal radioisotope accumulation in lesion
Vascular ectasia (angiodysplasia)	No characteristic imaging findings for this modality	CT Enterography: punctate or discoid areas of enhancement < 5 mm; or bulbous swelling of the intramural vessels in the wall of the small bowel, especially jejunum	Cluster or tangle of small arteries seen in arterial phase, with early filling and delayed emptying of dilated veins	No characteristic imaging findings for this modality

Table 3: Differential diagnosis table for causes of chronic occult GI blood loss originating from the small bowel includes Crohn's disease, Meckel's diverticulum, and small bowel tumors (polyposis syndromes and carcinoid).

ABBREVIATIONS

CT = Computed tomography
 DSA = Digital subtraction angiogram
 GI = Gastrointestinal
 H&E = Hematoxylin & eosin
 RBC = Red blood cell
 Tc-99m = Technetium-99m pertechnetate

KEYWORDS

Meckel diverticulum; Meckel's diverticulum; omphalomesenteric duct; vitelline artery; vitellointestinal artery; angiography; mesenteric angiogram; Technetium 99m pertechnetate; scintigraphy; Meckel's scan; ileum; hemorrhage

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