Imaging Workup of Acute and Occult Lower Gastrointestinal Bleeding

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KEYWORDS

• Gastrointestinal • Bleed • Acute • Occult • Lower • Radiology • Angiography • Enterography

KEY POINTS

- Lower gastrointestinal bleeding is defined as occurring distal to the ligament of Treitz and presents as hematochezia, melena, or with anemia and positive fecal occult blood test.
- Imaging tests in the workup of acute lower gastrointestinal bleeding include computed tomography (CT) angiography, nuclear medicine scintigraphy, and conventional catheter angiography.
- Imaging tests in the workup of occult lower gastrointestinal bleeding include CT enterography and nuclear medicine Meckel scan.

INTRODUCTION

Lower gastrointestinal (GI) bleeding is a frequent cause for hospital admissions with an annual incidence of approximately 20 to 27 cases per 100,000 persons in the United States.[1] Morbidity and mortality vary according to the underlying cause of the GI bleed, with reported mortality rates of 2% to 20% for lower GI bleeding and as high as 40% for hemodynamically unstable patients.[2]

Lower GI bleeding is defined as bleeding that occurs distal to the ligament of Treitz, with upper GI bleeding occurring proximally. Clinical presentations vary based on the source of the bleed and cause; however, acute lower GI bleeds typically present with hematochezia, noting that secondary to the cathartic effects of blood, a brisk upper GI bleed may present in a similar manner.[3] Causes of lower GI bleeding may be anatomic, such as diverticulosis (33.5%); vascular, such as hemorrhoids (22.5%), angioectasia, or ischemia; neoplastic (12.7%); inflammatory as with inflammatory bowel disease; or infectious.[4] If the workup of the large bowel is negative, then patients are suspected of having a small bowel bleed.

There are several classification schemes used to describe lower GI bleeding related to the duration and severity of the bleed as well as the results of upper and lower endoscopy/imaging. When correlating with the amount of bleeding, lower GI bleeds can be categorized as massive, moderate, or occult. Massive bleeding is defined by the passage of profuse hematochezia with hemodynamic instability. Moderate bleeding reflects hematochezia in hemodynamically stable patients. Occult bleeding refers to the presence of a positive fecal-occult blood test or iron deficiency anemia without another identifiable source and without frank hematochezia.[5] Obscure bleeding refers to patients who have recurrent bleeding after negative endoscopic evaluation and advanced

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radiologic assessment of the small bowel and can be either acute or occult.[2]

WORKUP RECOMMENDATIONS FOR ACUTE LOWER GASTROINTESTINAL BLEEDING

The workup of patients presenting with acute lower GI bleeding involves resuscitation, localizing the site of bleeding, and intervention to stop the source of the bleeding, as appropriate. The main tools of the workup include direct visualization with proctoscopy/colonoscopy and imaging with computed tomography angiography (CTA), nuclear scintigraphy, or angiography. Although surgery was once a necessity for patients with ongoing lower GI bleed, advanced techniques in endoscopy and angiography have improved detection and treatment, with surgery now reserved for cases in which more conservative management has failed.[6]

The clinical presentation of patients during the triaging process as well as the services available at a hospital dictate the order and priority in which tests are used in the workup of an active lower GI bleed.[1] Any patient with hemodynamic instability must first be resuscitated. If endoscopy is available, it is generally the first test preformed; however, there are significant limitations. The colon must first be prepped in order to clear enteric contents and blood, which could obscure the source of bleeding. Even rapid bowel preparations take at least several hours, which may not be possible in patients with ongoing bleeding. Additionally, in some series, colonoscopy detects the source of bleeding in only 13% to 40%.[2] In cases whereby emergent endoscopy is not indicated, patients will typically be sent for an imaging study, such as CTA, nuclear scintigraphy, or catheter angiography, depending on the local availability and clinical expertise. In patients who are clinically stable at presentation, more conservative management is generally indicated, with many patients being worked up with elective endoscopy.[7]

COMPUTED TOMOGRAPHY ANGIOGRAPHY

CTA has excellent sensitivity and specificity for the identification and localization of acute GI bleeds. A meta-analysis by Garcia-Blazquez and colleagues[8] reported a sensitivity of 85.2% and specificity of 92.1% for the detection of acute, active GI bleeds. Yoon and colleagues[9] used arterial phase CTA in 26 patients with massive GI bleeding and reported an overall accuracy of 89%. CTA can detect bleeding rates as low as 0.3 mL/s in in vitro studies.[10] Advantages of CTA include that it is widely available, noninvasive, provides excellent localization, and additionally can provide the cause of the GI bleed. CTA can diagnose diverticular disease, vascular abnormalities (such as angioectasia), tumors, colitis/enteritis, bowel ischemia, and postoperative/iatrogenic causes. Additionally, the arterial phase imaging demonstrates vascular anatomy and any vascular variants. This information can be observed on the source images and reformatted using maximum intensity projections (MIPs) to provide valuable information for the subsequent mesenteric angiography.[2]

Disadvantages of CTA include radiation dose, as it is usually done in 3 phases; however, improvements in CT dose reduction have made this less of an issue than in the past.[11] CTA also requires an intravenous (IV) contrast dose, which is relatively contraindicated in patients with acute renal failure. As with all imaging tests, patients must be actively bleeding at the time of the scan.

CTA for acute GI bleeding is typically preformed as a triphasic study. Enteric contrast is not given as is critical to acquire the examination as quickly as possible in patients with active hemorrhage. A precontrast examination is first acquired using low radiation dose settings. The purpose of the precontrast portion of the examination is to identify any hyperdense enteric contents, such as pills, residual oral contrast, hyperdense stool, and so forth, so they are not confused for contrast extravasation on later phases. Next, at least 100 mL noniodinated contrast is administered intravenously by a power injector at a rate of 4 to 5 mL/s. Automated bolus technique is preferred, with arterial phase obtained 8 to 10 seconds after the attenuation coefficient in the proximal abdominal aorta reaches a threshold of 150 Hounsfield units (HU). Portal venous phase is then acquired approximately 50 seconds after start of the arterial phase.[12]

Computed Tomography Angiography: Findings

Active GI bleeding is manifest by contrast extravasation into the bowel lumen on CTA. The contrast extravasation appears as a blush on arterial phase imaging, which propagates further down the bowel on the portal venous phase due to peristalsis[11] (**Figs. 1** and **2**). If bleeding is arterial, a jet of contrast may be seen. Lower intensity bleeds are often better seen on the portal venous phase, as more time has been allowed for the contrast to accumulate.[13] It is important to look at the precontrast and contrast-enhanced images side by side, as inherently hyperdense intraluminal

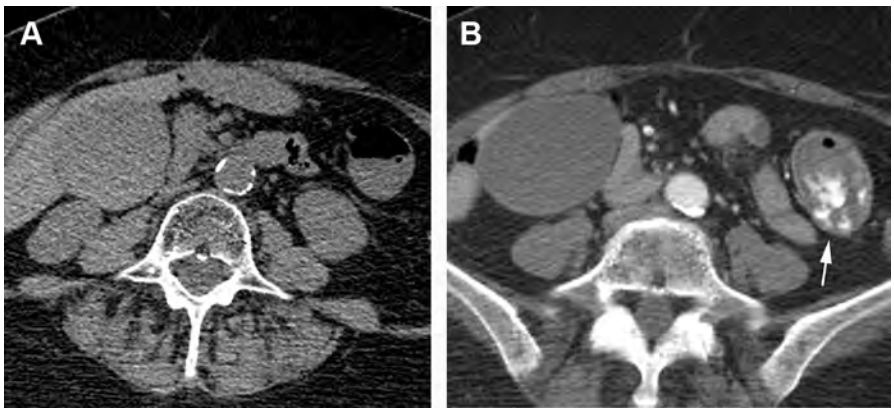

Fig. 1. CTA of active GI bleed. A 76-year-old woman with history of diverticulosis and recurrent lower GI bleeds presents with hematochezia. Axial precontrast (*A*) and arterial phase (*B*) images from a CTA examination demonstrate contrast extravasation into bowel lumen in the descending colon (*white arrow*), consistent with active GI bleeding. Precontrast images are critical to ensure that contrast extravasation is not confused for hyperdense enteric contents. Subsequent colonoscopy revealed a diverticular bleed.

contents can mimic contrast extravasation. In some cases, active bleeding with contrast extravasation is not identified, but there is visualization of a clot at the site of bleeding. The clot should be hyperdense compared with the enteric contents on precontrast images. HU should measure approximately 30 to 45 HU for unclotted blood and 40 to 70 HU for clotted blood.[13] The area of highest HU should be at the origin of the bleed, which is called the sentinel clot.[14]

NUCLEAR SCINTIGRAPHY

Nuclear scintigraphy is most commonly performed combining the patients' own red blood cells tagged with a radiotracer technetium 99-m (Tc-99m). Autologous red blood cells are tagged in vitro with 20 to 30 mCi Tc-99m and then administered as an IV bolus. Patients are placed supine under the gamma camera and scanned from the xiphoid process through the pubic symphysis. Initial dynamic flow images are obtained at 3 seconds each, for 1 minute, to show flow in the abdominal viscera. This imaging is followed by static images every minute continued for 90 minutes. If patients have an episode of rebleeding, additional static images can then be obtained up to 24 hours after the initial injection. Although patients can be reimaged up to 24 hours after injection without rebleeding, it is often not useful, as

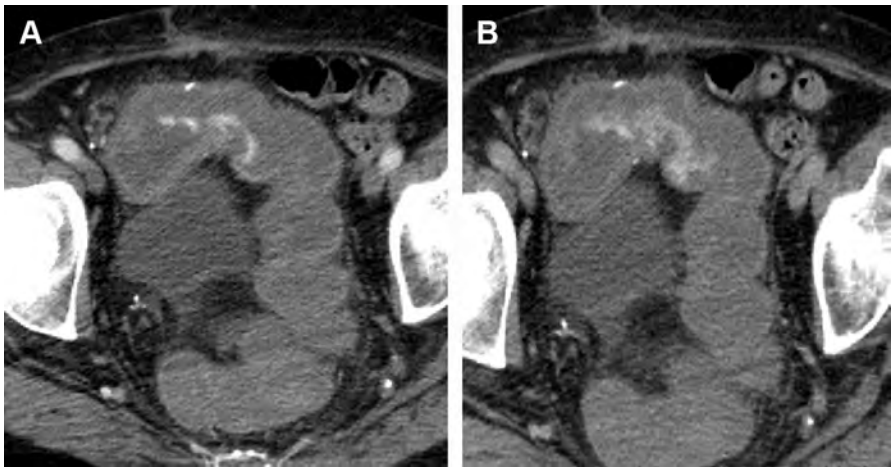

Fig. 2. CTA of active GI bleed. An 87-year-old woman with history of hemicolectomy due to colon cancer presents with hematochezia. Axial arterial phase (*A*) and portal venous phase (*B*) images demonstrate contrast extravasation into the sigmoid colon adjacent to the anastomosis. Note that there is increasing extravasation on delayed images. A subsequent sigmoidoscopy revealed ischemic colitis at the surgical anastomosis.

peristalsis can provide false localization of the site of the bleed. When positive findings are seen, the examination can be discontinued once the clinician is confident of the origin of the bleed.[15]

Nuclear scintigraphy is the most sensitive test to image GI bleeding, as it can detect bleeding rates as low as 0.05 mL/min.[16] Other advantages include that the test is noninvasive and that no patient preparation is needed other than obtaining a blood sample.

The main disadvantage of nuclear scintigraphy is that it generally relies on 2-dimensiona (2D) planar imaging, and localization of the bleed can be a significant limited factor. For example, a redundant transverse colonic loop in the pelvis could be confused for a small bowel loop or more distal colonic bleed. Also, because of intermittent bleeding and noncontinuous imaging, the radiolabeled blood may have already moved downstream from the bleeding site at the time the image is acquired, thus, giving false localization of the origin of the bleed. Single-photon emission CT/CT fusion imaging has shown promise to improve localization by pairing a CT scan with 3-dimensional radiotracer imaging; however, this is not widely available.[17]

In many institutions, nuclear scintigraphy is performed before angiography, because of the higher sensitivity for detection of active bleeding, with a negative examination potentially eliminating the need for the more invasive angiographic procedure.[18] When the study is positive, studies have shown improved bleed detection in subsequent angiography.[19] However, although nuclear scintigraphy is the most sensitive imaging study to detect GI bleeds, CT is far more widely available, with faster acquisition, and improved localization, making it the test of choice at many institutions.

Nuclear Scintigraphy: Findings

A positive nuclear bleeding study will show focal increased activity and radiotracer uptake at the site of the bleeding (**Fig. 3**). Over time, with bowel peristalsis, the radiolabeled blood will continue to move along the GI tract, which aids in localization. Observing the course the blood takes over time enables the clinician to determine if the blood is following a large or small bowel pathway. Imaging should be continued until the clinician is confident that they can identify the source of the bleed.

MESENTERIC ANGIOGRAPHY

Mesenteric angiography is typically reserved for treatment of bleeding that was first diagnosed on a previous CTA or nuclear scintigraphy. Selective mesenteric angiography can detect bleeding at a rate of 0.5 mL/min, an approximately 10-fold higher rate than that detected by nuclear scintigraphy.[20] The main advantage of angiography is that it can be used to deliver treatment if a focus of active bleeding is identified, such as embolization or vasopressin drip. Angiography also does not require bowel preparation and provides excellent localization of the site of bleeding.

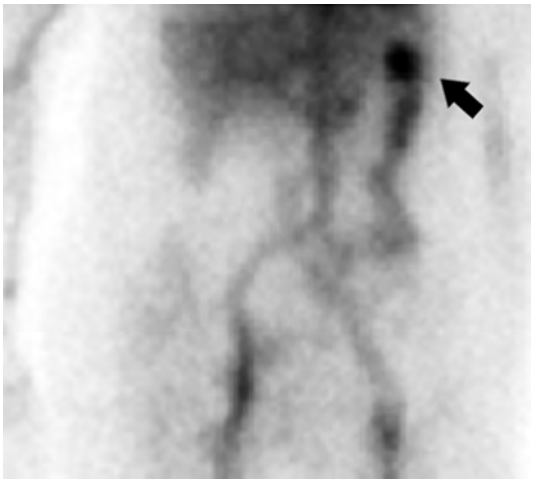

Fig. 3. Nuclear scintigraphy of active GI bleed. A 76-year-old woman with history of diverticulosis and recurrent lower GI bleeds presents with hematochezia (same patient as in **Fig. 1**A, B). A 2D planar image demonstrates increased radiotracer uptake in the region of the splenic flexure of the colon (*black arrow*), consistent with active GI bleeding.

There are significant disadvantages of using angiography as a first-line diagnostic method in GI bleeding. Angiography is invasive, may require a large load of iodinated contrast, and the radiation dose can be high in complicated cases. Angiography is not as widely available as CT, and many hospitals lack expertise. An associated complication of angiography is embolization causing bowel ischemia.

For diagnosis, angiography is reserved for patients with life-threatening, ongoing lower GI bleeding, when there may be no time for a CTA or nuclear study. In these cases, emergent angiography is often performed as a last remaining option before laparotomy. Typically, the superior mesenteric artery is cannulated first, as most significant lower GI bleeds occur from the right colon. If no bleed is identified, the inferior mesenteric artery is cannulated followed by the celiac axis. Digital subtraction angiography (DSA) is a technique that uses a computer algorithm to subtract a

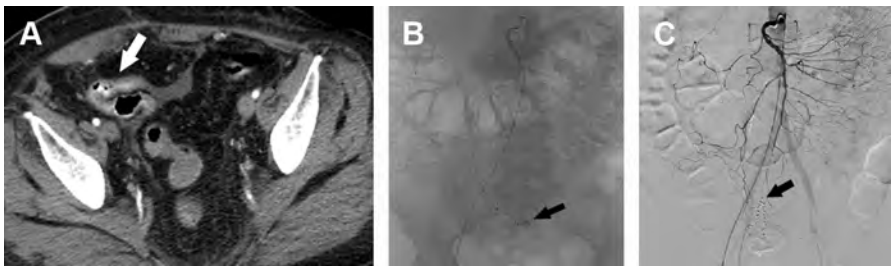

Fig. 4. CTA and DSA of active GI bleed. A 65-year-old woman with recurrent lower GI bleeds, without identifiable source despite extensive workup, presents with hematochezia. Axial image from a CTA (*A*) demonstrates active GI bleeding within the small bowel (*white arrow*). DSA of the superior mesenteric artery (SMA) (*B*) demonstrates small focus of extravasation in the pelvis (*black arrow*). Note the embolization clips from prior treatment. DSA of the SMA (*C*) after embolization demonstrates no evidence of contrast extravasation (*black arrow*).

precontrast image from a postcontrast image, so that only the blood vessels are visualized. This technique should be used if available, as it is generally thought to be more sensitive than angiography alone in the detection of GI bleeds.[21]

Mesenteric Angiography: Findings

On DSA, a lower GI bleed is identified as an area of contrast extravasation outside of the normal confines of a blood vessel, which typically increases over time (**Fig. 4**). After successful embolization, an additional angiogram can be done to show that the bleeding has stopped. Angiography also has characteristic findings in angiodysplasia, which often appears as a vascular blush with early and persistent visualization of a draining vein[21] (**Fig. 5**).

WORKUP RECOMMENDATIONS FOR OCCULT GASTROINTESTINAL BLEEDING

Occult GI bleeding is diagnosed when patients have a positive fecal occult test or iron deficiency anemia without another source and the absence of visible enteric blood. Upper endoscopy and colonoscopy identify an upper GI source of occult GI bleeding in 29% to 56% and a lower GI source in 20% to 30% of patients; synchronous lesions in the upper and lower tract are discovered in 1% to 17%.[22]

Patients with negative esophagogastroduodenoscopy and colonoscopy by definition have suspected small bowel bleeding (SBB). Small bowel lesions are responsible for 5% to 10% of all patients presenting with GI bleeding.[23] Video capsule endoscopy (VCE), CT enterography (CTE), and double balloon endoscopy (DBE) can all be used to assess the small bowel. VCE is recommended by gastroenterology societies as the first-line test because of its high yield (40%–60%) of positive findings after negative endoscopy; however, the test is limited by low specificity, the potential for obstruction/capsule retention, incomplete small bowel visualization, limited visualization of submucosal masses, and limited evaluation of the duodenum and proximal jejunum.[23]

Because of the limitations of VCE, CTE may be considered the first-line evaluation in patients with SBB who have suspicion of stricture (inflammatory bowel disease, prior surgery, nonsteroidal antiinflammatory drug [NSAID] use, radiation), obstruction, or a small bowel mass (young patients or known malignancy).[24,25] A meta-analysis showed a diagnostic yield of 40% for CTE compared with 53% for VCE in patients with SBB.[26] CTE and VCE are considered

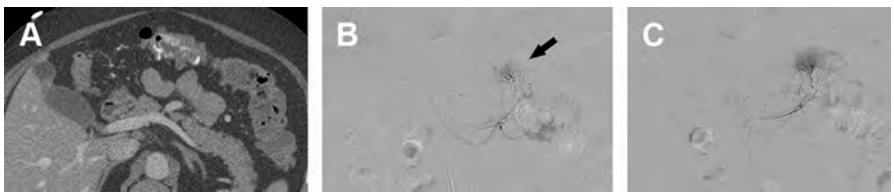

Fig. 5. CTA and DSA of active GI bleed. A 58-year-old woman presents with dark red bowel movements and dizziness. Axial CT in portal venous phase (*A*) demonstrates contrast extravasation into the transverse colon. Superselective DSA of the middle colic artery in the early (*B*) and more delayed (*C*) phase demonstrates a persistent blush of contrast (*black arrow*). Patient was treated with coil embolization. Patient had known angiodysplasia on the colon diagnosed on previous colonoscopy.

complementary modalities; when one study is negative, evaluation with the other should be considered before proceeding with DBE.[25]

DBE affords detailed examination of the small bowel but is costly and time consuming. Therefore, the test is typically used in a targeted fashion after the small bowel has been evaluated with VCE or CTE. Patients who do not receive a diagnosis or who have recurrent bleeding after full diagnostic evaluation of the bowel (obscure GI bleeding) may benefit from repeated capsule endoscopy, Meckel scan, surgical evaluation, or observation/iron supplements.[25]

COMPUTED TOMOGRAPHY ENTEROGRAPHY

CTE has been used successfully for the evaluation of occult obscure GI bleeding for more than a decade.[27] CTE is advantageous in the workup of occult GI bleeding because of its wide availability, relatively rapid examination performance, and consistent good examination quality. CTE has benefits over endoscopic techniques for evaluating the entirety of the intra-abdominal GI tract, delineating postoperative GI tract anatomy and evaluating extraenteric structures.

Limitations of CTE include exposure to ionizing radiation, iodinated IV contrast exposure, and need for large-volume oral contrast administration. Improvements in dose reduction techniques have allowed CTE radiation doses to decline substantially from 15 to 20 mGy to less than 10 mGy per phase.[28] Exposure to iodinated IV contrast is associated with a low risk of severe allergic reaction (0.04%) and contrast-induced nephropathy (minimal risk with renal function >30 mL/min/1.73 m^2).[29] Large-volume oral contrast administration may not be tolerated by patients, particularly those who are acutely ill; for some patients, placement of a nasogastric catheter may be necessary for contrast administration.

Studies have consistently demonstrated the ability of CTE to identify vascular, inflammatory, structural, and neoplastic conditions in the bowel responsible for GI bleeding.[27,30] Although the diagnostic yield for vascular and inflammatory lesions may be lower than that of VCE, the technique is superior for the detection of small bowel masses and has been shown to identify inflammation and vascular malformations not seen using VCE.[24,27,30] As with all imaging studies performed for the evaluation of GI bleeding, the diagnostic yield of CTE is higher in patients with overt bleeding than in those with occult bleeding.[23,27]

CTE requires distention of the small bowel by ingestion of 900 to 1350 mL of neutral oral contrast over 30 to 60 minutes. (Please see Shannon P. Sheedy and colleagues' article, "CT Enterography," in this issue for a detailed discussion of CTE.) A variation of enterography, enteroclysis may be used to increase distention of the small bowel. Enteroclysis involves the placement of a naso-enteric catheter and active infusion of contrast agent to increase small bowel distention. Enteroclysis may have an advantage in detecting subtle strictures and pathologic conditions of small bowel, but it is poorly tolerated by patients and rarely performed outside of referral centers (**Fig. 6**).

IV contrast administration for CTE is typically performed using 300 to 350 mg of iodine per milliliter contrast agents and infusion rates between 3 and 5 mL/s. CTE performed for the

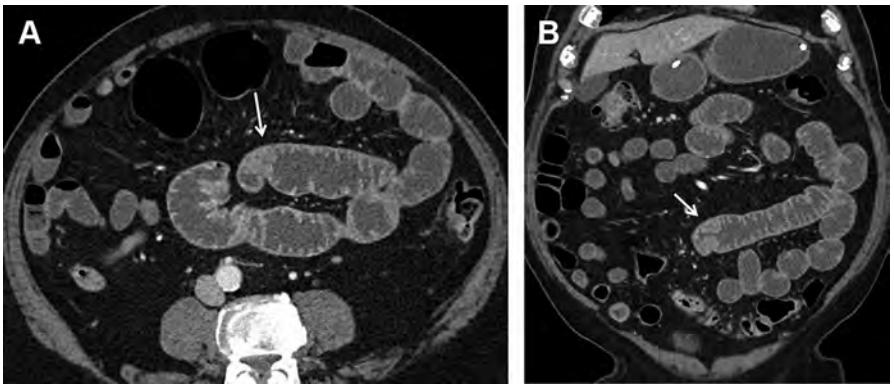

Fig. 6. Jejunal lymphoma. A 77-year-old man with history of occult GI bleeding. Capsule endoscopy suggested a possible small bowel mass. Axial (*A*) and coronal (*B*) images from a CT enteroclysis demonstrate a subtle mass (*arrows*) in the jejunum that was subsequently shown to be a lymphoma. Note the isodense appearance that potentially could have been missed with poor bowel distension with enterography.

evaluation of suspected small bowel bleeding requires acquisition of multiple phases of contrast enhancement, although the specific phases acquired vary between institutions. The examination typically includes the arterial phase timed using bolus tracking techniques and an enteric phase acquired at 50 to 60 seconds after injection. A precontrast phase and/or a delayed phase may also be acquired depending on the preferences of the radiologist. Precontrast images are helpful for identifying high-attenuation ingested material, which can mimic pathology. Data demonstrating the added benefit of additional contrast-enhanced phases are lacking; however, limited evidence suggests an improvement in sensitivity and reader confidence when increasing an examination from 2 to 3 contrast-enhanced phases.[31] The use of dual-energy data acquisition and postprocessing can be helpful for improving lesion detection and limiting the radiation dose. The generation of iodine maps and low kiloelectron volt monoenergetic series can be helpful for making enhancing pathology more conspicuous. The generation of virtual noncontrast series may negate the need for acquiring precontrast data sets.

Occult Gastrointestinal Bleeding: Causes and Findings

There are many potential causes of occult GI bleeding, which are listed in **Table 1**.[32,33] In the next section, the authors review some of the more frequently seen causes and their imaging findings. They highlight unique or subtle findings that may not be well known. The discussion focuses on CTE, which is the most commonly performed imaging test for occult bleeding. Although CTE can detect lesions in the stomach and colon missed by endoscopy, the authors focus their discussion on small bowel pathology.

Vascular lesions

Vascular lesions can be classified as high-flow lesions (arteriovenous malformation [AVM], Dieulafoy lesion) (**Fig. 7**), angioectasia (**Fig. 8**), and venous lesions (varix, venous angioma) (**Fig. 9**).[32] High-flow lesions are best seen on the arterial phase and may only be seen on this phase. The presence of an enlarged draining vein is more suggestive of an AVM. Angioectasias are usually best seen on the enteric phase and appear as nodular or discoid areas of enlargement of the intramural veins. Venous angiomas show slow progressive enhancement and may have associated phleboliths.

CTE has potential benefits for the evaluation of bowel vascular malformations in addition to evaluation with VCE. CTE has been shown to identify vascular lesions missed by endoscopy.[27,30] Dieulafoy lesions may be particularly conspicuous at arterial phase enterography and can be difficult to visualize at endoscopy.

Visualization at endoscopy is limited to the mucosal surface; therefore, intramural malformations may only be detected at cross-sectional imaging (**Fig. 10**). In addition, imaging is able to better localize lesions, provide a better overview of the extent of the malformation, and reliably survey the entire GI tract.

Polyps

Polyps can have variable enhancement. In a poorly distended bowel, a polyp that enhances similar to the adjacent bowel wall may be obscured. Examinations performed with positive oral contrast may perform better for identifying masses that enhance similar to the bowel wall; this should be considered when evaluating patients with polyposis syndromes, such as Peutz-Jeghers syndrome.

A unique enhancement characteristic with central lower density and surrounding hyperenhancement is suggestive of inflammatory fibroid polyps

Table 1
Common causes of occult small bowel gastrointestinal bleeding

Inflammatory	Neoplastic	Vascular	Miscellaneous
Celiac sprue	Metastasis	Angioectasia	Meckel diverticulum
Ulcerative colitis	Neuroendocrine tumor	AVM	
Crohn disease	Adenocarcinoma	Dieulafoy lesion	
NSAID	Lymphoma	Venous angioma	
	GIST		
	Pancreatic heterotopia		
	Polyp		

Abbreviations: AVM, arteriovenous malformation; GIST, gastrointestinal stromal tumor.

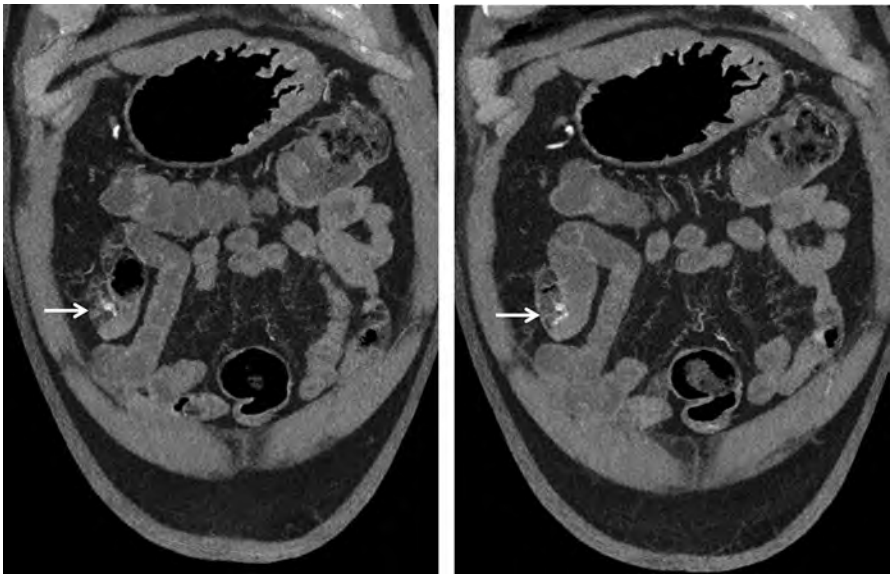

Fig. 7. High flow vascular lesion. A 71-year-old man with symptomatic anemia. Coronal MIP images from the arterial phase of a multiphasic CTE examination show a rapidly enhancing enlarged vessel in the ileum (*arrows*) suggestive of a high flow vascular lesion, such as a Dieulafoy lesion. The lesion was not seen on the enteric phase (not shown).

(**Fig. 11**). Inflammatory fibroid polyps are rare non-neoplastic lesions composed of blood vessels, connective tissue, and inflammatory cells. They originate within the submucosa, most commonly of the stomach, with the small bowel being the second most common site. These lesions frequently become several centimeters in size and may present with obstruction or intussusception.

Neoplasms

The most common primary malignancy of the small bowel is a neuroendocrine tumor (NET).[33] NETs most commonly develop in the ileum. With the more widespread use of CTE, small bowel NETs are being detected earlier and at a smaller size. These lesions are typically small with a flat or plaquelike morphology (**Fig. 12**). Desmoplastic reaction associated with the mass may cause bending/kinking of the bowel loop. The small size and shape of the lesion may make them difficult to detect. They are best seen on the arterial or enteric phases as a focus of mural hyperenhancement. When a small bowel NET is identified, it is important to carefully search the remaining bowel for additional lesions, as they can be multifocal.

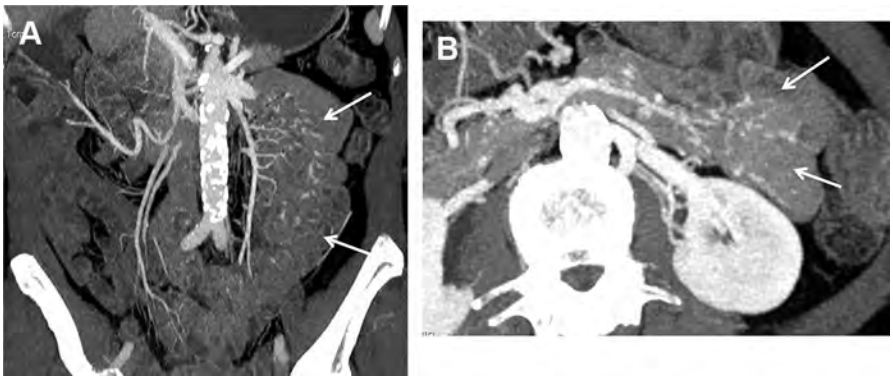

Fig. 8. Angioectasia. A 68-year-old man with iron deficiency anemia. Coronal (*A*) and axial (*B*) MIPs from the enteric phase of a multiphase CTE show enlarged and nodular vessels in the jejunum (*arrows*) suggestive of angioectasia.

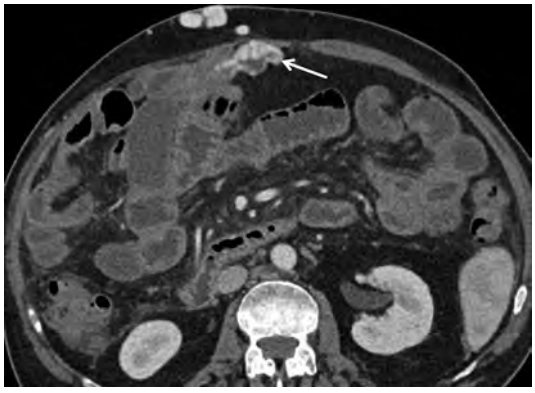

Fig. 9. Small bowel varix. A 68-year-old man with cirrhosis, portal hypertension, and recurrent GI bleeding. CTE demonstrates serpiginous enhancing structures in the small bowel consistent with varices (*arrow*). Also note the varices in the anterior abdominal wall.

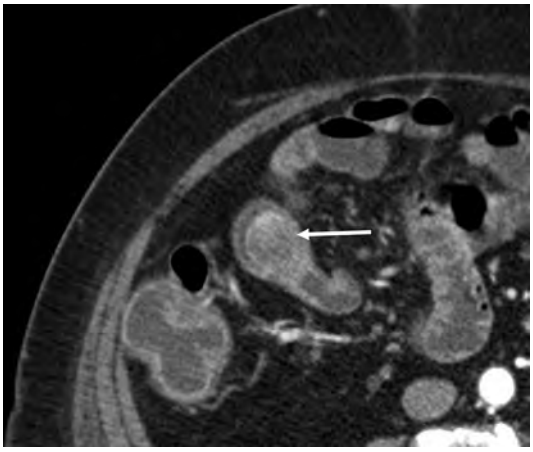

Fig. 11. Inflammatory fibroid polyp. A 56-year-old man with iron deficiency anemia. CTE demonstrates an intraluminal mass (*arrow*) in the ileum. The mass has unique enhancement characteristics with peripheral hyperenhancement and central low attenuation near water density.

Adenocarcinoma most commonly presents as a hypoenhancing polypoid mass or an annular constricting lesion (**Fig. 13**).[33] Lymphoma of the small bowel may have a similar appearance but also may result in aneurysmal dilation of the bowel (see **Fig. 6**). Lymphoma may also be multifocal, associated with lymphadenopathy or lymphomatous masses in other organs. Adenocarcinoma is more likely to obstruct than lymphoma.

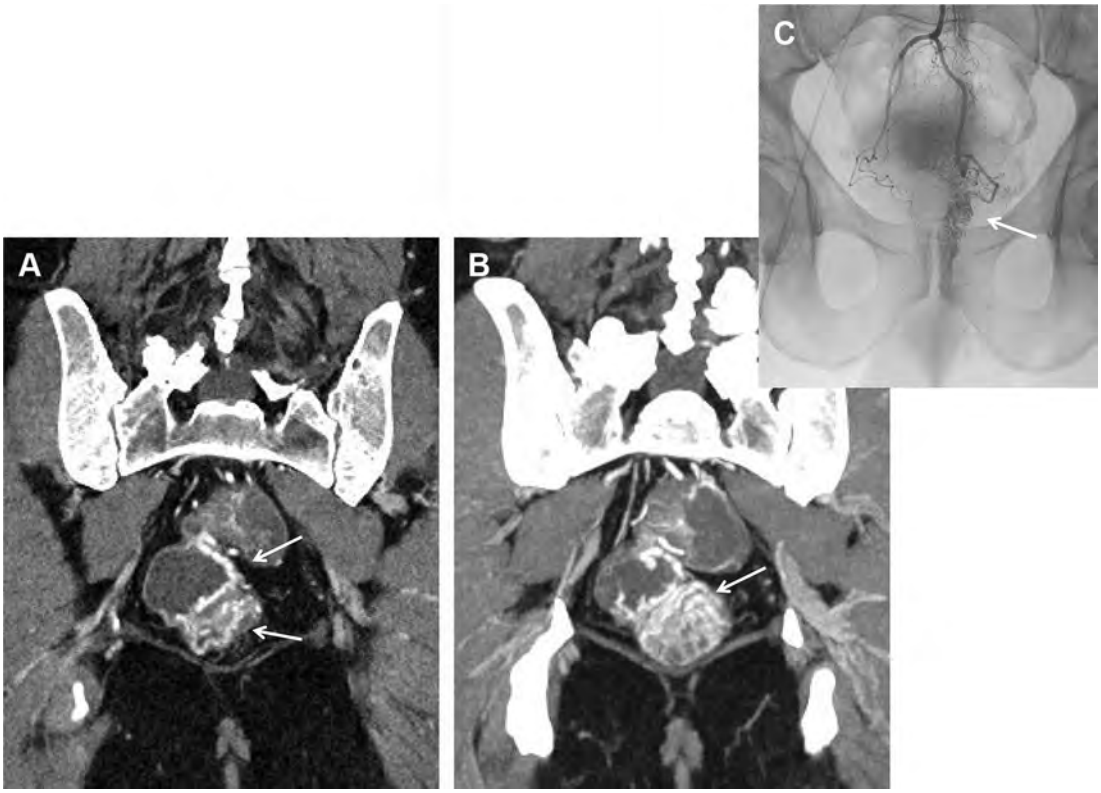

Fig. 10. Rectal vascular malformation. A 58-year-old man with recent black tarry stool. Enteric phase CTE images demonstrate a tangle of large vessels (*white arrows*) in the rectum on coronal reformats (*A*) and coronal MIPs (*B*) consistent with a rectal vascular malformation confirmed on subsequent angiography (*C*).

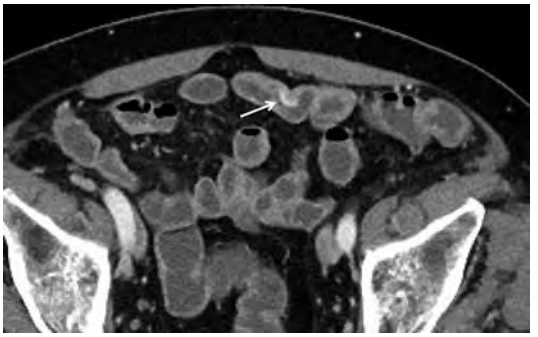

Fig. 12. NET. An 82-year-old man with iron deficiency anemia. CTE shows a small plaquelike hyperenhancing lesion (*arrow*) in the small bowel with puckering of the underlying wall consistent with a NET.

Gastrointestinal stromal tumors (GISTs) have varied appearances based on their size. When small, the masses are well circumscribed and hyperenhancing (**Fig. 14**). These masses originate from a mural position but typically become endoluminal or exophytic as they grow. As they grow, the enhancement becomes variable; necrosis, internal hemorrhage, and ulceration may be found. Large masses may also directly invade into adjacent structures.

Heterotopic pancreatic tissue

Pancreatic tissue with no anatomic continuity with the remaining pancreas is most commonly found in the stomach, duodenum, and proximal jejunum.[34] It can also be found within Meckel diverticula and the remainder of the ileum. Heterotopic pancreatic tissue typically has an intramural or serosal flat plaquelike appearance that can mimic a GIST or NET (**Fig. 15**).

Inflammation

Inflammatory bowel disease is discussed in greater detail elsewhere in this issue. Classic findings of small bowel Crohn disease include asymmetric mural hyperenhancement and bowel wall thickening in a skipping pattern. Penetrating (sinus tracts, fistula, abscess) and perianal disease may be present.

Nonsteroidal antiinflammatory enteropathy

Focal small bowel wall injury caused by NSAID exposure can result in thin circumferential regions of submucosal fibrous deposition and frequently have superimposed inflammation. The circumferential columns of fibrosis result in short (5–10 mm long) strictures or diaphragms with superimposed hyperenhancement, which are characteristic of NSAID exposure (**Fig. 16**). However, other causes, such as Crohn disease, may have similar findings. The strictures are often multiple and found in close proximity. They may be mistaken for peristaltic contractions or missed because of poor bowel distention, especially those without superimposed inflammation. Multiphase CT or MR imaging is helpful for identifying NSAID strictures by maximizing luminal distention in each segment of the bowel.

Meckel diverticulum

Meckel diverticulum occurs within 1% to 3% of the population and most (84%) are asymptomatic.[35,36] Of symptomatic diverticula occurring in adults, the most common presentation is bleeding (38%).[36] Fifty percent of diverticula contain ectopic tissue that is gastric in greater than 60% and pancreatic in 16%.[35]

Tc-99m pertechnetate scan (Meckel scan) is a useful test for detecting ectopic gastric mucosa within a diverticulum. The sensitivity of the test is 85% to 90% in the pediatric population and 62% in patients 16 years of age and older.[37] A Meckel scan may give false-positive results because of detection of ectopic mucosa, which may be in

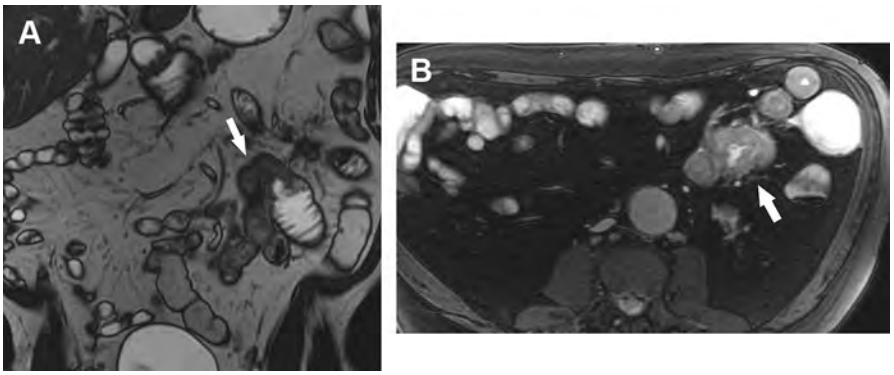

Fig. 13. Jejunal adenocarcinoma. A 64-year-old man with melena. Coronal (*A*) and axial (*B*) T2-weighted images from magnetic resonance enterography show a focal mass (*arrows*) in the jejunum with mild proximal dilatation suggestive of an adenocarcinoma. Most sites prefer using CTE for evaluating occult bleeding; however, magnetic resonance enterography can be used if there are contraindications to CT.

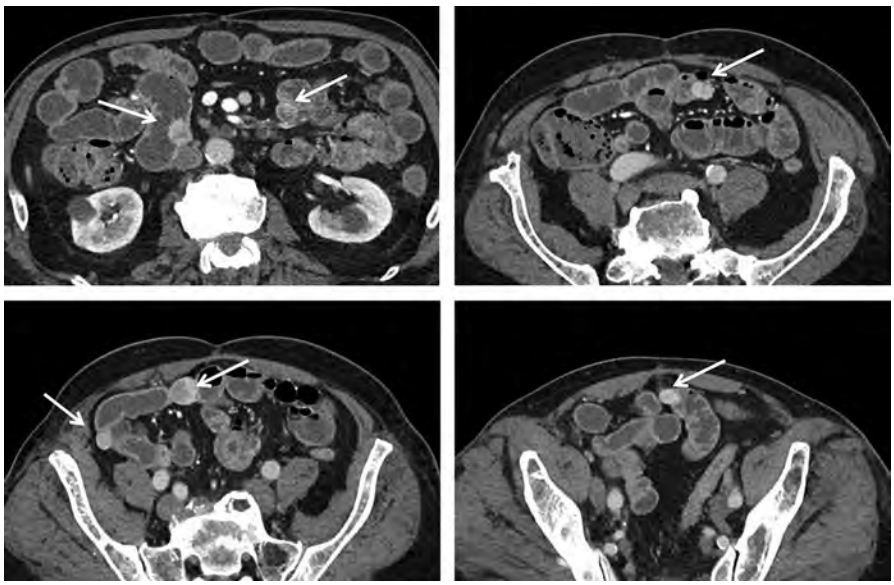

Fig. 14. Multifocal GIST. An 82-year-old man with melena requiring multiple transfusions. CTE shows multiple hyperenhancing lesions throughout the small bowel consistent with multiple GISTs (*arrows*).

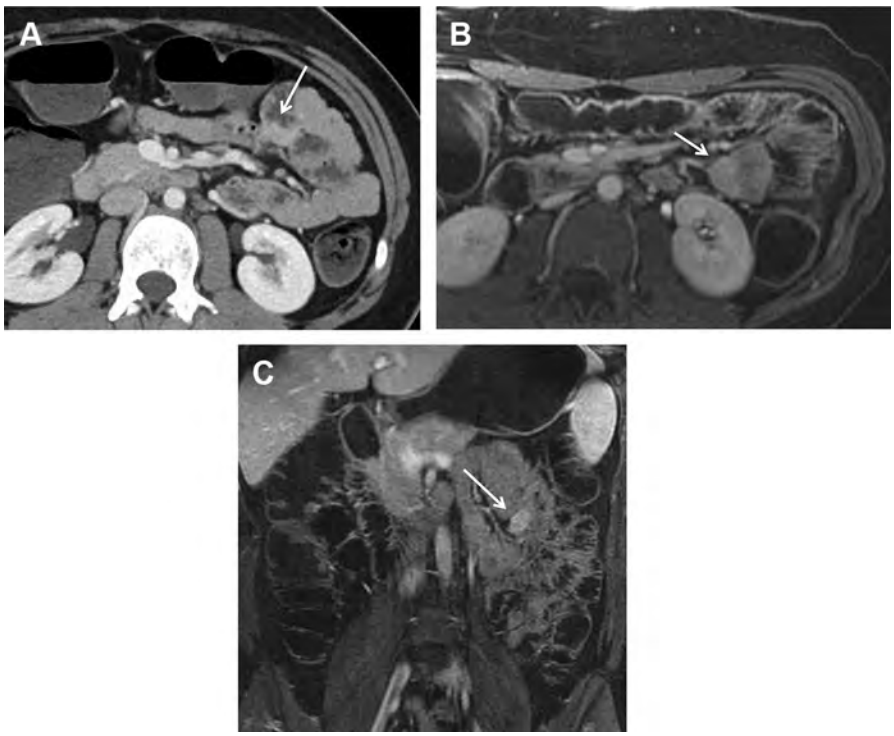

Fig. 15. Ectopic pancreatic tissue. A 21-year-old woman with abdominal pain and episodes of blood in stool. CTE (*A*) and magnetic resonance enterography (*B*, *C*) show a mural mass (*arrows*) in the jejunum near the ligament of Treitz. The lesion is somewhat flat in appearance and enhances similar to pancreatic tissue. Findings could represent a GIST or NET. However, heterotopic pancreatic tissue is also in the differential diagnosis which was confirmed at surgery.

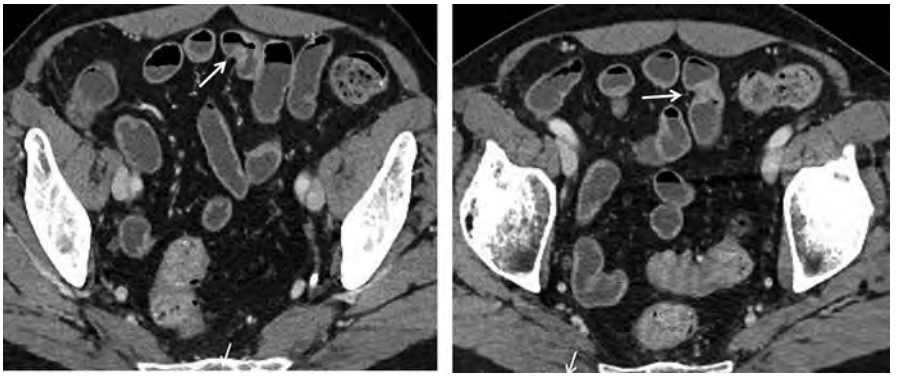

Fig. 16. NSAID diaphragms. A 64-year-old man with iron deficiency anemia. CTE demonstrates multiple focal inflammatory strictures (*arrows*) consistent with NSAID enteropathy.

another location, such as an enteric duplication cyst. Ectopic pancreatic tissue within the diverticulum can be a source of a false-negative Meckel scan.

To perform a Meckel scan, 1.85 MBq/kg Tc-99m pertechnetate is administered.[38] Pretreatment with pentagastrin and/or histamine receptor antagonists may increase the rate of positive examinations.[38] Dynamic planar images are typically acquired every 30 to 60 seconds for 30 minutes. Single positron emission CT can also be performed and may assist in better localization of tracer uptake. Positive examinations show a focal region of uptake in the right lower quadrant, which appears at the time the stomach is visualized (**Fig. 17**). Meckel diverticula can be identified by CTE. These diverticula appear as blind-ending pouches arising from the ileum. Superimposed

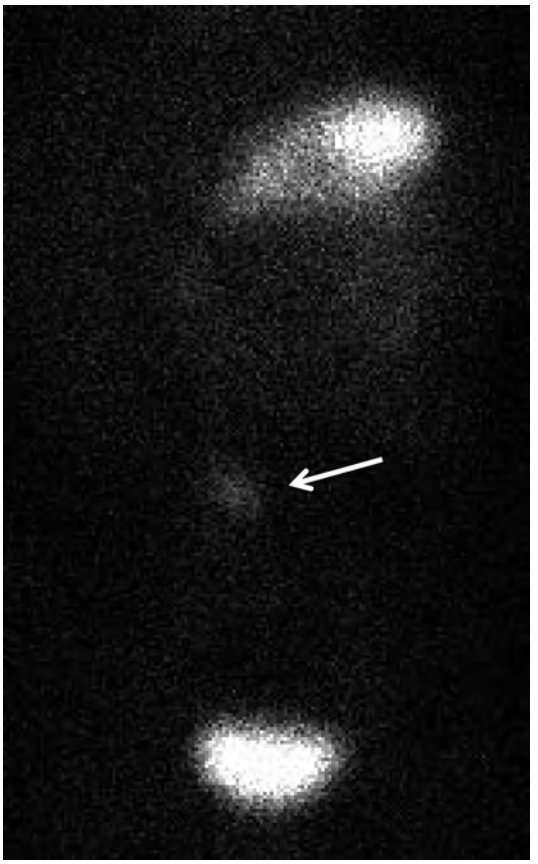

Fig. 17. Positive Meckel scan. A 4-year-old boy who presents with bloody stools. On the Meckel scan, there is a focal area of increased radiotracer uptake in the right lower quadrant (*arrow*) consistent with a Meckel diverticulum.

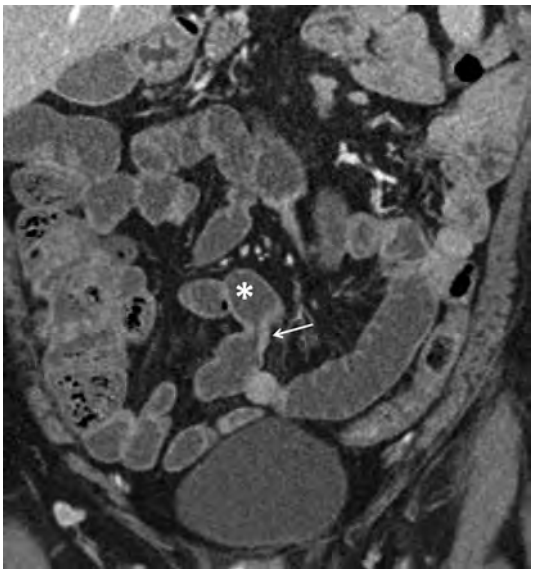

Fig. 18. Meckel diverticulum. A 73-year-old woman with melena and transfusion-dependent anemia. Coronal image from a CTE shows a blind ending loop arising in the distal small bowel (*asterisk*) consistent with a Meckel diverticulum. Associated wall thickening (*arrow*) consistent with superimposed inflammation.

hyperenhancement and wall thickening suggest superimposed inflammation (**Fig. 18**).

SUMMARY

Lower GI bleeding occurs distal to the ligament of Treitz and is an important clinical problem with a variety of causes. The bleeding can be acute, presenting with hematochezia, or occult, presenting with iron deficiency anemia and/or positive fecal occult blood test. Obscure bleeding refers to patients with rebleeding after a negative endoscopic and radiologic assessment of the bowel.

The workup of lower GI bleeding includes endoscopy, CTA, CTE, nuclear scintigraphy, conventional angiography, and surgery. The clinical presentation of patients dictates the order and urgency that the test/intervention is performed. Radiologic assessment of lower GI bleeding has come to the forefront of the workup, especially in patients with acute ongoing bleeding. Conventional angiography with embolization is now often the first-line treatment in patients who are unstable. CTE has become a first-line test for many patients with occult GI bleeding, especially in those whereby there is a contraindication to capsule endoscopy.

This article discusses the various imaging modalities used in the workup of lower GI bleeding and includes some of the common imaging findings using each modality.

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