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The Role of Imaging for Gastrointestinal Bleeding: Consensus Recommendations From the American College of Gastroenterology and Society of Abdominal Radiology

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The Role of Imaging for GI Bleeding ACG and SAR Consensus Recommendations

These consensus recommendations from the American College of Gastroenterology and the Society of Abdominal Radiology GI Bleeding Disease-focused Panel will improve the understanding of specific exams which are available for assessing gastrointestinal bleeding and how these should be used.



Key Results

1. Numerous guidelines for the management of gastrointestinal bleeding, institutional variations in the nomenclature of available radiologic tests, and limited understanding of the technology can cause confusion for clinicians.
2. Multiple exams available to evaluate gastrointestinal bleeding have unique advantages and limitations which help guide utilization in various clinical scenarios.
3. Radiologic exams play a major role in the diagnosis and treatment of gastrointestinal bleeding and are complementary to gastroenterology exams.

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Gastrointestinal (GI) bleeding is the most common GI diagnosis leading to hospitalization within the United States. Prompt diagnosis and treatment of GI bleeding is critical to improving patient outcomes and reducing high healthcare utilization and costs. Radiologic techniques including computed tomography angiography, catheter angiography, computed tomography enterography, magnetic resonance enterography, nuclear medicine red blood cell scan, and technetium-99m pertechnetate scintigraphy (Meckel scan) are frequently used to evaluate patients with GI bleeding and are complementary to GI endoscopy. However, multiple management guidelines exist which differ in the recommended utilization of these radiologic examinations. This variability can lead to confusion as to how these tests should be used in the evaluation of GI bleeding. In this document, a panel of experts from the American College of Gastroenterology and Society of Abdominal Radiology provide a review of the radiologic examinations used to evaluate for GI bleeding including nomenclature, technique, performance, advantages, and limitations. A comparison of advantages and limitations relative to endoscopic examinations is also included. Finally, consensus statements and recommendations on technical parameters and utilization of radiologic techniques for GI bleeding are provided.

KEYWORDS: GI bleeding; CT angiography; angiography; CT enterography; tagged RBC scintigraphy

SUPPLEMENTARY MATERIAL accompanies this paper at <http://links.lww.com/AJG/D143>

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SUMMARY STATEMENT

Consensus recommendations from the American College of Gastroenterology and the Society of Abdominal Radiology GI Bleeding Disease-Focused Panel will improve the understanding of specific examinations which are available for assessing gastrointestinal (GI) bleeding and how these should be used.

KEY RESULTS

1. Numerous guidelines for the management of GI bleeding, institutional variations in the nomenclature of available radiologic tests, and limited understanding of the technology can cause confusion for clinicians.
2. Multiple examinations available to evaluate GI bleeding have unique advantages and limitations which help guide utilization in various clinical scenarios.
3. Radiologic examinations play a major role in the diagnosis and treatment of GI bleeding and are complementary to gastroenterology examinations.

INTRODUCTION

A variety of radiological imaging techniques are instrumental in the evaluation of patients with gastrointestinal (GI) bleeding and are complementary to GI endoscopy. Existing clinical practice guidelines for GI bleeding differ in the recommended utilization of radiologic examinations (1–4), and a detailed comparison between endoscopic and radiologic techniques is lacking. Owing to widespread variation in the utilization of GI testing (5) and a general lack of knowledge of advantages and limitations of each technique, we sought to derive a set of multidisciplinary, consensus recommendations on the role of radiologic testing across the spectrum of GI bleeding. In this document, a panel of experts from the American College of Gastroenterology (ACG) and Society of Abdominal Radiology (SAR) provide a review of the radiologic examinations used to evaluate for GI bleeding including nomenclature, technique, performance, advantages, and limitations. A comparison of advantages and limitations relative to

endoscopic examinations is also included. Finally, consensus statements and recommendations on technical parameters and utilization of radiologic techniques for GI bleeding are provided.

PROCESS FOR CONSENSUS

A panel of experts from the ACG and SAR were assembled to develop this document and the consensus statements. The overall process is explained in Supplementary Appendix S1 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>) and summarized in Figure 1. A 4-point scale of agreement (Figure 2) was used to determine the level of consensus. The Grading of Recommendation, Assessment, Development, and Evaluations (GRADE) system for assessing the quality of evidence was not used for these recommendations. The decision not to use the GRADE system was based on its prior use in published ACG Clinical Practice Guidelines on the management of upper GI bleeding (UGIB) (6), lower GI bleeding (LGIB) (1,7), and small bowel bleeding (3) demonstrating low to very low quality of evidence in the support of consensus recommendations. Instead, we elected to use the expertise of a multidisciplinary panel of experts in the field of GI bleeding to develop our consensus recommendations.

OVERVIEW OF GI BLEEDING

GI bleeding can be characterized by the presumed location of origin. UGIB is defined as bleeding that originates from the esophagus, stomach, or duodenum. This accounts for approximately 80% of bleeding events (6). LGIB has previously been defined as bleeding that originates distal to the ligament of Treitz but more recently is defined as bleeding distal to the ileocecal valve and throughout the colon. LGIB, depending on its anatomical landmarks, accounts for approximately 15%–30% of all GI bleeding events (2,3). Finally, small bowel or midgut GI bleeding is defined as bleeding that occurs between the ligament of Treitz and the ileocecal valve and accounts for approximately 5%–10% of GI bleeding events (3,4). A more comprehensive clinical overview of GI bleeding is provided in Supplementary Appendix S2 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>).

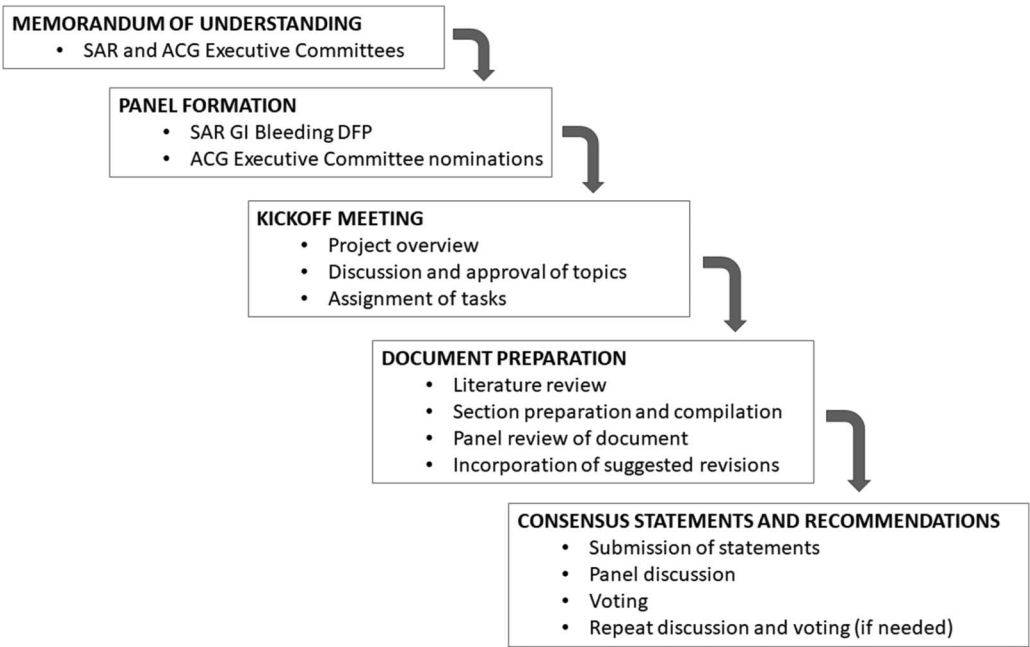


Figure 1. Project process. ACG, American College of Gastroenterology; GI, gastrointestinal; SAR, Society of Abdominal Radiology.

TERMINOLOGY OF CROSS-SECTIONAL IMAGING TECHNIQUES USED IN IMAGING GI BLEEDING

The terminology used for the cross-sectional imaging techniques to evaluate for GI bleeding can be confusing as the terms used, and technical parameters can vary by institution. In Supplementary Appendix S3 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>), we give a general overview of the terminology used for these techniques.

DIAGNOSTIC TESTING IN OVERT LGIB: REVIEW OF IMAGING TECHNIQUES

CT angiography

Technique. Computed tomography (CT) imaging protocols are tailored to the specific indication (Tables 1 and 2). In overt LGIB, the primary goals of CT are to determine the location and assess the intensity of the bleed, and a secondary goal is to identify the cause of bleeding. Confirmation of contrast extravasation typically requires a multiphase CT technique (Figure 3) that includes acquisition of a noncontrast phase, a late arterial phase (typically 25–35 seconds after intravenous contrast bolus initiation), and a portal venous phase (60–70 seconds after bolus initiation) or late venous phase (70–90 seconds after bolus initiation) series. Most CT scanners can acquire the arterial phase through bolus tracking, which may be more suitable in patients with differing cardiac outputs, rather than timed delays. A CTA includes postprocessed 3-dimensional images

to better demonstrate the vascular anatomy, which can be helpful in guiding subsequent angiography. The noncontrast images are needed to identify a high attenuation ingested material which can mimic bleeding. In centers with access to the newer generation multienergy CT scanners, a separate noncontrast phase may be omitted and replaced with a virtual noncontrast series (see Supplementary Appendix S6, Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>). Oral contrast should be avoided because this delays scanning, and positive oral contrast can obscure bleeding. The most important finding that confirms the presence of acute hemorrhage is extravasation of contrast-enhanced blood: This is defined by an accumulation of contrast within the bowel lumen which changes size and density on subsequent phases. In 2019, the GI Bleeding Disease-Focused Panel of the SAR published a white paper with consensus recommendations for acquisition techniques which can be used as a reference (8). **Performance data.** Several meta-analyses have found that CTA is highly sensitive (85%–90%), specific (92%), and accurate (94%–95%) for detection and localization of overt GI bleeding (9,10). CTA can also be prognostic. Extravasation volume can be quantified, and larger volumes are associated with higher transfusion requirements, active bleeding confirmation, and hemostatic therapy (11,12). Extravasation volumes correlate with the bleeding rate, and with multidetector CT scanners, the sensitivity of bleeding detection is estimated to be 0.1 mL/min (12). This is significantly improved from historic studies reporting a sensitivity of

Score		
1	Block	Strongly disagree; won't help implement
2	Stand-aside	Don't agree but won't block passage; may help implement
3	Accept with revisions	Will accept and help implement if suggested revisions are incorporated
4	Accept and support	Strongly agree and will help implement

Figure 2. Level of agreement.

Table 1. CT techniques for GI bleeding

Technical parameters	CTA ^a	CTE ^b
Oral contrast	None	Neutral contrast
Single-phase timing	Late arterial	Enteric or portal venous phase
Multiphase timing (>1 postcontrast phases)	Late arterial Portal venous or delayed	Late arterial phase Enteric or portal venous ± delayed

CT, computed tomography; CTA, CT angiography; CTE, CT enterography; GI, gastrointestinal.

^aCTA is defined as a CT with one of the phases acquired during the arterial phase with generation of postprocessed images to better demonstrate vascular anatomy. Most CTA examinations for GI bleeding also obtain a second more delayed phase (multiple phases) to detect slower venous bleeds.

^bCTE can be performed as a single-phase examination or multiphase examination. A multiphase examination is helpful to improve detection and characterization of vascular lesions which are more common in older patients. Single-phase examinations are adequate for detecting inflammatory conditions and masses.

0.5 mL/min, which used a single detector, thicker sections, and less robust contrast bolus (13). A negative CTA has been shown to be associated with a decreased rate of rebleeding and need for intervention (14–16).

Advantages. Because of its noninvasive nature, short examination time, and widespread availability, CTA is well-suited to evaluate patients with overt GI bleeding, particularly in hemodynamically unstable patients (5). In patients with overt GI bleeding, CT is used to identify intraluminal blood products or active contrast extravasation to localize the site of hemorrhage and can also detect etiologies outside of the GI tract. CT techniques such as digital subtraction and dual-energy acquisition have improved the ability of CT to detect subtle GI tract lesions (17). CTA also provides additional information regarding the patient's vascular and enteric anatomy, which is often helpful for choosing and planning a subsequent interventional radiology, endoscopic, or surgical procedure (18).

Limitations. CTA requires the administration of intravenous (IV) contrast and ionizing radiation, which can be higher than standard abdominal CT because of multiple phases of image acquisition. However, techniques such as dual energy CT and split contrast bolus acquisition can reduce radiation dose by reducing the number of phases obtained (19,20).

Nuclear medicine

Technique. The preferred radiopharmaceutical for LGIB imaging is ^{99m}Tc-labeled red blood cells (^{99m}Tc-RBCs) which have a long intravascular half-life that allows continuous imaging of the GI tract for several hours as necessary and have replaced ^{99m}Tc-sulfur

colloid for evaluation of LGIB (21). The labeling methods are further described in Supplementary Appendix S4 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>).

Imaging protocol. As ^{99m}Tc-RBCs are intravenously administered to the patient, imaging under the gamma camera begins with flow images (angiographic phase) obtained at 1–2 seconds per frame for 1 minute. Flow images can be helpful for localizing a rapid bleed, which rarely can be present at the start of imaging. Dynamic imaging obtained at 1 minute per frame for a minimum of 1 hour is generally recommended. Acquiring the dynamic images in 10- to 15-minute sequences and reviewing these images while subsequent sequences are still being acquired may decrease the time from detection of the bleed and catheter angiography (CA) (21). If no GI bleeding is detected after 1 hour of imaging, the study is usually ended. Single-photon emission CT (SPECT)/CT may be helpful to clarify indeterminate finding seen on planar imaging (22).

Performance data. The sensitivity and specificity of ^{99m}Tc-RBCs have been reported to be 93% and 95%, respectively (23). Bleeds that occur early on imaging and have high intensity of uptake have the highest likelihood of being detected on subsequent CA. Time to positive (TTP) defined as the time from the start of ^{99m}Tc-labeled RBC scanning to the appearance of a bleed can affect the diagnostic yield of CA. One study with a TTP threshold of ≤9 minutes identified 92% of the patients with positive studies. A TTP threshold of ≤9 minutes was associated with a positive CA study of 6 times greater compared with TTP of >9 minutes. TTP of >9 minutes accurately predicted negative CA findings in 94% of patients. Having shorter lag time from the detection of bleed on

Table 2. Timing of individual phases for CT and their utility

Phase	Seconds after beginning IV contrast injection	Utility
Noncontrast (or virtual noncontrast)	Not applicable	Identifies a high attenuation ingested material which can mimic bleeding
Late arterial	35	Provides arterial opacification and allows time for contrast extravasation to begin
Enteric	50	Peak bowel wall enhancement. Inflammatory conditions and some tumors (NET) may be most conspicuous on this phase
Portal venous	60–70	Provides good bowel wall enhancement and also allows better evaluation of other solid organs. Allows improved detection of slow venous bleeding
Delayed	90 sec or greater	Allows improved detection of slow venous bleeding

CT, computed tomography; IV, intravenous; NET, neuroendocrine tumor.

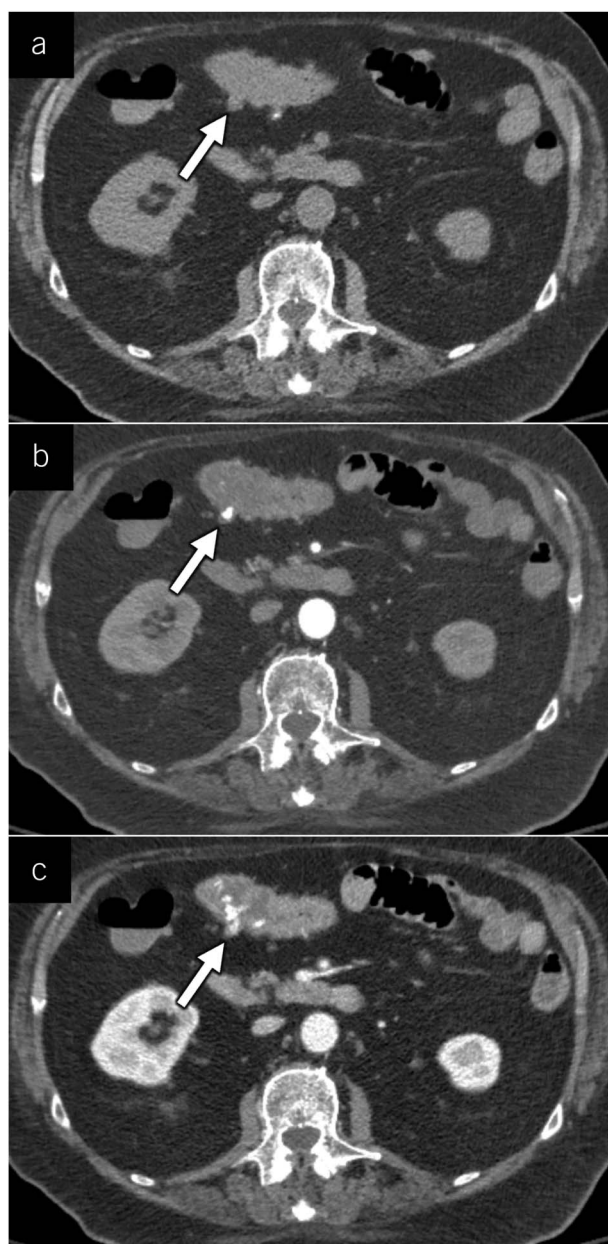


Figure 3. CTA demonstration of actively bleeding colonic diverticulum. A 78-year-old man with atrial fibrillation taking warfarin with an acute onset of rectal bleeding and dropping hemoglobin level. No clear source of bleeding identified on recent upper and lower endoscopy. Noncontrast (a), arterial phase (b), and portal venous phase (c) CT images show a diverticulum in the transverse colon (arrow in a) with contrast extravasation in the diverticulum on arterial phase images (arrow in b) which changes in size and density in the portal venous phase (arrow in c) and extends further into the adjacent colon consistent with active bleeding. Following the CTA, catheter angiography was performed which showed active bleeding from a vasa recta branch of the right colic artery (not shown). This was successfully treated with coil embolization. CT, computed tomography; CTA, CT angiography.

^{99m}Tc -RBCs to the start of CA was also associated with higher yield of CA (24). Therefore, early interpretation of these studies is important to facilitate faster time to CA. One study comparing CTA and ^{99m}Tc -RBC scans showed that ^{99m}Tc -RBC scans had a lower accuracy of 55.4% compared with CTA which had an

accuracy of 96%. ^{99m}Tc -RBC scans in this study were performed with standard planar imaging and did not have SPECT/CT performed (25). SPECT/CT may be helpful for distinguishing a small bowel bleed from a large-bowel bleed (22). In one study, planar imaging combined with SPECT/CT showed the highest diagnostic ability for detecting the site of GI bleeding compared with planar imaging or planar imaging combined with SPECT (26). There are currently limited data on the value of SPECT/CT when planar imaging is negative because few centers perform the examination in such circumstances. More studies are needed to validate the results with SPECT/CT, including its use when planar imaging does not show evidence of GI bleeding (21).

Advantages. The biggest advantage of ^{99m}Tc -RBCs is its high sensitivity because it can detect GI bleeding at a rate of as low as 0.04 mL/min in experimental animal models and 0.1 mL/min in clinical studies (21,27,28). As imaging is typically performed for at least 1 hour, intermittent bleeding can also be detected. ^{99m}Tc -RBCs also allow dynamic imaging for more than 1 hour, and it is possible to reimagine for up to 24 hours (21). The radiation dose to the patient is lower with ^{99m}Tc -RBCs compared with CTA (23,29).

Limitations. The biggest limitation of ^{99m}Tc -RBC scans is that this study can only be performed on hemodynamically stable patients. The RBC labeling preparation time and long imaging times prevent performing this study on patients who are hemodynamically unstable because of hypotension or abnormal heart rate (21). The risk-benefit ratio of obtaining a ^{99m}Tc -RBC scan, which has a long imaging times, vs correctly identifying an active LGI bleeding site has to be weighed in borderline hemodynamically unstable patients.

RBCs can also localize at sites other than active GI bleed. Physiologic activity in the ureters, penile activity, splenosis, pancreatic pseudocysts, or nonenteric bleeding/hematoma can be mistaken as sites of GI bleed (21,23,30). True GI bleeding will change in intensity and move over time, which will help differentiate GI bleeding from these normal variants and pitfalls. SPECT/CT can be performed for better characterization of indeterminate findings and help with pitfalls that can mimic GI bleeding (22).

There are patient-related factors which could potentially interfere with labeling of RBCs. Patients with low hematocrit, recent blood transfusion, and hemoglobin-related disease (sickle-cell disease or thalassemia) have lower labeling efficiency. Some medications such as heparin can also interfere with labeling (23).

Sometimes planar ^{99m}Tc -RBC scans can provide incorrect localization of the site of bleeding. Incorrect localization of bleeding has been reported in a few studies occurring in 10%–33% of cases (25,31,32). SPECT/CT can be performed to improve localization, but this could delay CA (22).

Catheter angiography

Technique. CA with intent to treat with embolization is most commonly performed for unstable patients with active LGIB who are not appropriate candidates for endoscopy (33). CA is rarely performed before CTA because of high reliability, noninvasiveness, access, ability to provide a vascular roadmap, and speed of CT angiography. Provocative angiography with heparin and tissue plasminogen activator can be performed to diagnose and treat patients with obscure and recurrent GI bleeding, if all other methods have failed to diagnose source of bleeding (34,35).

Ideally, the patient should undergo CTA of the abdomen and pelvis to allow identification of the vessel territory before angiography. This may reduce the amount of contrast during the

angiography by focusing on one of the 2 potential vessels (superior mesenteric artery and inferior mesenteric artery) supplying the colon. Of note, initial data did not demonstrate a decrease in contrast administration when CTA was performed before angiography (18).

CA is usually performed through common femoral artery or left radial artery access. Selective angiograms of the superior mesenteric artery and inferior mesenteric artery are performed to image the site of bleeding suspected based on the previous imaging studies. Contrast extravasation into the bowel lumen is definitive proof of active GI bleeding. When the exact site of bleeding is identified, a superselective angiogram of the end vessel vasa recta supplying the area of bleeding is performed. This is followed by microcoil (36) or glue (N-butyl 2-cyanoacrylate) embolization (37) of the vasa recta correlating with the site of bleeding. The goal of embolization is to decrease the blood flow to the bleeding site to achieve hemostasis while maintaining collateral perfusion to prevent ischemia of the bowel. Care should be taken to minimize the area embolized because collateral supply to the bowel is minimal at the level of vasa recta.

Performance data. Technical success of embolization is above 95%; however, up to 25% of patients may present later with recurrent bleeding (37,38). Angiography with embolization is a durable treatment for patients with acute LGIB and is proving to be a definitive therapy for most patients (39,40). Glue embolization seems to have better impact on the rate of recurrent bleeding than microcoil embolization (38).

Advantages. The major advantage of CA for LGIB is the ability to both diagnose and treat definitively at the same time with high technical success, minimal side effects, and relatively low rate of recurrent bleeding.

Limitations. A major limitation of CA is its invasiveness. Groin arterial access in elderly atherosclerotic patients may result in injury to the vessel with resultant hematoma, dissection, or arteriovenous fistula formation. Bowel ischemia may occur in rare cases and is more commonly seen with glue embolization (41); this usually occurs without bowel necrosis and can be treated conservatively (42). A recent publication showed severe adverse events involving embolization-induced bowel ischemia occurred in 3 of 56 (5.3%) patients who underwent particle embolization with or without coils vs 0 of 66 patients when coils alone were used (43). Overall, the risk of bowel ischemia after embolization is up to 10%, although most of the patients are asymptomatic (44–47). Only patients with active extravasation at the time of the angiography can be treated with targeted embolization because embolization of a wider vascular territory will result in significant bowel ischemia. As GI bleeding is frequently intermittent, this is a significant limitation of CA as both a diagnostic and therapeutic modality. In some patients, the extent of atherosclerotic disease may not allow navigation of the abdominal aorta and its branches. CA is usually performed with iodinated contrast to diagnose bleeding. Relative (renal insufficiency) and absolute (anaphylactic shock) contraindications to iodinated contrast should be considered before angiography. In younger patients with LGIB, consideration should be given to the significant radiation exposure associated with CA.

Gastroenterology perspective

A discussion of advantages and limitations of radiologic testing vs colonoscopy for LGIB is provided in Supplementary Appendix S5 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>).

CONSENSUS RECOMMENDATIONS FOR IMAGING IN OVERT LGIB

CT angiography

Technique

1. Unenhanced images (conventional or virtual noncontrast) should be acquired in all cases.
2. Images should be acquired during a late arterial phase and a portal venous or delayed phase.
3. No oral contrast should be administered.
4. Three-dimensional CTA images can be generated to help guide subsequent conventional angiography.
5. Dual-energy CT techniques may be used if available to improve visibility of sites of contrast extravasation.

Role/indications

1. CTA should be performed as the first diagnostic study in hemodynamically unstable patients.
2. CTA could be considered as the first-line study in hemodynamically stable patients where the suspicion of active bleeding is high.
3. CTA is not indicated as a first-line test in hemodynamically stable patients in whom bleeding has subsided.

Catheter angiography

Technique

1. CA for LGIB can be performed through common femoral artery or radial artery access.
2. Permanent agents, such as microcoils or glue, are used to embolize vasa recta at the site of identified bleeding.
3. In the absence of active extravasation on angiography, embolization should not be performed because the exact site of bleeding is not identified.

Role/indications

1. In most cases, if CTA is negative for GI bleeding, CA is not indicated.
2. In unstable patients with active extravasation on CTA, CA with embolization can be used as primary treatment modality.
3. If the patient has recurrent intermittent LGIB and all modalities have failed to identify source of bleeding, provocative CA can be performed to identify and treat the culprit lesion.

^{99m}Tc-RBC scan

Technique

1. The *in vitro* RBC labeling method has the highest labeling efficiency and is the preferred method.
2. Imaging should be continued for 1 hour if no bleeding is detected.

Role/indications

1. In a hemodynamically stable patient with evidence of ongoing LGIB, negative evaluation with colonoscopy, and a CTA is negative, contraindicated, or not available, tagged-RBC scan can be performed.

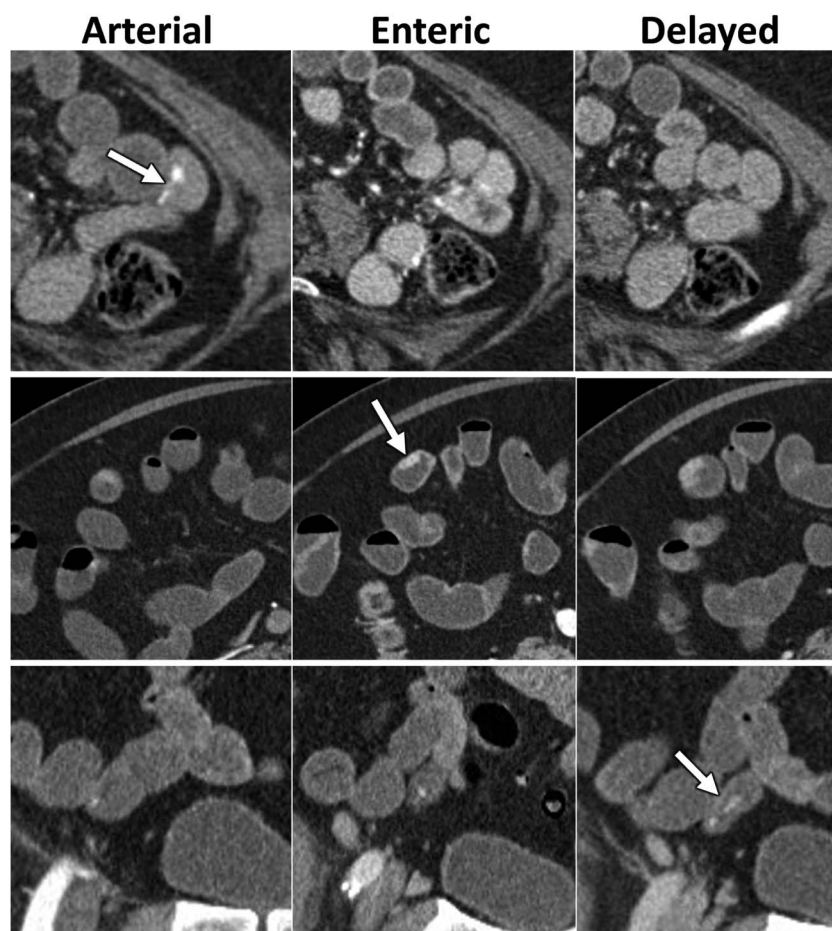


Figure 4. Multiphase CTE. Advantages of a multiphasic CTE for detection and characterization of GI bleeding etiologies. The top row shows a Dieulafoy lesion (arrow) which is most conspicuous on the arterial phase. The middle row shows a small neuroendocrine tumor (arrow), most conspicuous on the enteric phase. The bottom row shows a slowly bleeding angioectasia (arrow), most conspicuous on the delayed phase. Modified from Huprich et al (49), Copyright © 2013, copyright owner as specified in the American Journal of Roentgenology. CT, computed tomography; CTE, CT enterography; GI, gastrointestinal.

DIAGNOSTIC TESTING IN SUSPECTED SMALL BOWEL BLEEDING: REVIEW OF IMAGING TECHNIQUES

CT enterography

Technique. CTE protocols are designed to optimize evaluation of the small bowel wall and require ingestion of a large volume of oral contrast to distend the bowel. Approximately 1.5 L of fluid is ingested in divided doses over the hour preceding the examination. Neutral oral contrast agents, with attenuation values near water density, are the preferred agents for evaluating suspected small bowel bleeding. This is because most small bowel pathology which cause GI bleeding hyperenhance after the administration of IV contrast (inflammation, vascular lesions, and some neoplasms) and will be brighter or more conspicuous against the hypodense neutral enteric contrast (48). IV contrast is required to visualize these enhancing lesions. Scans can be performed using a single-phase or multiphase technique (Tables 1 and 2). A single phase, performed during the enteric or portal venous phase (50 or 70 seconds after starting the contrast injection, respectively), is adequate to detect inflammation and most masses. Multiphasic examinations (Figure 4) improve the detection and characterization of vascular lesions (49). Multiphase examinations are most commonly performed with the addition of an arterial phase

series to the enteric or portal venous phase, and at some institutions, a delayed phase (90 seconds after starting contrast injection) is also added (5,49). The visualization of an abnormality on multiple phases may also increase the level of confidence in identifying the abnormality.

Performance data. Nearly all reports on the diagnostic accuracy of CTE for evaluating suspected small bowel bleeding published in the literature contain substantial numbers of patients with overt bleeding. Therefore, specific data on CTE accuracy in patients with occult GI or suspected small bowel bleeding are scarce. In one study, which recruited patients referred for double-balloon enteroscopy for suspected small bowel bleeding, the sensitivity and specificity of CTE were 30.9% (25/81) and 69.4% (34/49), respectively, in patients with occult bleeding (50). These values were slightly lower than 39.5% (30/76) and 73.9% (34/46), respectively, in patients with overt bleeding in the same study (50). The overall (i.e., not distinguishing overt and occult) sensitivity and specificity of CTE for detecting the causes of suspected small bowel bleeding reported in the literature are quite heterogeneous, with the pooled sensitivity of 72.4% ($P = 80.8\%$; range, 40%–100%) and specificity of 75.2% ($P = 77.7\%$; range, 45.5%–100%) according to a meta-analysis (51).

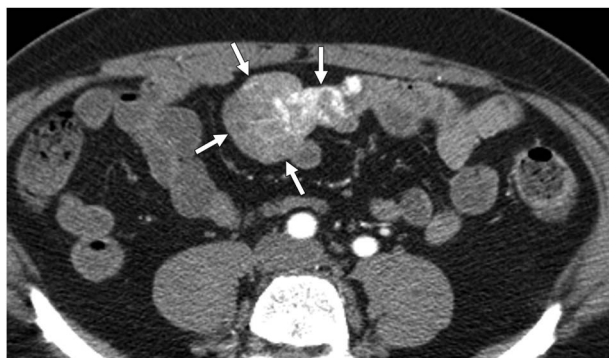


Figure 5. Small bowel gastrointestinal stromal tumor on CTE. A 53-year-old woman with suspected small bowel bleeding and negative capsule endoscopy. Single-phase CTE shows a large exophytic vascular mass (arrows) arising from the small bowel consistent with a gastrointestinal stromal tumor which was proven at surgical resection. CTE, computed tomography enterography.

Several studies reported the diagnostic yields of CTE in patients with occult GI and/or suspected small bowel bleeding (i.e., patients in whom CTE detected the bleeding causes divided by all patients examined with CTE) (50,52–56). Overall, the diagnostic yields were lower in patients with occult bleeding (0%–33.3%) than in patients with overt bleeding (22.4%–66.7%) (50,52–56).

Advantages. CTE may have several advantages over endoscopic techniques (3). CTE has greater sensitivity for detecting small bowel masses particularly those that are mural-based and can help direct targeted, deep enteroscopy procedures when a source is identified (Figures 5 and 6). Cross-sectional imaging techniques (CT and MR) allow visualization of extraintestinal abdomino-pelvic structures such as malignancies that may involve bowel or changes in the mesentery, bowel wall, and bowel/mesenteric vessels as potential causes of GI bleeding even in the absence of active contrast extravasation. In patients with occult small bowel bleeding and relative contraindications to capsule endoscopy such as radiation, prior surgery, Crohn's disease, and/or small bowel stenosis, CTE may be the first-line study to characterize the abnormality (3).

Limitations. Limitations of CTE include the use of ionizing radiation and the need for IV contrast in patients. Although usually

not an issue in the setting of an occult GI bleed, the neutral oral contrast agent used in CTE theoretically may dilute contrast extravasation making it more difficult to identify (20,48). Similar to CTA, subtle masses or vascular abnormalities may be obscured on CTE secondary to hyperdense bowel contents, radiopaque foreign bodies, and cone beam artifacts. Incompletely distended bowel may also obscure or mimic mucosal abnormalities. If there is brisk ongoing bleeding with hemodynamic instability, CTA should be performed instead of CTE.

Meckel scan

A Meckel scan can be performed to investigate for a Meckel diverticulum. The technique involves the IV administration of ^{99m}Tc pertechnetate, which accumulates in gastric mucosa often found ectopically in a Meckel diverticulum. After administration, scintigraphy is performed dynamically for a period of 30–60 minutes to identify a fixed abdominal region of ectopic gastric mucosa (57). Most symptomatic Meckel diverticula are found in children and young adults but occasionally can be seen in older individuals and can be considered when other tests are negative. There are data to suggest that the test is less sensitive in adults (63%) as compared with children (85%) (58). A Meckel diverticulum can be difficult to visualize on CTE unless there is associated inflammation or intussusception.

Gastroenterology perspective

A discussion of advantages and limitations of radiologic testing vs capsule endoscopy and balloon-assisted endoscopy for small bowel bleeding is provided in Supplementary Appendix S5 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>).

CONSENSUS RECOMMENDATIONS FOR IMAGING IN SUSPECTED SMALL BOWEL BLEEDING

CT enterography

Technique

1. CTE should be performed using a multiphase technique in patients older than 40 years of age where vascular lesions are a common cause for bleeding.
2. Multiphase CTE should include at least arterial, and enteric or portal venous phases.

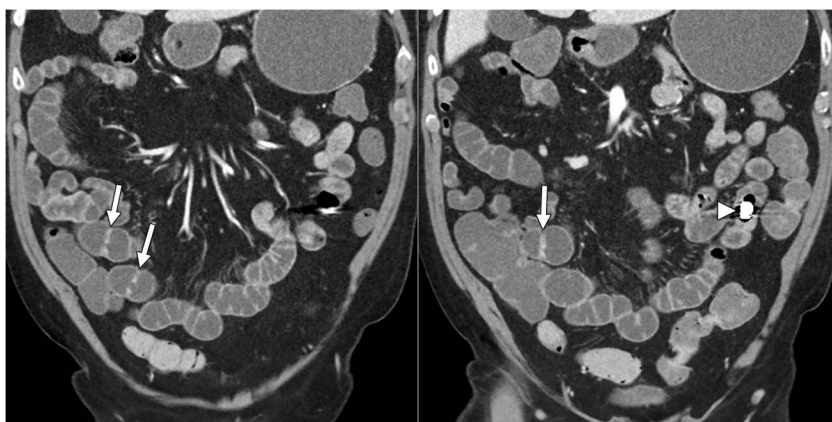


Figure 6. Obstructing NSAID diaphragms on CTE. A 50-year-old man with a history of nausea, vomiting, diarrhea, and suspected GI bleeding. Prior negative routine CT. CTE shows multiple diaphragms (arrows) in the distal small bowel with retained capsule (arrowhead) from prior capsule endoscopy. CT, computed tomography; CTE, CT enterography; GI, gastrointestinal; NSAID, nonsteroidal anti-inflammatory drug

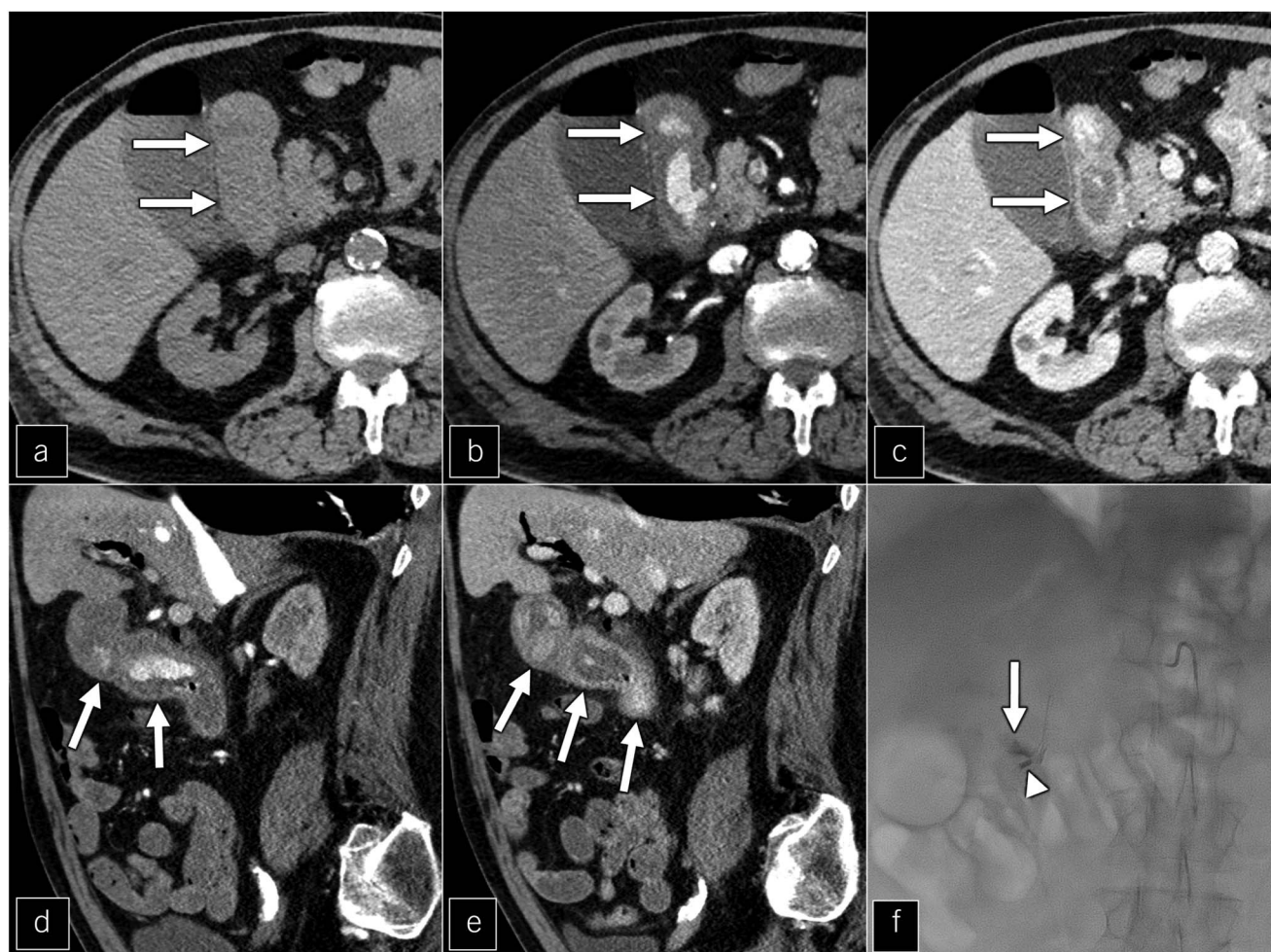


Figure 7. Actively bleeding duodenal ulcer. A 70-year-old man with a history of a large duodenal ulcer previously treated with endoscopic clipping who presents with recurrent GI bleeding. Noncontrast (a), arterial phase axial (b), and sagittal (d), and portal venous phase axial (c) and sagittal (e) CT images show high-density fluid in the duodenum on noncontrast images (arrows in a) representing a sentinel clot. On contrast enhanced images, there is arterial phase contrast extravasation in the duodenum (arrows in b and d) which changes in size and density in the portal venous phase (arrows in c and e) consistent with contrast extravasation. Catheter angiography image (f) shows a focus of contrast extravasation (arrow) adjacent to a metal clip from a prior endoscopic procedure (arrowhead). The GI bleed was successfully treated with coil embolization. CT, computed tomography; GI, gastrointestinal.

3. Multiphase CTE is the recommended term for a CTE performed for suspected small bowel bleeding and acquired with multiple phases after the administration of IV contrast.
4. A single phase performed during the enteric or portal venous phase is adequate to evaluate for inflammatory conditions such as Crohn's disease, radiation enteritis, nonsteroidal anti-inflammatory drug enteropathy, and most malignancies.
5. Neutral enteric contrast should be administered in divided doses beginning 1 hour before CTE.

Role/indications

1. CTE should be performed instead of CTA in hemodynamically stable patients presenting with ongoing suspected small bowel bleeding after negative colonoscopy and esophagogastroduodenoscopy (EGD), and capsule endoscopy (if negative or not performed).
2. If there is brisk ongoing bleeding with hemodynamic instability, CTA should be performed instead of CTE.

3. CTE should be the first-line imaging test for suspected small bowel bleeding in hemodynamically stable patients if patients are at increased risk for video capsule retention.
4. CTE should be the first-line study for suspected small bowel bleeding in hemodynamically stable patients if small bowel neoplasm is the suspected cause for small bowel bleeding.
5. CTE can be performed as the first-line diagnostic study for suspected small bowel bleeding in hemodynamically stable patients depending on clinical scenarios such as local availability and expertise.
6. CTE should be performed if there is no definitive cause for small bowel bleeding identified on capsule endoscopy and there is suspicion for ongoing bleeding.

Meckel scan

Role/indication

1. A Meckel scan can be considered to identify the cause of unexplained intermittent GI bleeding in children and adolescents after negative endoscopic evaluation, including

capsule endoscopy if available, and cross-sectional evaluation of the small bowel.

DIAGNOSTIC TESTING IN NONVARICEAL UGIB: REVIEW OF IMAGING TECHNIQUES

CT angiography

The technique, advantages, and limitations of CTA are the same as those discussed for overt LGIB. Most of the published data have reported the performance of CTA in LGIB. Therefore, there is a paucity of data in those patients presenting with nonvariceal UGIB. In the rare circumstance when endoscopy identifies UGIB but cannot identify the source, CTA may be helpful in localizing the bleeding site. CTA can be considered if there is no in-house emergency gastroenterology coverage or the patient is not suitable for EGD including when postoperative anatomy limits endoscopic access (Figure 7).

Catheter angiography

Treatment of patients presenting with symptoms of UGIB (both variceal and nonvariceal) should prioritize medical stabilization followed, in most cases, by endoscopy (59). In select cases, such as hepatic pseudoaneurysm, angiography may be the preferred first-line treatment (59,60).

If endoscopy visualizes but is unable to treat a source of bleeding, CA should be performed with the intent to embolize (61–63).

Technique. Before CA, the patient's renal and coagulation status should be optimized (59). If the bleeding site has previously been localized, angiography should initially be targeted to the bleeding vessel (63). Next, both the celiac and superior mesenteric arteries should be interrogated to evaluate all potential bleeding sources and collateral vessels (62,63) with high volume of contrast (20 mL volume with 5 mL/sec injection rate) and long imaging time (30–40 seconds) until opacification of the portal system is seen.

In the absence of visualized contrast extravasation, but documented extravasation on upper endoscopy or CTA, prophylactic embolization of suspected vessel should be considered. When possible, superselective embolization should be performed in a distal to proximal fashion which reduces the risk of “back door,” rebleeding through collaterals. Currently, microcoils are the most commonly used embolic agent. Other options include gel-foam, particles, glue, and plugs (63). Placement of an endoscopic clip next to the bleeding site at the time of endoscopy may help guide embolization (Figure 7).

Outcomes. Outcomes data for angiographic treatment of non-variceal UGIB are limited. A technical success rate has been reported up to 95%. The clinical success rate has been reported at 67% with a 33% rebleeding rate on the first attempt (60,63). Reported complication rates are up to 10% including access site issues, kidney damage, nontarget embolization, bowel ischemia, and bowel infarct; however, these are highly variable due to the differences in technique, embolization material, and reported complications (61,62).

Gastroenterology perspective

A discussion on the role of CTA vs EGD for nonvariceal UGIB is provided in Supplementary Appendix S5 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>).

CONSENSUS RECOMMENDATIONS FOR IMAGING IN NONVARICEAL UGIB

1. CA with intent to treat is indicated when an EGD is unsuccessful in achieving initial hemostasis, or the patient experiences recurrent bleeding after a successful initial EGD and a repeat EGD is either unsuccessful or not recommended.
2. In the setting of ongoing bleeding, CTA can be considered:
 - If the patient is not believed to be suitable for EGD or if there is no in-house emergency gastroenterology coverage.
 - After negative EGD or if EGD is unable to identify the site of bleeding.

Additional cross-sectional imaging techniques and potential future advances

Additional cross-sectional imaging techniques including dual energy CT and MR are discussed in Supplementary Appendix S6 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>).

Special considerations

Supplementary Appendix S7 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>) discusses an approach to imaging for GI bleeding in special considerations including pregnancy and renal impairment.

Comparison of recommendations with the American College of Radiology appropriateness criteria

The American College of Radiology has developed appropriateness criteria for nonvariceal upper GI tract bleeding (64) and management of lower GI tract bleeding (65) which will be compared with our recommendations in Supplementary Appendix S8 (see Supplementary Digital Content 1, <http://links.lww.com/AJG/D143>).

CONFLICTS OF INTEREST

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